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Papers downloaded from **AgEcon Search** may be used for non-commercial purposes and personal study only. No other use, including posting to another Internet site, is permitted without permission from the copyright owner (not AgEcon Search), or as allowed under the provisions of Fair Use, U.S. Copyright Act, Title 17 U.S.C. The Global Vector Error Correction Model application on the dynamics and drivers of the World Butter Export Prices: Evidence from the U.S., the EU, and New Zealand

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Abstract: Recently, the world has experienced the striking economic and policy changes, and subsequent uncertain factors have significant impacts on milk and dairy products price fluctuations across the world. The Global Vector Autoregressive (GVAR) methodology has established in this paper to better understand international butter export prices volatilities and the link among global butter export prices, energy and other commodities prices. We assessed what variables are typically associated with price movements with a focus on the short and long-run responses of butter export prices to a shock to palm oil price, to changes in domestic economic situation, to the shock to real exchange rate and energy price. Using generalized impulse response functions, we find that all these influential factors have long-run effects on butter export prices, though different shocks have different impacts on different countries. Moreover, the generalized impulse response analysis of shocks to butter export price of each countries shows that New Zealand is unaffected to the butter export price changes of the EU and the USA. Recent policy and economic structure changes such as EU milk quota abolishment, Russia bans on imports and the currency devaluation will cause volatility and unstable of butter export prices.

Keywords: GVAR, Spatial price transmission, Spill-over effect, Error-Correction Model

JEL code: Q02, Q17, Q18

1 Introduction

Recently, the world has experienced the striking economic and policy changes and the subsequent phases of uncertainties have an important impact on international commodity trade across the world, thus results in considerable exports prices fluctuations and volatilities. As the increasingly demanded and highly protected export commodities in the global market, dairy product have become one of the most volatile agricultural commodities in the world because of several factors and phenomena affecting the availability, stability and utilization in the short run.

Dairy industry, which gains increasing importance in the international trade market with substantially growing demand of its products from developing countries, is characterized by a market with a limited number of major exporters. In 2013, the United States of America (U.S.), 28-member countries of the European Union (EU 28) and New Zealand account for 86.92% (selfcalculated by FAO data) of world total butter export, and over 80% of other dairy products such as skim milk powder (SMP), whole milk powder (WMP), cheese, and whey powder. As one of the most significant food and nutrition resources, dairy products price transmissions along the supply chain and in geographically separated markets have drawn much attention of policy makers and scholars. Extensive studies have been conducted that the pattern of price linkages may provide useful information on whether a given set of spatial markets are integrated. Regarding the international butter export, the major producing and exporting regions (i.e., the U.S., the EU 28 and New Zealand) of butter apply different trade policy and strategies with different targeted markets. The research on the dynamics of global butter export prices and the factors behind the changes demonstrates particular interest for two main reasons. The butter is a vital important commodity that has long history of intervention stocks in major dairy exporters such as the EU and the US. Importantly, the price dynamics of butter of different exporters could be linked to each other due to the substitution effects and market integration. Therefore, understanding the price dynamics and spatial transmission mechanism could facilitate the policy making process and help adjust investment and trade strategy of the major exporters.

The food commodity price transmission and the influential factors have been widely studied. However, to the best of our knowledge, there are no research conducted to analyse the international butter export prices spatial transmission and its influential factors. The GVAR model, as a highdimensional cross-section time series model seldom relying on the economic theory and restrictions, is an ideal model to analyse the spatial commodity price transmission and to identify the impacts of various shocks in a visual and efficient way. In this study, the GVAR model is employed to analyse the pattern of spatial price linkages in butter export markets and the impacts of influential factors. The findings of this study add to the literature on empirical analysis of dairy products price spatial transmission and the impacts of shocks such as policy, exchange rate on export prices.

The overall objective of this paper is to understand the interaction and links among international butter export prices, policy changes, energy prices and shocks from demand and supply sides in the short-run and long-run period. The following questions will be answered through this empirical analysis:

Firstly, what factors are typically associated with butter export price movements and in what degree do they influence the export prices of different countries?

Secondly, how do different shocks have impact on export prices in the short-run and long-run periods respectively?

The rest of the paper is organized as follows. Section 2 presents methodology, after which Section 3 reports the empirical model and the results. Section 4 presents further evidence to understand the mechanism, and Section 5 is the conclusions of the paper.

2 Methodology

The Global Vector Autoregressive (GVAR) model first proposed by Pesaran et al. (2004) comprises two steps: the first step of construction of the individual unit (countries and regions) models VARX and the second step of stacking estimated country models to form one large global VAR model.

Firstly, let's take a look at how the individual country models are constructed.

We assume that there are *N* cross-section units, with each of which k variables observed during the time period t=1, 2, 3, ..., T. x_{it} denotes the $k_i \times I$ vector of variables specific to unit *i* in time period t. $x_t = (x'_{1t}, x'_{2t}, ..., x'_{nt})'$ denotes the k×1 vector of all the variables, where $k = \sum_{i=1}^{N} k_i$. For our empirical model, the cross-section units refer to the specific countries and regions defined (i.e., the U.S.A, the EU 28, New Zealand and the Rest of World) for research purpose.

Therefore, the country-specific conditional models are estimated separately. These individual country models explain the domestic variables of a given economy, x_{it} , conditional on country-specific cross-section averages of foreign variables, collected in the $k^* \times I$ vector

(1)

$$x_{it}^* = \widetilde{W}_i' x_t$$

for i=1, 2, 3, ..., N, where \widetilde{W}_i is $k \times k^*$ matrix of country-specific weights, typically constructed using data on bilateral foreign trade or capital flows.1 Both k_i and k^* are treated as small (typically 4 to 6).

 x_{it} is modelled as a VARX^{*} model, namely a VAR model augmented by the vector of the 'star' variables x_{it}^* , and their lagged values as Equation (2a). Moreover, when country models need to be augmented by global variables d_t and its lagged values, in addition to the country-specific

vector of cross-section averages of the foreign variables, the model will be represented as Equation (2b).

(2a)

$$x_{it} = a_{i0} + a_{i1}t + \sum_{l=1}^{p_i} \Phi_{il}x_{i,t-l} + \Lambda_{i0}x_{it}^* + \sum_{l=1}^{q_i} \Lambda_{il}x_{i,t-l}^* + \varepsilon_{it}$$

(2b)

$$x_{it} = a_{i0} + a_{i1}t + \sum_{l=1}^{p_i} \Phi_{il}x_{i,t-l} + \Lambda_{i0}x_{it}^* + \sum_{l=1}^{q_i} \Lambda_{il}x_{i,t-l}^* + \Psi_{i0}d_t + \sum_{l=1}^{s_i} \Psi_{il}d_{t-l} + \varepsilon_{it}$$

for i = 1, 2, ..., N, where Φ_{il} , for $l = 1, 2, ..., p_i$, Λ_{il} , for $l = 0, 1, 2, ..., q_i$, are $k_i \times k_i$ and $k_i \times k^*$ matrices of unknown parameters, respectively, and ε_{it} are $k_i \times l$ error vectors.

For simplicity, we assume $\Psi_{il} = 0$ for $l = 0, 1, 2, ..., s_i$ in the following derivation. Therefore, let $Z_{it} = (x'_{it}, x^{*'}_{it})'$ be $k_i + k^*$ dimensional vector, thus we can rewrite equation (2a) as

(3)

$$\Lambda_{io} \mathbf{Z}_{it} = a_{i0} + a_{i1}t + \sum_{l=1}^{p} \mathbf{A}_{il} \mathbf{Z}_{i,t-l} + \varepsilon_{it}$$

Where

$$A_{i0} = (I_{ki} - \Lambda_{i0}), A_{it} = (\Phi_{il}, \Lambda_{il}) \text{ for } l = l, 2, ..., p.$$

The estimation of country models in (2), which allows for cointegration within and across countries (via the star variables), is the first step of the GVAR approach.

Equation (3) can be written as the error-correction representation.

$$\Delta x_{it} = a_{i0} + a_{i1}t + \Lambda_{i0}\Delta x_{it}^* - \pi_i Z_{i,t-1} + \sum_{l=1}^p H_{il}\Delta Z_{i,t-l} + \varepsilon_{it}$$

Where $\Delta = 1 - L$ is the first order difference.

The second step of the GVAR approach consists of stacking estimated country models to form one large global VAR model.

Using the $(k_i + k^*) \times k$ dimensional 'link' matrices $W_i = (E'_i, \widetilde{W}'_i)$, where E_i is $k \times k_i$ dimensional selection matrix that select x_{it} , namely $x_{it} = E'_i x_t$, and \widetilde{W}'_i is the weight matrix introduced in (1) to define country-specific foreign star variables. We have

(4)

$$z_{it} = (x'_{it}, x^{*'}_{it})' = W_i x_t$$

(5)

$$A_{i0}W_i x_t = a_{i0} + a_{i1}t + \sum_{l=1}^p A_{il}W_i x_{t-l} + \varepsilon_{it}$$

(6)

$$G_0 x_t = a_0 + a_1 t + \sum_{l=1}^p G_l x_{t-l} + \varepsilon_t$$

Where $\varepsilon_t = (\varepsilon'_{1t}, \varepsilon'_{2t}, \dots, \varepsilon'_{Nt})'$, $a_0 = (a'_{10}, a'_{20}, \dots, a'_{N0})'$, $a_1 = (a'_{11}, a'_{21}, \dots, a'_{N1})'$

$$G_l = \begin{pmatrix} A_{1,l}W_1 \\ A_{2,l}W_2 \\ \vdots \\ A_{N,l}W_N \end{pmatrix}$$

If matrix G_0 is invertible, then by multiplying (6) by G_0^{-1} from the left we obtain the solution to the GVAR model

(7)

$$x_{t} = b_{0} + b_{1}t + \sum_{l=1}^{p} F_{l}x_{t-l} + G_{0}^{-1}\varepsilon_{t}$$

Where $F_l = G_l G_0^{-1}$, $b_0 = a_0 G_0^{-1}$, $b_1 = a_0 G_0^{-1}$.

Equation (7) can be solved recursively and used for analyzing the impulse responses, or to compute the forecast error decompositions, or to forecast the x_t variables.

The deduction of getting Error-Correction representation

Minus $x_{i,t-1}$ on both side of equation (2), we get

$$\Delta x_{it} = a_{i0} + a_{i1}t + \Lambda_{i0}x_{it}^* - \Lambda_{i0}x_{i,t-1}^* + \Lambda_{i0}x_{i,t-1}^* - x_{i,t-1} + \sum_{l=1}^{p_i} \Phi_{it}x_{i,t-l} + \sum_{l=1}^{q_i} \Lambda_{it}x_{i,t-l}^* + \varepsilon_{it}x_{i,t-l}^* + \varepsilon_{it}x_{i,t-1}^* +$$

$$\Delta x_{it} = a_{i0} + a_{i1}t + \Lambda_{i0}\Delta x_{it}^* + \Lambda_{i0}x_{i,t-1}^* - x_{i,t-1} + \sum_{l=1}^{p_i} \Phi_{it} x_{i,t-l} + \sum_{l=1}^{q_i} \Lambda_{it}x_{i,t-l}^* + \varepsilon_{it}$$

$$\Delta x_{it} = a_{i0} + a_{i1}t + \Lambda_{i0}\Delta x_{it}^* - A_{i0}Z_{i,t-1} + \sum_{l=1}^{p} A_{il}Z_{it-l} + \varepsilon_{it}$$

Therefore, by rearranging terms, we can get the error-correction representation of equation (2) as follows.

$$\Delta x_{it} = a_{i0} + a_{i1}t + \Lambda_{i0}\Delta x_{it}^* - \Pi_{i0}Z_{i,t-1} + \sum_{l=1}^p H_{ll}\Delta Z_{i,t-l} + \varepsilon_{it}$$

Where $\Pi_{i0} = -(A_{i0} - \sum_{l=1}^{p} A_{il}), \ H_{il} = -\sum_{l=1}^{p-1} A_{i,l+1}.$

3 Empirical models and the results

Conventional models have not provided a complete picture of recent price fluctuations in butter export markets, especially prices interaction among different commodities. The world dairy industry has experienced a and there is an urgent need for appropriate policy responses to the uncertainty faced by world dairy industry. Therefore, it is necessary to know the mechanism of butter export price volatility. The development of Global Vector Autoregressive Models with application on dairy markets is quite effective. Combining the econometrics and policy analysis with statistic estimation, this chapter shows the results from a new worldwide dynamic model that gives the short and long-run responses of butter export prices in different country or region to different sort of shocks.

We construct four VARX models, one for each of the main export regions: USA, EU and New Zealand. Also, we specify a Rest of the World regional VARX model to represent the effects from all the other countries. These four countries are estimated from January 2010 to December 2016 at monthly intervals. Although Belarus and Australia are also major butter exporters, we exclude them from this analysis due to the data insufficiency such as the lack or low quality of data. Besides, considering the export among EU member countries are protected under the Common

Agricultural Policy (CAP) which is different from world export policy, we use the butter export price of EU to countries beyond EU 28 to analyse the EU butter export prices.

The country-specific variables¹ include: 1) the index of export prices in U.S. Dollars as p_{it}^e , 2) the index of fertilizer price in the local currency as p_{it}^f , 3) the consumer food price index CPI_{it} which reflects the food inflation in each country.

The foreign-specific variables are established as a geometric average of the country-specific variables. The weights we use are computed as averages of shares of exports in total world exports from 2011 to 2015. Therefore, the foreign-specific variables include: 1) the average of competitors' export prices, $p_{it}^{e*} = \sum_{i \neq j} w_j p_{jt}^e$, 2) the average of countries bilateral exchange rate, $e_{it}^* = \sum_{j \neq i} w_j e_{jt}$, 3) the average of the food price indexes, $CPI_{it}^* = \sum_{j \neq i} w_j CPI_{jt}$.

Global variables can impact the system of each region and are of vital importance to all countries. The dairy industry is depended on the energy in that oil and energy are necessary for the production of milk and dairy products. Therefore, the dairy market can be affected by changes of energy prices such as world crude oil price, p_t^o . butter has long been consumed by western people and its price is relatively high and volatile. Palm oil is a versatile vegetable oil and, with a share of more than 30 % of global vegetable oil production, it is also the most produced vegetable oil (USDA 2014). Both butter and palm oil are sources of fat. The margarine which can be produced using palm oil is a good substitute for butter. So, international butter export price to some degree can be influenced by palm oil price, p_t^p . In the GVAR model we constructed, the crude oil price is set to

¹ We didn't include variables related to production due to unavailable of monthly data. Nevertheless, the model is still effective to analyse the effect of supply shocks. For example, production shortfalls result from extreme weather or sudden supply-side policy change can still be analysed by imposing a corresponding price increase in the specific country.

be endogenous in the USA VECX model and palm oil price is set to be endogenous in the EU VECX model.

$$\begin{aligned} x_{it} &= (p_{it}^{e}, e_{it}, p_{it}^{f}, CPI_{it}), \\ x_{0t} &= (p_{it}^{e}, p_{it}^{f}, CPI_{it}), \\ x_{3t} &= (e_{it}, p_{it}^{f}, CPI_{it}), \\ \widetilde{x_{it}^{*}} &= (p_{it}^{e*}, e_{it}^{*}, CPI_{it}^{*}), \\ i &= 0, \dots, 3; \ d_{t} = (p_{it}^{co}, p_{it}^{po}) \end{aligned}$$

All the variables used in this paper was transformed to its indexes using the period (Jan/2010-Dec/2016) = 100 as the base year. As agri-food commodities usually have strong seasonality with may influence our analysis, we first of all used multiple X11 seasonal adjustment method to adjust the butter export price indexes for all country or regions. Both the adjusted and unadjusted time series of butter export price index was plotted in Figure 1. As we can see, there is not significant differences between the adjusted and unadjusted ones. Therefore, we constructed the GVAR model using the unadjusted butter export price index series while made decomposition of these series using seasonal adjusted series.

Figure 1: Time series plot of seasonal adjusted and unadjusted butter export price index



For each country or region, we decompose the time series of butter export price index into trend and cycle to depict an overall picture as illustrates in Figure 2. As we can see, the butter export price of USA has similar pattern with the EU and New Zealand before June 2012, however, it changed into a more volatile pattern since then, especially since 2014. While for the EU 28 economy, there exists a slightly increase and then a decreasing trend and around 20% peak-totrough swing. As for New Zealand, there is a mild decreasing trend and 25% peak-to-trough swing over our study period.







Figure 2 depicted that the cycle patterns of butter export price of New Zealand and EU are much similar and have cycles of around 2 years. While the butter export price of USA is much volatile than that of EU and New Zealand. Moreover, the butter export price of USA has two spikes in 2014 and 2015, besides, the peak and trough of cycles are of wider range than that of EU and New Zealand. What's more, the rising and decreasing patterns of the USA lags behind that of New Zealand for several months but displays a coherent format. Therefore, the butter export prices in the world's major exporters to some extend have co-movement patterns.

Figure 3: The cycles of butter export price index of USA, EU and New Zealand



The weights are of vital importance on the analysis of the dynamics of the model. Most practically, researchers using the trade flow between these countries as the weights to indicate their mutual trade partnership. Besides this, in the gravity models distance also popularly applied to explain their trade importance. For our GVAR butter export price model in which includes only exporters and thus distance cannot properly signal trade between the included countries due to the negligible trade value in butter between these countries. So, we use the average of shares of total dairy products exports value in total exports of countries we included from 2011-2015 as the fixed trade weights over time which are presented in Table 1. Data to compute these are from United Nation data displayed in USDA-GATS.

Countries	USA	EU 28	New Zealand	Rest of World
USA	0	0.05039	0.039375	0.910235
EU	0.286717	0	0.697201	0.016082
New Zealand	0.165426	0.071756	0	0.762818

Table 1: Trade Weights Based on Total Dairy Products Export Values

ROW	0.704301	0.289934	0.005766	0

Source: USDA-GATS.

Note: Trade weights are computed as average of shares of exports value in total exports of countries we included from 2011-2015; In the above table, the exporters are displayed in column and each row not each column sums to 1.

When dealing with time series data, testing the stationarity is the first and necessary step. The results are shown in Table 2. As indicated by the ADF tests, the butter export price series are stationary, while all the other series included in our model do not reject the null hypothesis of nonstationarity and thus they are I (1). Therefore, there are high possibility that the variables in each country or region have cointegrating relationships.

Table 2: Augmented Dickey-Fuller (ADF) Unit Root Tests Statistics for Domestic and Foreign Variables

Variables	USA	EU 28	New Zealand	Rest of World
p_{it}^{e} (with trend)	-3.82587	-2.72354	-2.96659	-
p_{it}^{e} (no trend)	-3.47767	-1.80624	-2.35068	-
$\mathrm{D.}p_{it}^{e}$	-5.75902	-4.66519	-5.86269	-
e_{it} (with trend)	-	-1.97032	-2.08577	-2.97086
e_{it} (no trend)	-	-0.59787	-1.5759	0.276155

D.e _{it}	-	-4.59448	-5.28989	-5.79514
p_{it}^{f} (with trend)	-2.53686	-2.3606	-2.41813	-2.14812
p_{it}^{f} (no trend)	-1.12897	-1.62559	-1.0646	-2.48809
$\mathrm{D.}p_{it}^{f}$	-5.20118	-4.86358	-6.0038	-5.83253
CPI_{it} (with trend)	-0.0425	-1.98057	-2.54787	-1.69492
CPI_{it} (no trend)	-2.49386	-1.86864	-2.86458	0.67203
D.CPI _{it}	-4.62541	-5.43977	-6.79291	-4.05024
p_{it}^{e*} (with trend)	-2.39911	-3.01642	-3.82496	-3.82511
p_{it}^{e*} (no trend)	-1.82908	-2.80816	-3.75330	-3.74655
$\mathrm{D}.p_{it}^{e*}$	-4.54188	-3.56941	-5.53106	-5.54053
e_{it}^* (with trend)	-2.88178	-2.09949	-2.88518	-1.94901
e_{it}^* (no trend)	-0.10278	-1.47746	-0.09808	-0.58407
D.e [*] _{it}	-4.01078	-5.30004	-3.99079	-4.56629
p_{it}^{pot} (with trend)	-2.92996	-2.92996	-2.92996	-2.92996
$p_{it}^{\mu\nu*}$ (no trend)	-1.21040	-1.21040	-1.21040	-1.21040
$\mathrm{D.}p_{it}^{po*}$	-6.60716	-6.60716	-6.60716	-6.60716

p_{it}^{co*} (with trend)	-2.04206	-2.04206	-2.04206	-2.04206
p_{it}^{co*} (no trend)	-0.89048	-0.89048	-0.89048	-0.89048
$\mathrm{D}.p_{it}^{co*}$	-5.87831	-5.87831	-5.87831	-5.87831
CPI_{it}^* (with trend)	-1.71745	-1.83143	-1.75127	-0.16726
CPI_{it}^* (no trend)	0.597129	-2.88861	0.467239	-2.81911
D.CPI [*] _{it}	-4.05366	-6.31947	-4.08049	-4.55169

Note: The 95% critical values of variables with trend and without trend are -3.45 and -2.89, respectively.

For each country or region's VARX model, we selected the orders of p and q using the AIC, BIC and Loglikelihood criteria based on our pre-constraint $4 \ge q_i \ge 1$. We assumed that the model has both an unrestricted intercept and a co-trending restriction to each country or region model thus to find to appropriate lag orders. The results are shown in Table 3.

	р	q	Cointegrating relations
	2	1	2
USA	2	1	2
EU 28	4	4	3
New Zealand	1	1	1
Rest of World	2	2	0

Table 3: VARX Order and Number of Cointegrating Relationships

For the USA, the EU and New Zealand their cointegrating relationships are 2, 3 and 1 respectively, while for the rest of world there is no cointegrating relation among the variables. Given that we tried to figure out the response of butter export prices on the shocks of other variables and make the GVAR model stable enough for impulse response analysis, we artificially set each country or region's cointegrating relation as 1, namely, the butter export price as the dependent variables in the following established Vector Error Correction Model (VECM). In this way, we normalized the cointegrating vector with respect to the export price coefficient. Therefore, the VECMX form was estimated and displayed in the following analysis.

Country	Critical Value	p_{it}^{e*}	e_{it}^*	CPI_{it}^*	p_{it}^{po}	p_{it}^{co}
USA	3.171626	0.566486	0.397015	-	0.601687	3.261225
EU 28	2.786229	3.666319	2.799077	-	1.222145	-
New Zealand	4.023017	1.078531	0.627644	0.037957	0.013003	1.057378

Table 4: F statistics of Weak Exogenous test at the 5% significant level

The results of Table 4 reported the F statistics of the weak exogenous test which indicate that we couldn't reject the null hypothesis of weak erogeneity for foreign-specific variables. Therefore, the GVAR model satisfied the condition to do comparative studies on the relationship between country-specific and foreign-specific variables and conduct the impulse responses analysis.

Table 5: Contemporaneous Effects of Foreign Variables on Domestic Counterparts

Country	p^e_{it}	e _{it}	CPI _{it}
USA	0.070346	-	0.02099
	(0.26618)	(-)	(0.36096)
EU 28	0.064688	0.591336	0.03427
	(0.66255)	(4.519)	(0.36627)
New Zealand	0.010062	0.58719	0.12438
	(0.14911)	(7.8104)	(1.00469)
Rest of World	-	0.148442	0.37679
	(-)	(1.33014)	(1.45596)

Note: In parentheses, White's heteroscedastic robust t-statistics are given.

We could analyse the effects of foreign-specific variables have on the corresponding domestic variables when we performed the cointegrating VECMX. As reported in Table 5, we could interpret the contemporaneous effects as the impact elasticities to show the short-run relationship between domestic and foreign variables. When taking a look at the butter export price index, the effects coefficients for all country or region are positive, however, all the estimates are not significant and also very small, which means the foreign-specific butter export prices doesn't have a strong effect on domestic butter export price for each country. As for the exchange rate, all the country or region have positive and significant short-run relationships between foreign and domestic exchange rate. However, there is not significance for the short-run co-movement of foreign and domestic food consumer price index, except for the rest of world which has a positive and significant short-run contemporaneous effect coefficient.

Variables	p^e_{it}	p_{it}^f	CPI _{it}	p_{it}^{co}	e _{it}	p_{it}^{po}
USA	2014M09	2012M07	2014M10	2011M09	-	-
EU 28	2015M07	2012M02	2011M08	-	2014M05	2011M08
New Zealand	2013M07	2013M02	2013M07	-	2013M11	-
Past of World		2012105	2014M02		2014M11	
Rest of world	-	20121003	20141005	-	20141/111	-

Table 6: Structural Stability Tests: Break Dates for QLR Tests

GVAR model automatically identify the break dates for each domestic variable in each country or region as reported in Table 6. Notably, the butter export price index of the EU encountered a structural break in July 2015, this break was expected and could reasonably be associated with the great policy change of Common Agricultural Policy which formally abolished of the milk quota scheme in March 2015 and the Russia import bans of EU agricultural products such as dairy products on 7 August 2014. Usually, the milk production increases in Spring and reaches its peak in summer and the quantity is influenced by the decision made since October. Therefore, given Russia had previously been a particularly important and main market destination, EU's dairy export market was unable to adjust so quickly and thus was particularly affected by this decision. Plus, the abolishment of milk quota to some degree made the production of milk and dairy products boom thus caused an accompanying price decline. We could notice that the CPI break of EU happened in January 2012 when European economy being experiencing the severe sovereign debt crisis shock. As for New Zealand, all the variables encountered a structural break in 2013, which

could be highly linked to the extreme and unusual drought in 2012-2013 because agricultural industry is the most vulnerable to bad weather condition.

4 The Generalized Impulse Response Analysis

The GVAR model we established is dynamically stable with 15 eigenvalues equal to unity and with the remaining moduli less than unity. The eigenvalues in moduli are decreasing to zero gradually, thus we expect to observe convergence towards a steady-state equilibrium.

First, we simulated a positive one-standard-error shock to the crude oil price. As we can see from Figure 4, the USA butter oil price response to the positive shock to crude oil price is differently from that of others. With the positive shock to crude oil price, butter export price index of USA is increasing and thereafter stay at the level of +1%. In the case of the EU 28, the butter export price increases immediately at first and then fluctuate slightly, after 12 months the response converges to zero. Therefore, shock to crude oil price almost has no impact on EU butter export price in the long run. Contradictory to the US, butter export price of New Zealand response positively with the crude oil price at the level of 0.5% at first and after three months, the response converges to a negative stable level of -0.5%. Usually, crude oil is a main source of butter export input, the increase of butter export price will raise the cost to process and export butter and further causes the increase of export price. therefore, we expected increases of butter export prices in the USA, EU and New Zealand. Nevertheless, the contradictory behaviour could be explained when we take a consideration of the relationship between U.S. dollar value and crude oil price. Several oilproducing countries are major butter destinations of New Zealand. In the short run, it is likely that the high price of oil enables oil-producing countries to purchase more butter, the butter price is forced to rise immediately, combining with the high cost of butter production. However, since crude oil is US-dollar denominated, the rising oil price indicates a fall in the production of crude oil and thereafter the U.S. dollar is appreciated. In this way, the butter export price of the USA which settled in dollars will rise accordingly. In this sense, butter export price of EU and New Zealand which settled in local currency but transferred to U.S dollar will decrease to some degree. If the effect of U.S. dollar appreciation exceeds (or offsets) the effect of rising cost, the butter export price of other country or region will decrease (or has no response) to some extent.

To sum up, the crude oil price has more significant and positive effect on the U.S. butter export price than the effect on that of the EU and New Zealand according to the GVAR model we constructed.



Figure 4: Generalized impulse response of a positive one-standard-error shock to crude oil price on butter export price (bootstrap median estimates with 90% bootstrap error bounds)

Palm oil, a resource to process margarine, is a good substitute for butter. Moreover, lots of dairy import countries such as China and Japan are using palm oil as their main fat source which also makes butter less competitive in these countries. Thus theoretically, Palm oil to a large degree could influence the butter demand. From what the figure depicted, one-standard-error shock to palm oil price instantly raises 0.8% of the butter export price of New Zealand, after 6 months the increase of butter price is around 1.9% and stabilizes at the level of +1.8%. while for the USA, there is merely no response of butter export price when there is a positive one-standard-error shock to palm oil price. However, the response of the EU's butter export price is much weak and unusual

with a slight decrease at first month and then increase a little until stable at the level of +0.8% after 6 months.

The generalized impulse responses shown in Figure 5 could be reasonably explained by their market strategy and structure. The main butter export destinations of New Zealand are African and Asian countries and Russia, where butter is not the major diet while palm oil is popularly used for cooking. Thus, the butter export price of New Zealand is sensitive to the shocks of palm oil price compared to the EU. So, when a positive shock happens on the palm oil price, the demand of palm oil shifts to butter and then the price of butter export begins to rise. Although the USA is a major exporter of dairy products, it is also a big butter consumption and import country to some degree. Given that the crude oil price is highly linked with palm oil price and the USA is sensitive to the shock to crude oil price, the positive shock to palm oil price raise the price of crude oil which leads to an increase of butter export price. Thereafter, the increased palm oil price itself will result in the increase of butter export price via substitution effect. Thus, in this way the positive shock to palm oil price caused an enhancement effect. However, for the EU VECX model, the palm oil price was set to be endogenous.



Figure 5: Generalized impulse response of a positive one-standard-error shock to palm oil price on butter export price (bootstrap median estimates with 90% bootstrap error bounds)

The fluctuation of exchange rate is regarded as one of the major influential factors that causes the volatility in commodity prices in our study time span. The Figure 6 shows some interesting results that could have implications on optimization of the international butter export "destination portfolio". The positive one-standard-error shock to exchange rate of New Zealand and the rest of world resulted in the decline of butter export prices of New Zealand at similar scale of around - 1%, however, the positive shocks has no impact on the butter export price of the US and EU in the long run.

The reason for the behaviour may be that the butter export price change contrarily to the exchange rate shocks of dairy export-dominant countries and dairy import-dominant countries and market power of exporters exists. In our cases, most of the countries we aggregated as the Rest of World (ROW) are net importers of dairy products. So, when the exchange rate of ROW declines, their butter export prices in their local currency stay the same, so the prices in US dollar increase correspondingly.



Figure 6: Generalized impulse response of a positive one-standard-error shock to exchange rate of the EU (left) and New Zealand (middle) and the rest of world (right) on butter export price (bootstrap median estimates with 90% bootstrap error bounds)

Figure 7 shows how the butter export prices behave when facing a positive shock from each country or region. There are several remarkable phenomena in the behaviour. Firstly, the butter export prices of New Zealand and EU have only slight responses to the positive butter price shock to others. Moreover, the butter export price shock to the USA seems to have little impact on the butter export price of others and even itself and no long-run effect exist in the responses of all countries or region. As the Figure 7 shows, the impacts converge to zero in each country after the 8 months of the USA butter export shock. However, the impact of price shock to New Zealand is much strong to the USA in the long run while butter export shock to EU has strong instantaneous effects and reach a stable level after 6 months. From the mathematical property of the GVAR model, the degree to which shocks in the domestic price of country are channelled through to the

domestic prices of all other countries depends on the weights used to construct the domestic variables out of the country-specific foreign prices. When considering the export destinations of



each country or region, we could find some points to explain the different behaviour. Firstly, the main butter export destinations of New Zealand are African countries and China, while the EU usually focus on Russia, the USA, Saudi Arabia and South Asia which is more highly connected to US butter market. So, the butter export price of the USA inclines to rise immediately after the positive shock to EU butter export price. Secondly, although the USA is the major dairy products exporter, however, it is also a large consumer and importer of butter. That's why the USA is less competitive and influential in the butter export market.

Figure 7: Generalized impulse response of a positive one-standard-error shock to butter export prices of the EU (left), New Zealand (middle) and the USA (right) on butter export price (bootstrap median estimates with 90% bootstrap error bounds)

5 Conclusion and Discussion

This paper established a Global Vector Autoregressive (GVAR) model to analyse the global butter export market. The main purpose of this paper was to assess the possible influential factors that are typically related to butter price movements in recent years. The constructed GVAR model depicted a convenient and vivid way to the short-run and long-run responses of butter export prices to the shocks on several possible influential factors of the butter price movement. Besides, we also detected the structure break of the series we analysed thus gives implications for policy construction.

We conclude that the butter export price of the USA reacts differently from that of EU and New Zealand to the shock to crude oil prices. Moreover, the shocks of USA butter export price have little influence on others but highly influenced by shocks of the EU and New Zealand. While the EU and New Zealand are estimated to have similar responses behaviour in both level and duration when facing with the shocks of crude oil price increase and currency devaluation, palm oil price increase and butter export prices increase of other countries. Besides, the spatial price shock spillovers are weak and butter export markets are not well-integrated, but the export price of EU would be more influenced by the price of New Zealand and the US.

Thus, the results still carry important policy implications for the world butter export market. Firstly, our results indicate that palm oil price is of vital importance to the world butter export price. This may imply that the policy makers should pay more attention to the palm oil price to draw up the government intervention on butter export market. Secondly, the butter export price may not have strong co-movement among major exporters, nevertheless, their price movement could have strong and persistent influence on big importers. So, not only should exporters concern about the price volatility but the importers also need to raise concern to avoid price shocks impacts from exporters on domestic market.

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Appendix

This appendix describes the data sources.

Dairy Product Export Prices (HS-4)

European Union-28: EUROSTAT

United States: USDA

New Zealand: UN Comtrade/ NZ.STAT HS System can only get export values

Note: we use the export values and quantity of EU 28 dairy products (Categorized by Harmonized System for 4 digits) export to export out of EU 28 countries to compute dairy product export price of EU.

0405-Butter and other fats and oils derived from milk; dairy spreads

Index: 2010=100

Consumer Price Index Food Index

United States: OECD

European Union-28: EUROSTAT

New Zealand: Statistics New Zealand

Base: 2010=100

Nominal Exchange Rates

Nominal exchange rate: Local currency per unit of US dollar;

EU-28: Euro

New Zealand: New Zealand Dollar

Australia: Australian Dollar

Rest of World: Weighted average of China: Chinese yuan; India: Indian rupee; Japan: Japanese yen; Mexico: Mexican peso; Russian Federation: Russian ruble; Ukraine: Ukrainian Hryvnia;

Weight are given by the dairy export quantity of each country on the total export quantity of these countries.

-Index: 2010=100

Source: FRED& International Financial Statistics (IFS)

Fertilizer Price

- Fertilizers index includes natural phosphate rock, phosphate, potassium and nitrogenous products.

-Source: World Bank Global Economic Monitor (GEM) Commodities

-Index: 2010=100

Oil Price

- Crude oil price. Average spot price of Brent, Dubai and West Texas Intermediate, equally weighed

Nominal US dollar per barrel.

-Palm Oil Price.

Nominal US dollar per Metric Ton (MT).

- Source: World Bank Commodity Price Data

- Index: 2010=100

energy prices affect food commodity prices by influencing the cost of inputs such as nitrogen fertilizer and the cost of transport.

The rest of world includes China, India, Japan, Mexico, Russian Federation and Ukraine.

By construction, the GVAR model allows for interaction among the different economies through two channels, namely: i) the contemporaneous interrelation of domestic variables with foreignspecific variables; and ii) the contemporaneous correlation of shocks across countries.