Spatial Price Transmission and Strategic Trade Patterns for Global Dairy Trade

By

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Statement of Original Authorship

“I hereby certify that the submitted work is my own work, was completed while registered as a candidate for the degree stated on the Title Page, and I have not obtained a degree elsewhere on the basis of the research presented in this submitted work.”

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List of Abbreviations

1st Diff	First Difference
ADF	Augmented Dicken-Fuller
AECM-C-MTAR	Asymmetric Error-Correction Model-Consistent Momentum-Threshold Autoregressive Model
AIC	Akaike Information Criterion
APEC	Asia-Pacific Economic Cooperation
APT	Asymmetric Price Transmission
AV duty	Ad Valorem Duty
BIC	Bayesian Information Criterion
Brexit	The Withdrawal of The United Kingdom from The European Union
CAP	Common Agricultural Policy
CPI	Consumer Price Index
EU	European Union
FAO	Food and Agriculture Organization of the United Nations
FOB	Free-on-Board
GARCH	Generalized Autoregressive Conditional Heteroskedasticity
GIRF	Generalised Impulse Response Function
GVAR	Global Vector Autoregressive
GVECM	Global Vector Error Correction Model
HICP	Harmonised Index of Consumer Price
HPT	Horizontal Price Transmission
HS	Harmonized System
IRF	Impulse Response Function
ITC	International Trade Centre
IMF	International Monetary Fund
KG	Kilogram
MFN	Most Favoured Nations
M-TAR	Momentum-Threshold Autoregressive
NAFTA	North American Free Trade Agreement
NTBs	Non-Tarif Barriers to Trade
NZ	New Zealand
NL	The Netherlands
OECD	Organisation for Economic Co-Operation and Development
PDO	Protected Designation of Origin
PGI	Protected Geographical Indication

R^2	R-Squared
REU	Rest of the EU
RoW	Rest of the World
SMP	Skim Milk Powder
SPS	Sanitary and Phytosanitary
Std. dev.	Standard Deviation
TAR	The Threshold Autoregressive
TBT	Technical Barriers to Trade
TRQs	Tariff Rate Quotas
TSG	Traditional Specialities Guaranteed
U.S.	The United States
UK	United Kingdom
UN	United Nations
USD	US Dollar
VARM	Vector Autoregressive Model
VECM	Vector Error-Correction Model
WMP	Whole Milk Powder
WTO	World Trade Organization

p_{nz}^{w}	New Zealand SMP export price in the global market
p_{nz}^{c}	New Zealand SMP export price in the Chinese market
p_{ie}^{w}	Ireland SMP export price in the global market
p_{ie}^{c}	Ireland SMP export price in the Chinese market
er_{euro}	Nominal Exchange rate US dollar per Euro
p_{it}^{e}	the index of butter export prices in U.S. Dollars of country i at time t
p_{it}^{f} in chapter 5	the index of fertilizer price in the local currency of country i at time t
e_{it}	the bilateral nominal exchange rate of country i's local currency against the US dollar at time t
CPI_{it}	the consumer food price index/consumer price index of country i at time t
p_{it}^{e*}	Foreign butter export prices, the weighted average of competitors' export prices
e_{it}^{*}	Foreign exchange rate, the weighted average of other countries' bilateral exchange rate

CPI_{it}^{*}	Foreign CPI for food/CPI, the weighted average of the other countries' consumer food price indexes
p_t^o	Global variable, crude oil price in US dollar
p_t^p	Global variable, palm oil price in US dollar
$p_{it}^{e\_ex}$	index of extra-EU28 cheese export prices in Euro
$p_{it}^{e\_in}$	index of intra-EU28 cheese export prices in Euro
$HICPF_{it}$	Harmonised Index of Consumer Price (HICP) of food
Pro_{it}	Cheese production index
p_{it}^{f} in chapter 6	the index of farm-gate raw milk prices in Euro
$p_{it}^{e\_ex*}$	Foreign extra-EU cheese export price, the weighted average of competitors' export prices for extra-EU28 trade
$p_{it}^{e\_in*}$	Foreign intra-EU cheese export price, the weighted average of competitors' export prices for intra-EU28 trade
$HICP_{it}^{*}$	Foreign HICP for food, the weighted average of the HICP for food
Pro_{it}^{*}	Foreign cheese production index, the average of the cheese production index
p_{it}^{f*} in chapter 6	Foreign farm-gate raw milk price, the average of competitors' raw milk prices

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could offer, love me unconditionally and always encourage me. Without all their support and endless love for years, I could not have completed this tough work.

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Abstract

This thesis aims to make empirical contributions to spatial price transmission following market shocks in international agri-food trade markets with a focus on the dairy sector. It comprises one background, one literature review and three empirical studies on spatial price transmission of dairy product export prices at three different spatial levels, that is, national, regional and global, respectively.

The thesis provides a comprehensive framework and analysis of spatial price transmission and market mechanisms for major dairy export countries (regions) under different shocks. At the national level, threshold cointegration models along with asymmetric error correction models are employed to examine spatial price transmission and price leadership for New Zealand and Ireland in the Chinese market and in the global market. A finding is that whereas New Zealand's export prices maintain a leadership position in China, Ireland's export prices are well integrated into global markets. In terms of price transmission, in contrast to Ireland's relatively symmetric and swift adjustments, asymmetric price transmission from Chinese to global markets is found in New Zealand's skim milk powder exports. At the regional level, Global Vector Autoregressive (GVAR) methodology was used to investigate market integration and price dynamics following shocks for both intra-EU and extra-EU exports in the EU cheese sector. Significant differences are evident in these two markets and the EU internal market is estimated to be better integrated than its external market. At the global level, a GVAR model was applied to understand butter export price transmission among geographically separated exporters as well as the dynamics of global butter export prices after shocks to macroeconomic factors and energy input prices, in both the short- and long-run. The study of this chapter finds that the global butter export market is not well integrated, with butter export prices greatly affected by palm oil prices, exchange rates and food inflation shocks.

This thesis sheds light on the spatial price transmission of dairy export prices and deciphers interactions of export prices with various influencing factors in international trade. It addresses price leadership in a dairy major import country, market integration, as well as impacts of market shocks and the economic policy uncertainties on the export price and trade patterns for the global dairy sector. It also connects the research

on dairy international trade to domestic dairy market and economic conditions, energy market and markets of the other commodities, thus highlighting the market mechanism and strategic trade patterns of the dairy sector in the contexts of dynamic economic and policy scenarios at global scope.

Chapter 1 Introduction

1.1 Introduction

1.1.1 Research Motivation

This research was motivated by the highly interactive and volatile global dairy market, soaring demand for dairy products from emerging countries such as China, along with recent economic shocks from both supply side and demand side such as policy changes, trade protectionism, a global economic downturn, and uncertainties due to unexpected events, such as “Brexit”, causing high volatility in dairy industry supply chains and international trade.

In this study, the term “milk” always refers to cow’s milk.

1.1.2 Research Objectives and Questions

This research is conducted to investigate spatial price dynamics for multi-dairy products (butter, cheese and milk powder) over multi-periods following market shocks and uncertainties at three different spatial levels, namely, country, regional, and global. To fulfil this goal, the specific aims of this thesis are:

(a) at a national level, to understand the asymmetry in spatial price transmission between two competitive exporters in a specific market and between a specific import market and the global market, as well as to test the “lost opportunity” effect for new entrants and price leadership relations between new entrants and dominant players in a specific import market.

(b) at a regional level, to understand market integration and spatial price transmission among major dairy exporters in the EU, compare price dynamics following market shocks in EU internal and external markets, and evaluate the strengths and weaknesses of the EU single market in terms of dairy export price mechanisms. Additionally, to evaluate the possible impacts of “Brexit” on the EU dairy trade.

(c) at a global level, to understand international dairy export price volatilities, interaction between market shocks and price fluctuations, and links between the global dairy market, energy markets and other commodity markets in the short-run and long-run.

The overall research objective is to gain an understanding of spatial price transmission, factors influencing price dynamics and trade market mechanisms in the dairy sector under different spatial scales and various market scenarios, leading to the following core research question and three sub-objectives:

Overall Research Question: How do spatial price transmissions and price for dairy products interact with various influencing factors and market shocks in global trade markets?

Sub-objective 1: Gain an understanding of price dynamics between two dairy exporting countries (i.e. Ireland and New Zealand) within a major dairy import market (i.e. China), and between this major import market and global market.

Questions:

- In a specific import market, such as China, how do export prices for two geographically separated dairy exporters, e.g. Ireland and New Zealand, interact with each other?
- Which takes the role of price leader?
- Is the price transmission process between these two countries asymmetric or not?
- Is price transmission from a specific market to the global market asymmetric or not?

Sub-objective 2: Determine the factors associated with dairy export price movement and extent of influence on export prices in different countries.

In a global and uncertain world, food commodity prices are highly linked, and influenced by macroeconomic factors, including energy prices and demand-supply side shocks.

Questions:

- Does market integration exist in international dairy markets?
- How and to what degree do different export prices affect one another?
- How and to what degree do different shocks impact export prices for dairy products (e.g. butter, milk powder, cheese, etc.) in the short-run and in the long-run?

Sub-objective 3: Evaluate the impact of uncertainties and market shocks on spatial price transmission and price dynamics in EU internal and external trade markets for EU dairy products.

“Brexit” and the removal of EU milk production quotas brings uncertainty from both demand- and supply- side for EU dairy exports. This is exacerbated by trade protectionism, global economic downturn, and economic policy uncertainty, which negatively impact international trade and global supply chains.

Questions:

- How, and to what extent, do these uncertainties and market shocks affect spatial price transmission and price dynamics for EU dairy products?
- How do trade barriers and policies that obstruct the dairy trade determine dairy market integration of the EU?
- Does market integration exist in EU internal and external dairy export markets?

1.2 Research Framework and Structure

Figure 1.1 illustrates the framework and structure of the research. The overall structure of the thesis comprises seven chapters including this brief introductory chapter. The rest of the thesis is organised as follows:

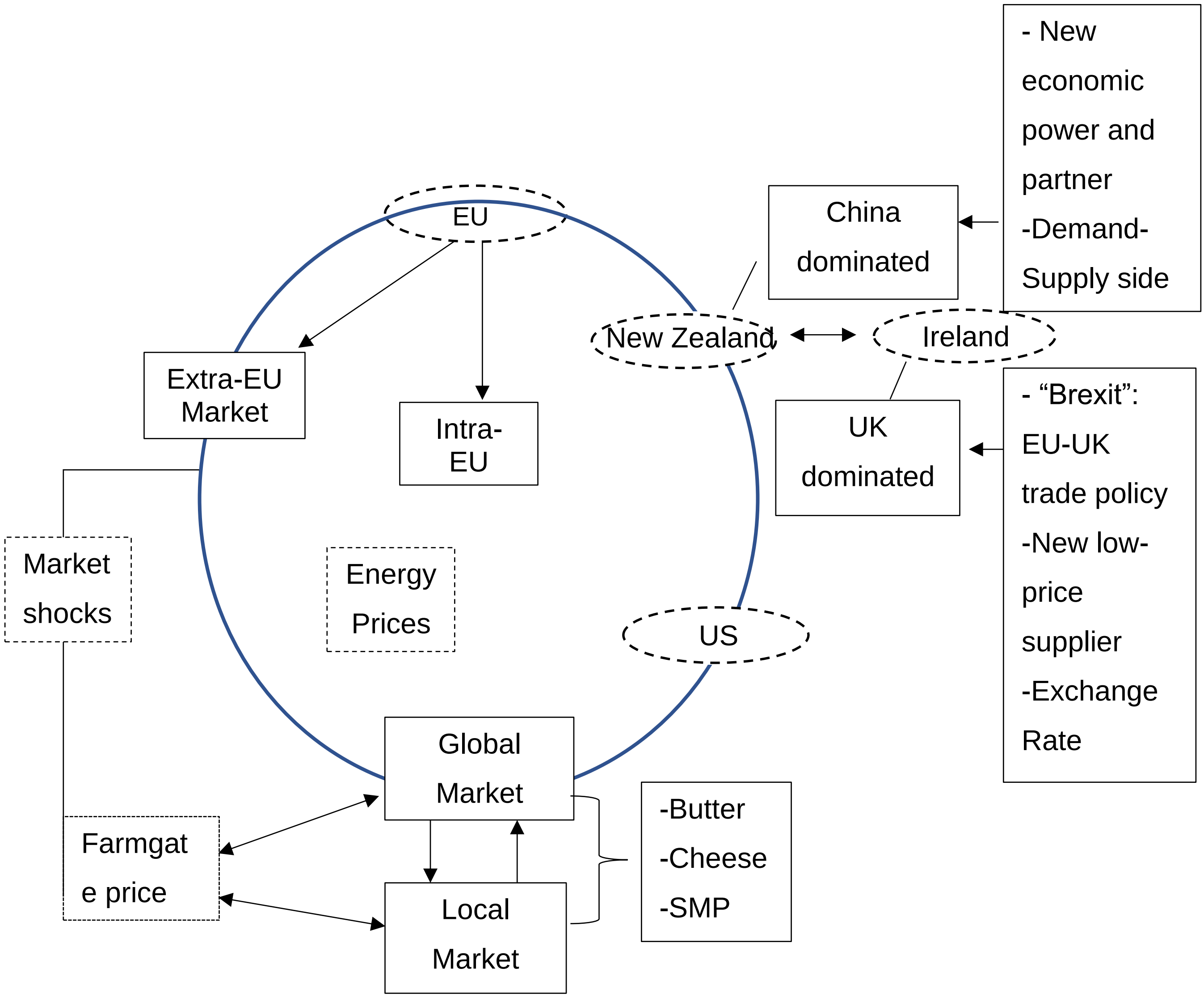

Figure 1.1: Research framework and structure

Source: Author's depiction

Chapter 2 outlines the policy and trade contest for global dairy trade markets. It provides an overview of dairy policy and trade contexts for the EU, New Zealand and the U.S. Ireland is taken as a case for the EU with a detailed descriptive analysis of its dairy sector. Finally, the chapter explores the Chinese dairy market and outlines its import and trade policies.

Chapter 3 conducts an extensive review of the rapidly growing literature on agri-food related spatial price transmission. The main models and techniques, variables focused on, questions answered, the key findings in the literature and their policy implications, are highlighted and discussed. Furthermore, gaps in the literature and future research direction for empirical analyses are highlighted.

Chapter 4 employs nonlinear time series models to examine spatial price dynamics and price transmissions for New Zealand and Ireland dairy products in Chinese and international markets. It identifies market integration and price leadership in Chinese markets and provides useful information on asymmetries of spatial price transmission from international markets to a specific import market.

Chapter 5 empirically investigates butter export price transmission among geographically separated exporters and explores the interlinkages of global butter export prices with macroeconomic factors, energy prices and other shocks using a global vector autoregressive model. The analysis provides a framework to incorporate various influencing factors and prices across different countries over certain periods and to decipher spatial price transmission mechanisms and market integration within the global butter market.

Chapter 6 focuses on the EU cheese exports in intra-EU and extra-EU markets. Four influencing factors from supply-demand sides are analysed with intra-EU and extra-EU cheese export prices for six representative EU cheese exporters, respectively, by using a high-dimension global vector error-correction model. It addresses the current trade issues on market integration and uncertainties resulting from “Brexit”, trade tensions and economic downturn trends for the cheese sector and provides insightful economic and policy implications for the EU cheese sector.

Chapter 7 sets out the conclusions of this thesis, identifies the contributions and limitations of this research, and proposes and discusses future research directions.

1

Chapter 2 Background

2.1 Introduction

After pursuing economic liberalisation for almost two decades following establishment of the World Trade Organisation (WTO) in 1995, countries have been introducing measures of protectionism since the global economic recession of 2008, but particularly in the past two years. Countries have adopted many policy measures to protect their domestic sectors by creating additional barriers to trade (e.g. raising tariffs and introducing non-tariff barriers[1]). The dairy sector was not immune from these tariff and non-tariff trade protection measures.[2] The development of dairy sector also has been challenged by significant economic and policy change, and the subsequent uncertainty has had an impact on dairy product price fluctuations globally, creating unpredictability for international trade. An in-depth study of price mechanisms in the dairy trade market, will contribute to a better understanding of the economic impacts of policy measures and shocks. This should benefit industrial strategic development and marketing, but will also provide insights on economic implications for, and policy evaluation of, producer and consumer welfare, market integration, and strategy development for industrial marketing and international trade.

This chapter provides a broad overview of the dairy industry for different geographical areas and spatial levels, divided into two sections to facilitate discussion and explanation in later chapters around suitable policy measures for industry and policy makers. The first section focuses on EU, New Zealand, and US dairy and trade policies and its objective is to facilitate an understanding of possible trade barriers and policy changes that affect spatial price transmission of dairy products. The second section outlines trade in the dairy sector and provides an overview of dairy exports for the EU, New Zealand and US, and the Chinese dairy import market. A brief outline of the past, present and future dairy export context for Ireland is set out in the overview of the EU

[1] In terms of tariff measures, the US has been raising tariffs on various products targeting at many countries or regions, such as the US-China trade tension, US-India trade tension, US-EU trade tension, etc since 2018.
In terms of non-tariff measures, Russia has implemented an import ban on many EU agriculture products (including dairy).

[2] For example, the Russian import ban on EU dairy, raising tariffs on EU dairy products by the US and possible “no deal” Brexit imposing tariffs on EU dairy, etc.

dairy market. The aim of the first section is to delve deeper into dairy trade policy to better serve policy perspective interpretations and implications for the three empirical chapters. The second section can give a comprehensive understanding of current export structures and trends for the EU, New Zealand and the US, as well as the import context for China, in order to ascertain appropriate dairy products on which to conduct empirical studies and assess economic and market implications.

2.2 Trade Policy and International Trade in the Dairy Sector

During the General Agreement on Tariffs and Trade (GATT) era, agriculture as a sector was not completely covered under the multilateral trading system, and international trade in the dairy sector was governed by individual countries' commitments made to reduce tariffs or devise policies on their own. The international trade in dairy sector was facilitated at a global level after conclusion of the Uruguay Round of multilateral trade negotiations under the GATT 1986-1994 which established the World Trade Organisation (WTO). This ensured that agriculture as a sector was covered by tariff reduction commitments by members of WTO. In addition to tariffs, the new WTO agreement also governed use of non-tariff barriers through agreements on Technical Barriers to Trade (TBT) and Sanitary and Phyto-sanitary measures (SPS).[3] These brought transparency and fairness in the use of non-tariff measures to international trade. To govern subsidies in the agriculture sector, binding limits were prescribed on agricultural exports and disciplines were imposed on providing domestic supports. Due to regulatory and country specific obligations, spending by developed countries on domestic supports and trade distorting export subsidies for agriculture products, including dairy products, were gradually reduced from 1995.[4] However, dairy remains one of the most protected sectors (Hadjigeorgalis, 2005) and is also kept out of tariff liberalisation schemes under bilateral and regional preferential trade agreements (RTAs) (Rude & An, 2013; Thompson-Lipponen & Greenville, 2019). Protective policies can distort market and price transmission mechanisms. Theoretically, spatial price determination models suggest that if two markets trade freely with each other, demand and supply side shocks will have an equal impact on price in both markets

[3] The GATT years: from Havana to Marrakesh, WTO. https://www.wto.org/english/thewto_e/whatis_e/tif_e/fact4_e.htm. Accessed in 19/12/2019.
[4] Agriculture: Domestic Support, WTO. https://www.wto.org/english/tratop_e/agric_e/ag_intro03_domestic_e.htm. Accessed in 20/12/2019.

(Georege Rapsomanikis, Hallam, & Conforti, 2006). Stable import tariffs can lead to proportional price transmission. However, if tariff levels are high, international price change is only partially transmitted to domestic markets. Tariff rate quotas may cause disproportional price transmission from international to domestic markets due to two types of tariff level, e.g. in-quota and out-of-quota. Domestic price support policies, such as intervention mechanisms and floor prices, may cause non-linear or weak price transmission. (Georege Rapsomanikis et al., 2006)

The EU, New Zealand and the U.S. are three geographically separate major dairy exporters and representative of developed countries in Europe, Oceania and America, respectively. They are also major dairy exporters that exhibit different domestic and trade policies to compete globally.

2.2.1 EU Dairy Policy

In the EU, the dairy sector is subject to the Common Agricultural Policy (CAP), which includes various instruments such as import duties, export refunds, and stockholding interventions for butter, skimmed milk powder, etc. [5] In Western Europe, CAP originated in the 1950s, aimed at encouraging better productivity in food supply chains, ensuring a fair standard of living for the agricultural community, market stabilization and the availability of food to EU consumers at a reasonable price (European Commission, 2019[6]). As the most influential agricultural policy, CAP has experienced a series of reforms and amendments to become more market-oriented and to embrace global dairy trade competition and transition. CAP is one of the most remarkable tools for the EU dairy sector, with milk quota regimes exercising a series of reforms and evaluations. A brief history of the EU's milk quota policy under CAP, as shown in Figure 2.1, is outlined to understand how the milk quota regime has influenced the EU dairy industry for over three decades.

[5] European Commission, milk and dairy products: https://ec.europa.eu/info/food-farming-fisheries/animals-and-animal-products/animal-products/milk-and-milk-products_en. Accessed on 19/12/2019.
[6] European Commission, the common agricultural policy at a glance: https://ec.europa.eu/info/food-farming-fisheries/key-policies/common-agricultural-policy/cap-glance_en. Accessed on 20/12/2019.

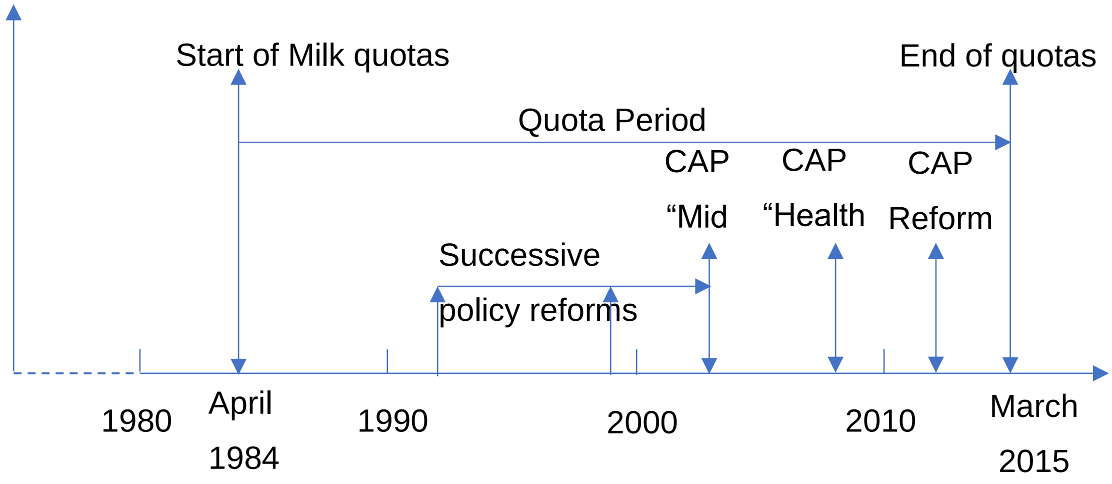

Figure 2.1: Common Agricultural Policy (CAP) reform milestones and historical developments

Source: Author's depiction from European Commission (European Commission, 2017)

As illustrated in Figure 2.1, EU milk production quota policy began in April 1984, when the EU's milk and dairy production far outstripped demand. Milk quotas played an important role over a long period in overcoming structural surpluses and maintaining market and price stability in the EU dairy industry. The CAP system of milk quotas underwent a series of reforms in 1992 and in 1999, including a reduction in the previously set minimum guaranteed prices. In return, farmers received a Direct Payment to maintain a steady income during this period. On 26th June 2003, European ministers of agriculture agreed major changes in dairy policy at the Luxembourg Reform of the Common Agricultural Policy (CAP). The reform entailed a 15% reduction in intervention prices for skimmed milk powder (three annual steps of 5%, from 2004 to 2006) and a 25 % reduction for butter (three annual steps of 7% from 2004 to 2006 and 4 % in 2007). This important CAP "Mid Term Review" agreed to abolish milk quotas in 2015 to improve the market orientation of the EU dairy sector. The 2008 CAP "Health Check" then agreed on a gradual increase in quotas over 5 years to soften the impact of removal of milk quotas by March 2015. On 31 March 2015, this 32-year historic EU dairy policy came to an end. (European Commission, 2017)

Milk production quota policy led to two types of quota in each EU Member State (MS): the first defined the maximum amount of milk delivered to dairies for further processing and the second set the limits for direct sales at farm level. If quantities of milk were above defined thresholds, a levy applied to farmers. Since the introduction of milk production quotas in 1984, EU dairy policy remained almost unchanged until 2003.

Milk quota policy placed constraints on milk production, which to some extent changed the market structure and stabilised dairy product prices.

The removal of milk production quotas brought both challenges and opportunities. On the one hand, gradually phasing out milk quotas prior to 2015 resulted in significant domestic price declines. The reason for this was that following the Luxembourg reforms and WTO obligations, producers tended to enlarge farm sizes to increase milk and dairy production when quota constraints were relaxed and removed (Bouamra-Mechemache, Jongeneel, & Réquillart, 2008). On the other hand, this policy change enabled some member states, whose dairy sector had been constrained by the milk quota system, the flexibility to expand market share and profit from increasing extra-EU demand for milk and dairy products. The major EU dairy companies, particularly those in northern Europe, have benefitted from the removal of milk quotas and adjusted to counteract market shocks by investing in processing capacity and actively seeking a greater share of emerging markets and new export destinations (Vitaliano, 2016).[7]

In addition to the milk quota system, there are plenty of useful policy instruments to support dairy trade among EU member states. The following table provides a brief overview of policy instruments, evaluation of the effect of these policies, and recent policy changes. In terms of domestic policies, the public intervention for butter and skim milk powder that can control the quantity of products on the market and reduce the price volatility has been reduced in recent years. The EU has switched from market price support to a decoupled payment. A Basic Payment Scheme replaced the Single Payment Scheme to support producers through direct payments to farmers. However, coupled direct payments for milk production still exist. In terms of policies for dairy trade, efforts to be more market-oriented are relatively weak. The EU still has strict border and import protections, which set import duties and tariff rate quotas for products entering the EU market. It also has a supportive policy such as export refunds for certain dairy products to make the EU dairy export price competitive in the international trade. (see Table 2.1 below for a brief illustration)

[7]http://eda.euromilk.org/fileadmin/user_upload/Public_Documents/Press_Room__PR_and_EDA_in_the_media_/RLF_-_EDA_Nice_2016.pdf.

Table 2.1: CAP Instruments for dairy products and estimated effects

Instruments	Category	Effects	Policy changes
Milk quota system	Supply side (Production)	• Stabilises price • Constrains production and market expansion	Abolition of milk quota in 2015
Public intervention measures for butter and skimmed milk powder	Supply side (Public Intervention)	• Stabilizes milk and dairy product prices • Reduction of structural surplus • Improvement in international competitiveness • Lower safety-net increases probability of periods of high volatility transmission from international to domestic prices	Reduction of intervention to a safety net[8]
Mandatory and optional private storage aids (PSA)[9] for butter, skimmed milk powder and cheese	Supply side (Private storage aids)	• Market stabilization • Deadweight impacts	Open PSA for butter and certain cheeses, skimmed milk powder in 2014[10]
Single Payment Scheme (SPS) and Single Area Payment Scheme (SAPS)	Subsidies	• Maintaining producers' incomes despite lowering of milk prices	SPS was replaced by Basic Payment Scheme (BPS)[11] in 2014

[8] There are fixed buying-in periods of butter and skimmed milk powder limited to specific months. The periods can be extended at the Commission's discretion in cases of serious market disturbances (Matthews, Salvatici, & Scoppola, 2017)
[9] Under the PSA schemes, products remain in private ownership and the owner receives aid to cover the cost of storage for periods specified in the contracts before they can be released onto the market.
[10] European Commission Press Release (2014): https://ec.europa.eu/commission/presscorner/detail/en/IP_14_954
[11] CAP direct payments in post-2013 are based on basic act regulation (EU) No. 1307/2013, under Regulation (EU) No. 639/2014 and implementing act Regulation (EU) No. 641/2014.

Import Licence, tariff rate quotas, import duties	Import side	• Tariffs and tariff rate quotas as a precondition for maintaining higher domestic price	
Export Licence[12] and export refunds	Export side	• Market support mechanism to bridge the gap between usually higher EU prices and lower world price. Export license is required to get export refund. • Export refunds as s disposal mechanism for surpluses and as an instrument of price stabilisation for dairy products and raw milk, and for improving international competitiveness	

Source: adapted from R Jongeneel, Burrell, and Kavallari (2011)

In global markets external EU dairy trade encounters legacy obstacles and limitations. Till Nov 2019, the EU have 37 Regional Trade Agreements (RTAs) in force, yet it doesn't have trade agreements with its top two dairy importing countries, namely China and the U.S. (Table 2.2 below). EU dairy product exports to China and the U.S. are subject to Most-Favored-Nation (MFN) tariffs.

Table 2.2: RTAs in force in the EU (Nov 2019) [13]

Country (Region)	**Agreement**	**Status** **In force since:**
Albania (Western Balkans)	Stabilisation and Association Agreement	2009
Algeria	Association Agreement	01/09/2005
Andorra	Customs Union	01/01/1991
Armenia	Partnership and Cooperation Agreement	09/09/1999
Bosnia and Herzegovina (Western Balkans)	Stabilisation and Association Agreement	01/06/2015

[12] Only the export of certain milk products under Commission Regulation (EC) No 1187/2009, 27 November 2009, requires export licenses since 19th July 2013

[13] Customs Unions: eliminate customs duties in bilateral trade and establish a joint customs tariff for foreign importers. Association Agreements, Stabilisation Agreements, (Deep and Comprehensive) Free Trade Agreements and Economic Partnership Agreements: remove or reduce customs tariffs in bilateral trade. Partnership and Cooperation Agreements: provide a general framework for bilateral economic relations and leave customs tariffs as they are.

Botswana (SADC) Y	Economic Partnership Agreement	05/02/2018
Chile	Association Agreement and Additional Protocol	01/03/2005
Egypt	Association Agreement	01/06/2004
Eswatini (SADC)	Economic Partnership Agreement	05/02/2018
Faroe Islands	Agreement	01/01/1997
Georgia	Association Agreement	01/07/2016
Iceland	Economic Area Agreement	1994
Israel	Association Agreement	01/06/2000
Japan	Economic Partnership Agreement	01/02/2019
Jordan	Association Agreement	01/05/2002
Kosovo	Stabilisation and Association Agreement	01/04/2016
Lebanon	Association Agreement	01/04/2006
Liechtenstein	Economic Area Agreement	1995
Lesotho (SADC)	Economic Partnership Agreement	05/02/2018
Mexico	Global Agreement	01/10/2000
Moldova	Association Agreement	01/07/2016
Montenegro (Western Balkans)	Stabilisation and Association Agreement	01/05/2010
Morocco	Association Agreement	01/03/2000
Mozambique (SADC)	Economic Partnership Agreement	05/02/2018
Namibia (SADC)	Economic Partnership Agreement	05/02/2018
North Macedonia (Western Balkans)	Stabilisation and Association Agreement	01/04/2004
Norway	Economic Area Agreement	1994
Palestinian Authority	Interim Association Agreement	01/07/1997
San Marino	Customs Union	01/04/2002
Serbia (Western Balkans)	Stabilisation and Association Agreement	01/09/2013
South Africa	Economic Partnership Agreement	05/02/2018
South Korea	Free Trade Agreement	01/07/2015
Sri-Lanka	Co-operation and Partnership Agreement	01/04/1995
Switzerland	Agreement	01/01/1973
Syria	Co-operation Agreement	01/07/1977
Tunisia	Association Agreement	01/03/1998
Turkey	Customs Union	31/12/1995

Source: European Commission, website: https://ec.europa.eu/trade/policy/countries-and-regions/negotiations-and-agreements/. Accessed on 27/11/2019.

In general, policy support reforms for the EU dairy sector became more market oriented while remaining highly protective. Sluggish growth in EU member states in recent years, agriculture policy changes such as the abolition of milk production quotas in March 2015, a ban imposed by Russia on EU dairy products, delays in establishing trade agreement with key dairy trading partners, and the uncertainty of Brexit, have created challenges for, and changes in, the EU dairy sector. Increasing trade activity with China and other emerging markets requires more market-oriented policy to seize the opportunity for market expansion and remain resilient to market shocks in a more integrated global dairy market.

2.2.2 New Zealand Dairy Policy

New Zealand doesn't subsidise its dairy sector and promotes a free market-oriented agricultural development strategy. New Zealand is the largest exporter of various dairy products with 19.3% of its dairy products sold internationally,[14] and therefore its dairy export prices are heavily influenced by global demand and priced effectively at international market levels due to the lack of a large domestic market demand. In New Zealand, Fonterra Co-Operative Group Ltd. was formed in 2001 by a merger between the New Zealand Dairy Board and the two largest domestic dairy cooperatives. Given the fact that the creation of Fonterra Co-Operative Group Ltd. gave it an absolute monopoly in the dairy sector, the company was able to set the price of dairy products and thereby control its marketing and export. Hence, during a period of price slumps, farm-gate milk prices received by New Zealand dairy farmers are much lower than other major dairy export countries (Vitaliano, 2016). Fonterra sets the price for its milk producers via its internal annual pooling arrangement. When international dairy product prices are higher, Fonterra can avail of this payment system to offer decent pay-outs to farmers and get enough flexibility to maintain and extend market share in its export destination markets (Vitaliano, 2016).

New Zealand tried to expand its market for dairy products to many Asia-Pacific countries and persuade several emerging economies, such as China, Japan and Malaysia, to import more of its milk products by providing preferential tariffs on its

[14] Top Milk Exporting Countries, December 19, 2019 by Daniel Workman: http://www.worldstopexports.com/top-milk-exporting-countries/

exports through RTAs and Free Trade Agreements (FTAs), as well as through industry cooperation and foreign investments. Till Nov 2019, New Zealand has 12 RTAs entered into force, which includes 8 bilateral FTAs & Economic Integration Agreements (EIAs) with Australia, China, Hong Kong SAR of China, Malaysia, Singapore, Taiwan Province of China, Thailand and Republic of Korea; 3 plurilateral FTAs & EIAs, namely, ASEAN-Australia-New Zealand, CPTPP, Trans-Pacific SEPA (P4) and 1 plurilateral Partial Scope Agreement (PSA), namely, SPARTECA. (Table 2.3 below)

Table 2.3: RTAs in force of New Zealand (in Nov 2019)

Title	**Members**	**Year**
ASEAN-Australia-New Zealand	Australia; Brunei Darussalam; Cambodia; Indonesia; Lao People's Democratic Republic; Malaysia; Myanmar; New Zealand; Philippines; Singapore; Thailand; Viet Nam	2010
Australia-New Zealand	Australia; New Zealand	1983
China-New Zealand	China; New Zealand	2008
Comprehensive and Progressive Agreement for Trans-Pacific Partnership (CPTPP)	Australia; Brunei Darussalam; Canada; Chile; Japan; Malaysia; Mexico; New Zealand; Peru; Singapore; Viet Nam	2018
Hong Kong, China-New Zealand	Hong Kong, China; New Zealand	2011
Malaysia-New Zealand	Malaysia; New Zealand	2010
New Zealand-Singapore	New Zealand; Singapore	2001
New Zealand-Taiwan Province of China	New Zealand; Taiwan Province of China	2013
New Zealand-Thailand	New Zealand; Thailand	2005
Republic of Korea-New Zealand	Republic of Korea; New Zealand	2015
South Pacific Regional Trade and Economic Co-operation Agreement (SPARTECA)	Australia; Cook Islands; Fiji; Kiribati; Marshall Islands; Micronesia; Nauru; New Zealand; Niue; Papua New Guinea; Samoa; Solomon Islands; Tonga; Tuvalu; Vanuatu	1981

Trans-Pacific Strategic Economic Partnership Agreement (P4)	Brunei Darussalam; Chile; New Zealand; Singapore	2006

Source: Asia-Pacific Trade and Investment Agreement Database – APTIAD, website: https://www.unescap.org/content/aptiad/. New Zealand Regional Affairs and Trade, website: https://www.mfat.govt.nz/en/trade/free-trade-agreements/. Accessed on 27/11/2019.

2.2.3 U.S. Dairy Policy

The United States has made major changes in its dairy policies to increase its competitiveness and facilitate its export growth-led marketing strategy in global markets. The US discontinued its long-standing Dairy Price Support Program in 2014, and in 2018 the Farm Bill authorized the new Dairy Margin Coverage (DMC) Program to protect dairy producers from exceeded price-feed cost margin.[15] Milk in the United States is subject to price pooling under Federal Milk Marketing Orders (FMMO) which establish a minimum milk price and make prices paid to producers largely reflective of the value of producing the milk where it is delivered for manufacturing into products sold at domestic prices (Greene, 2017; Vitaliano, 2016). However, in international markets, dairy trading is more competitive and market-oriented, with US dairy products competitively priced to compete with other exporters with lower prices. So, US export prices are sometimes subsidised at lower prices compared to domestic prices to better compete with other global exporters. For some dairy products where the US has a small share of global exports, such as cheese, butter and other milkfat products, prices are different in domestic and international markets. To assist and support US export of cheese, milkfat and whole milk powder, the voluntary, farmer-funded national programme Cooperatives Working Together (CWT)[16] developed by National Milk Producers Federation is founded.

The U.S. had 14 FTAs in force with 20 countries including 2 country-bloc FTAs and 12 bilateral FTAs in November, 2019: Australia, Bahrain, Chile, Colombia, Israel, Jordan, Korea, Morocco, Oman, Panama, Peru, Singapore; DR-CAFTA (Costa Rica,

[15] Dairy Margin Coverage Program. Website: https://www.fsa.usda.gov/programs-and-services/dairy-margin-coverage-program/index. Accessed in Dec 2019.
[16] Cooperatives Working Together (CWT), official website: http://www.cwt.coop/

Dominican Republic, El Salvador, Guatemala, Honduras, & Nicaragua); and NAFTA (old name, Canada & Mexico)/ the United States-Mexico-Canada Agreement (new name, USMCA).

Mexico and Canada are the two largest dairy export destinations for the U.S. The important North American Free Trade Agreement (NAFTA) in effect since January 1, 1994 eliminates most tariffs on trade between Mexico, Canada, and the United States. However, dairy products remain under heavy import tariff protections. On September 30, 2018, NAFTA was replaced by USMCA—The United States-Mexico-Canada Agreement- with several new provisions to grant better trade advantages to the U.S. and Canada. U.S. dairy products still enjoy duty-free access to Mexico under USMCA. Two key provisions in USMCA include: (1) the elimination of the Canadian Class 7 milk price; and (2) increased market access for selected dairy products such as expansion of Tariff Rate Quotas (TRQs) of milk, cheese, cream, skim milk powder, condensed milk, yogurt, and several other dairy categories from the US.[17]

In summary, the EU, New Zealand and the US formulate their dairy policies to address domestic and global markets, and different features are evident for each. In current international trade markets for dairy products, substantial policy differences among the three dominant dairy exporters determine global competitive configuration and market share.

2.3 Global Dairy Trade Market

Global dairy production, consumption, and trade is unevenly distributed. The European Union, Asia and North America are three major cows' milk producing regions accounting for over 60% of global cows' milk production in 2017, while Oceania only accounts for 4.5% as outlined in Table 2.4. The EU, Asia and the North America also have the largest consumption of milk and dairy products.

[17] Dairy Provisions in USMCA (March 26, 2019). https://fas.org/sgp/crs/row/IF11149.pdf, accessed on 19/12/2019.

Table 2.4: Global cows' milk production, 2011-2017 (Tons x 1000)

Country/Region	2011	2012	2013	2014	2015	2016	2017
European Union	150.1	150.5	152.2	158.3	161.5	161.3	163.2
Asia	105.0	110.2	114.7	121.4	129.3	135.1	143.9
North America	97.4	99.6	99.7	101.9	102.8	104.5	105.8
South Central America and Caribbean	78.2	78.6	80.0	81.1	81.5	78.4	78.7
Europe (Others - extra EU)	60.3	60.9	59.8	59.9	59.8	59.7	60.3
Asia - South East	50.2	51.8	49.6	51.8	46.7	45.7	43.6
Africa	35.5	36.8	36.5	36.4	36.2	36.3	35.4
Oceania	26.5	28.7	29.1	30.9	31.5	30.7	30.2
Asia - Middle East	13.0	13.2	13.9	14.4	11.9	12.3	13.2
World	616.2	630.3	635.5	656.2	661.1	663.9	674.5

Source: FAOSTAT, website: http://www.fao.org/faostat/en/#data/QL. Accessed in 2019.

The global dairy product market is dominated by a few major exporters. As illustrated in Table 2.5, the EU 28, New Zealand and the United States (U.S.), are three major dairy producers and exporters, accounting for more than 80% of butter, cheese, whey, Skimmed Milk Powder (SMP) and whole fresh milk exports in 2013 as Table 2.5 shows.

Table 2.5: Combined global export share of major dairy products for the EU, New Zealand and the U.S. (2013) [18]

Butter, cow milk	Cheese, whole cow milk	Milk, skimmed	Milk, whole fresh cow	Whey, dry	Yoghurt, concentrated or not
86.92%	83.52%	85.09%	88.19%	80.74%	80.05%

Data source: FAOSTAT, website: http://www.fao.org/faostat/en/#data/QP. Accessed in 2017

In the international dairy trade market, market shares for different regions vary due to differences in domestic consumption to production ratios. In 2018, the total share for the main dairy products of the EU[19], New Zealand and the U.S. accounted for over 70%

[18] Share in quantity, with year 2014 as latest data available, re-checked in Nov 2019.
[19] For exports, the aggregated EU data excludes the United Kingdom in the analysis that used the OECD-FAO Agricultural Outlook Database, and it is difficult to incorporate the UK's exports and imports

of total global exports. Specifically, New Zealand is the leader in terms of butter exports (43% of global butter exports) and whole milk powder (WMP, 56% of global WMP exports), while the EU is the largest cheese (44% of global cheese exports) and skim milk powder (SMP, 32% of global SMP exports) exporter. The New Zealand dairy sector is exported-oriented with a relatively small share of global dairy production, a low consumption to production ratio, and high share of global exports. The milk fat sectors, such as butter and cheese, in both the EU and the U.S. are characterized by high consumption to production ratios and a high share of global production as indicated in Figure 2.2 (a) and Figure 2.2 (b).

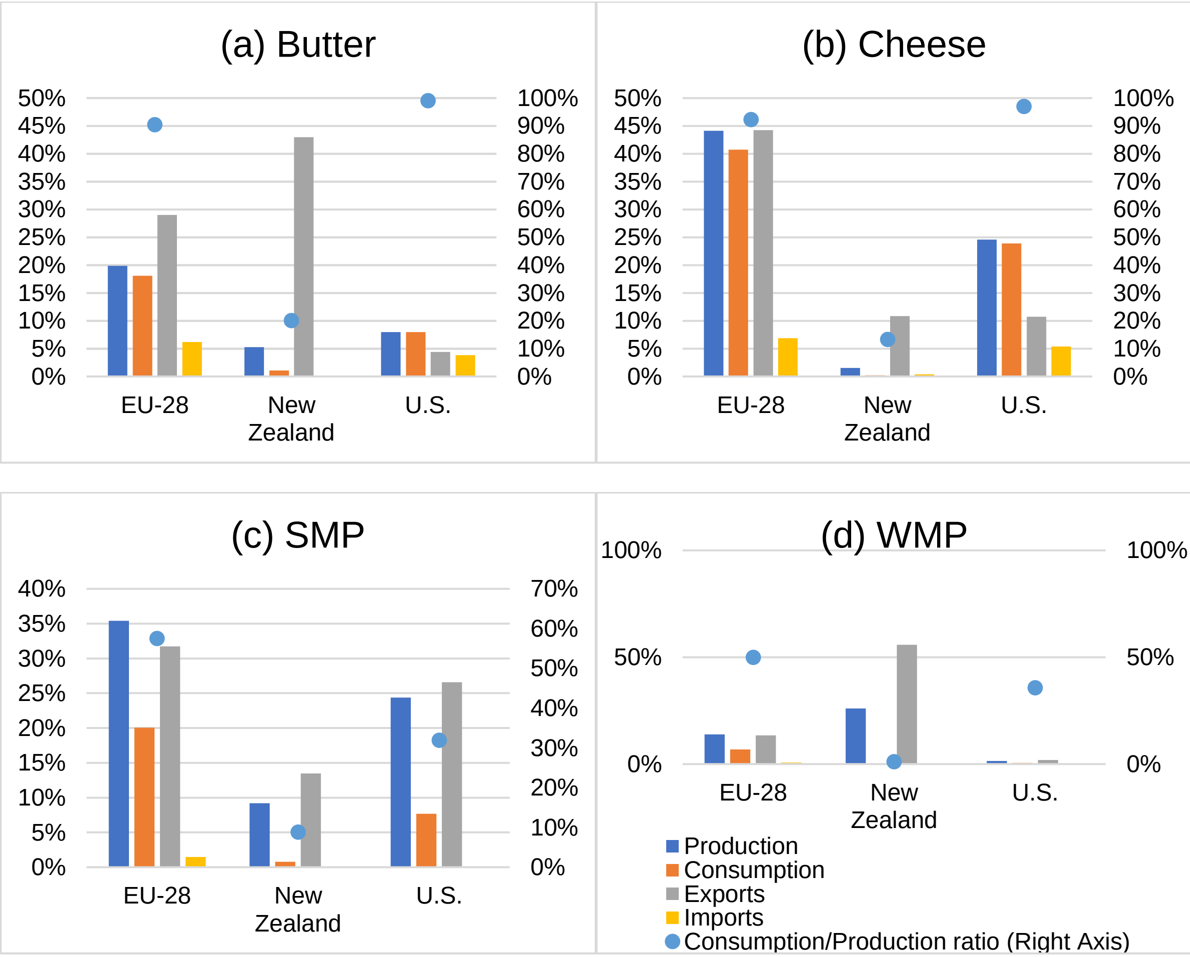

Figure 2.2: Share of global production, consumption and trade in major dairy products for the EU, New Zealand and the U.S. (2018)

Source: OECD-FAO Agricultural Outlook Database (2019-2028), assessed from website: https://stats.oecd.org/. Accessed in Nov 2019.

into the existing data. For details, please refer to the OECD-FAO database at: https://stats.oecd.org/viewhtml.aspx?QueryId=91990&vh=0000&vf=0&l&il=&lang=en

These three major exporting countries have dominated globally competitive dairy markets for a long time. However, their comparative advantages and target export markets differ because of their distinctive agri-ecological and geographical characteristics and trade strategies. The following sections outline current dairy market sectors in the EU, New Zealand and the U.S.

2.3.1 EU Dairy Export Context

The European Union (the EU) is a political and economic union of 28 member states[20] that are located primarily in Europe and regarded as an integrated economy in international trade. The EU is one of the major global dairy producers and exporters. All member states produce milk with the dairy sector contributing over 12% of the value of EU agriculture outputs.[21] The EU is the leading exporter for many dairy products, especially cheese. For dairy industry development in EU member states, the Common Agricultural Policy (CAP) plays an important role. Production, product standards and prices are subject to CAP. Among the 28 members, Germany, the Netherlands, France, Belgium, Italy and Ireland are leading countries in the production of milk and dairy product exports (Figure 2.3). In 2018, dairy export value in Germany ranked first accounting for 18.5% of EU total exports by value, followed by the Netherlands (17.6%) and France (12.7%).

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[20] The United Kingdom is still considered to be a member state of the EU, yet in the following analysis, imports and exports of the UK are not be included in the aggregated EU exports, if data from OECD-FAO Agricultural Outlook Database is used.

[21] Marie-Laure Augère-Granier (2018). The EU dairy sector Main features, challenges and prospects. European Parliamentary Research Service (EPRS), accessed at: https://www.europarl.europa.eu/RegData/etudes/BRIE/2018/630345/EPRS_BRI(2018)630345_EN.pdf

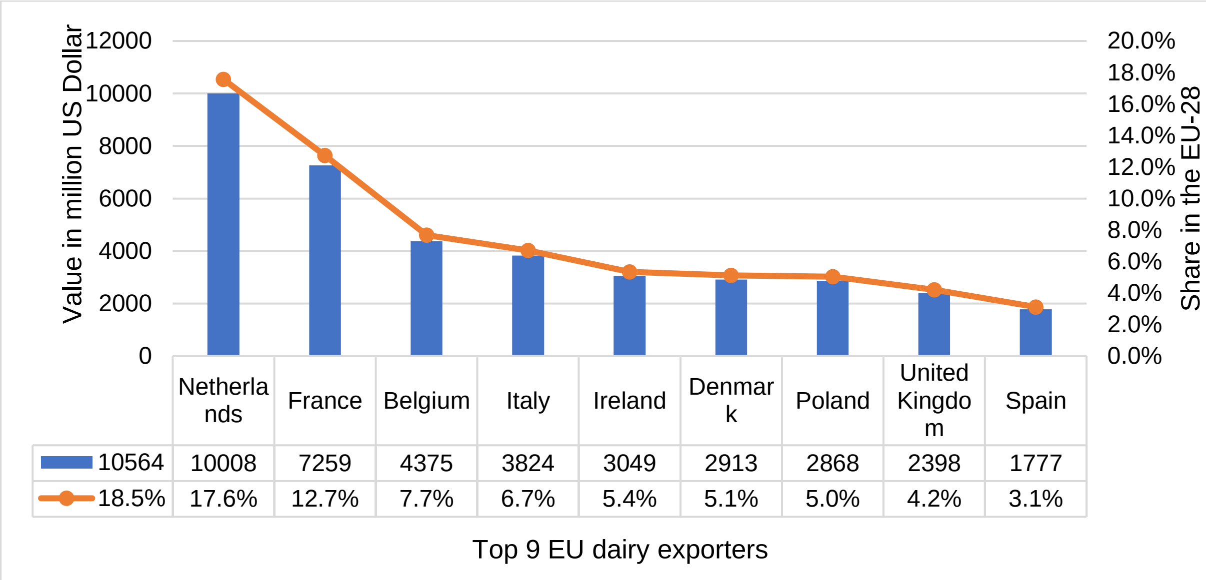


Figure 2.3: Dairy product exports by value and share among Top 9 EU dairy exporters in 2018

Source: ITC Trade Map

Dairy product exports between EU members accounts for a large share of total EU exports with Germany (15%), the Netherlands (8.9%), France (8.1%), Italy (7.4%) and the UK (7.1%) ranking as the top 5 export destinations as illustrated in Figure 2.4 (a). Germany is at the first place again as the EU’s main export destination with a share of 15% of EU dairy exports by value. Dairy products exported to countries outside of the EU comprise a smaller share. China is the largest extra-EU export destination for EU dairy products accounting for over 2.4% of EU total dairy exports by value, followed by the U.S. (2.4%), Japan (1.1%), Switzerland (1.0%) and Saudi Arabia (0.9%) as depicted in Figure 2.4 (b).

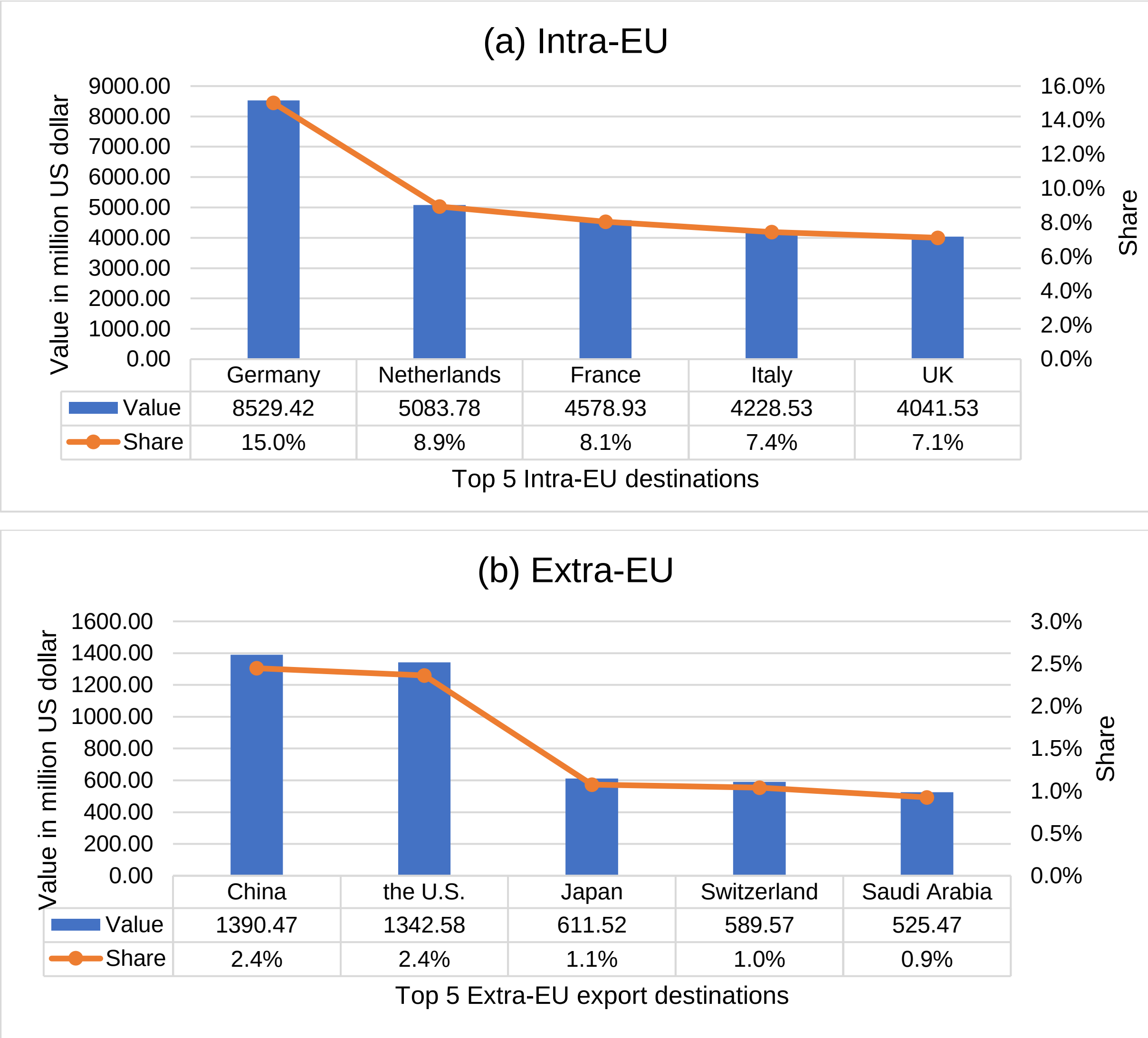


Figure 2.4: EU dairy product[22] exports by value and share in main Intra-EU and Extra-EU export destinations in 2018

Source: ITC Trade Map[23]

Over the past decades, major dairy product (such as SMP, butter and cheese) exports between EU members have experienced steady growth, while quantities of SMP and cheese exported to countries outside the EU display large fluctuations and butter exports are stable as shown in Figure 2.5 (a) on the next page.

[22] Categories by Harmonized System digits 2 (HS-2) chapter 04: Dairy produce, birds' eggs; natural honey; else

[23] ITC Trade Map, website: http://www.trademap.org/Country_SelProductCountry_TS.aspx?nvpm=1|372||||04|||2|1|1|2|2|1|2|1|1

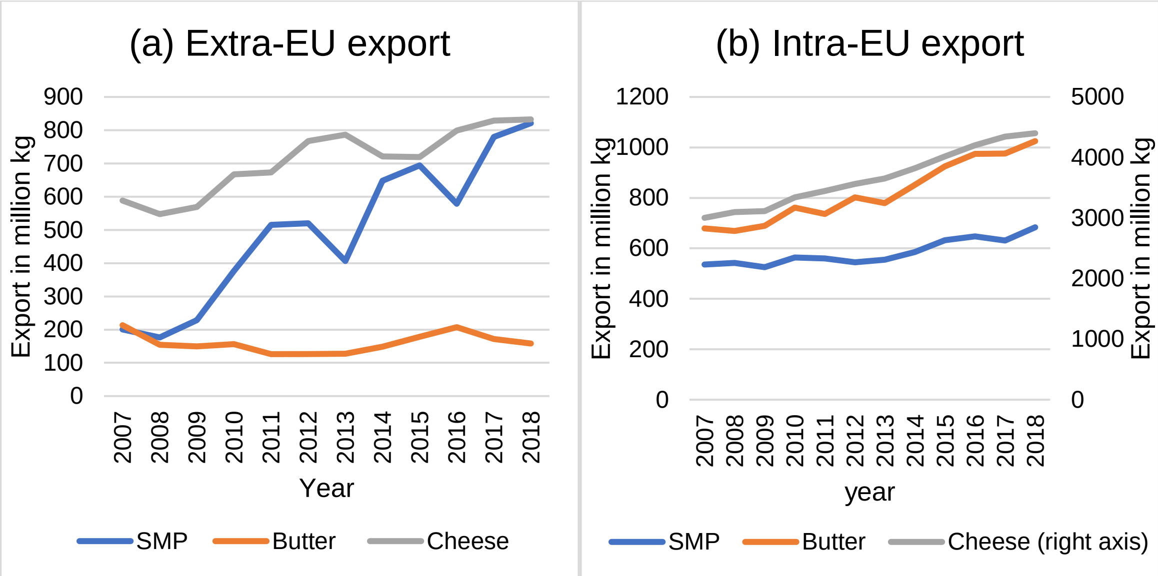


Figure 2.5: Major dairy product exports extra-EU and intra-EU, 2007-2018

Source: Eurostat database. EU trade since 1988 by HS2,4,6 and CN8 (DS-645593).

2.2.1.1 Dairy History in Ireland: Past, Present and Future

The Republic of Ireland, an island lying in the North Atlantic off the western coast of Europe, is famous for its high-quality milk and dairy products. Although Ireland is a relatively small country, it is the sixth largest exporter of dairy products among the 28 EU member countries (see Figure 2.3). As an important sector for the agri-food industry in Ireland, dairy plays a vital role in Irish economic sustainable development with its export value reaching €3.38 billion in 2015, an increase of 50% compared to 2010 (Bord Bia, 2017).

2.2.1.1.1 Supply side of Irish dairy industry

Ireland has a long history of producing and exporting dairy products. Ireland's dairy industry originates in farm produced butter with flavouring butter practised up to 17th century (Foley, 1993), and butter remained one of Ireland's main exports until the late 19th century (DAFM, 2003).

As illustrated in Figure 2.6, Irish milk production has a strong and obvious seasonal characteristic with high production levels from March to September. Irish milk producers rely mostly on summer-grazing and spring-calving systems. Seasonality causes a supply imbalance resulting in a mismatch with market demand for particular months. Milk and dairy products have stable consumer demand throughout the year, but they are vulnerable to perishability. Therefore, seasonality to some extent acts as a constraint. Highly seasonal patterns generate a need to build sufficient (peak-load) capacities for transporting and processing peak production of perishable products. This leads to idle capacity during months of low supply (Hennessy & Roosen, 2003). To cope with strong seasonality, dairy farm management is of vital importance. October is the most important month for grazing, managing cow body condition scores and taking soil samples to ensure high-quality production for the following spring (Teagasc, 2016).

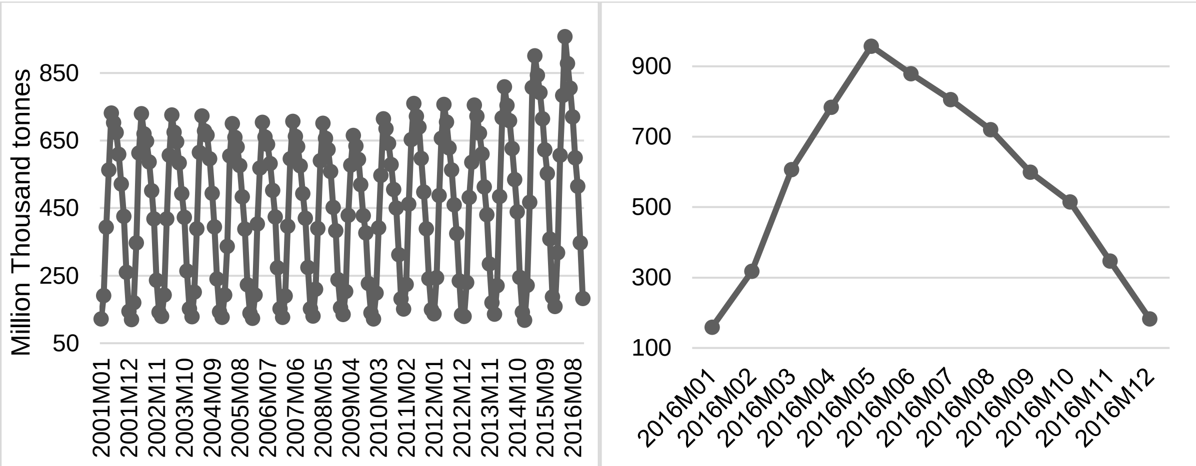


Figure 2.6: Monthly farm-gate raw milk production in Ireland from Jan 2001 to Dec 2016

Source: Author’s depiction using data retrieved from Eurostat, accessed in 2017

Although there is obvious seasonality in Irish milk production, both the raw milk price and retail milk price remains relatively stable. It can be observed from Figure 2.7 that retail price and raw milk price of Ireland have co-movement patterns over the years.

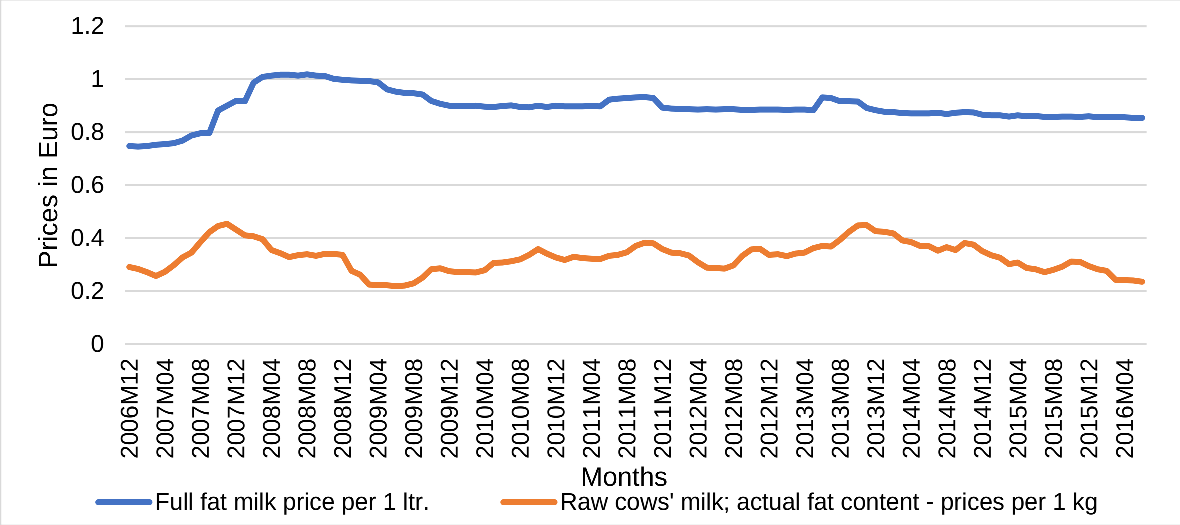
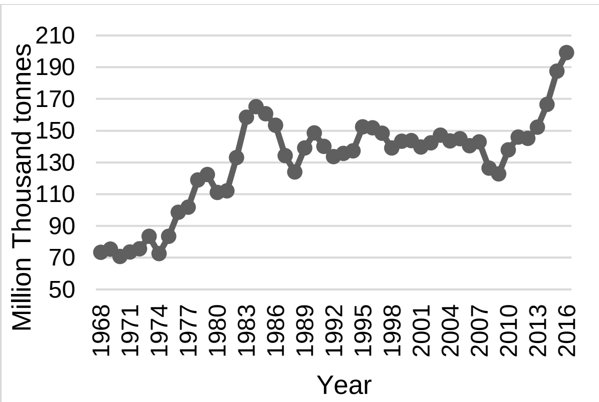


Figure 2.7: Retail and Farm-gate raw milk price in Ireland from Dec 2006 to June 2016

Source: Central Statistics Office Ireland (CSO), website: https://www.cso.ie/en/index.html. European Commission Milk Market Observatory

As Figure 2.8 shows, Irish butter production increased until 1984 when the EU Common Agricultural Policy (CAP) introduced milk quota tools. In 2009, the relaxing of quotas allowed producers to gradually increase production. Thus, there is an obvious and clear upward trend of butter production from then on. Compared to butter, SMP production fluctuates more. SMP production declined from 1992 and increased slightly since 2009. In recent years, Ireland's dairy export revenue is still heavily dependent on base products such as butter, WMP and SMP.



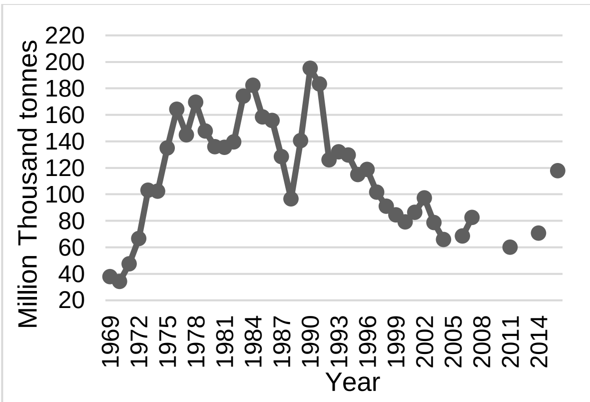


Figure 2.8: Annual production of butter and Skimmed Milk Powder (SMP)[24] in Ireland 1968-2016

Source: Author's depiction using data retrieved from Eurostat

[24] for SMP data in year 2005, 2008, 2009, 2010, 2012, 2013 and 2015 are labelled confidential on Eurostat

2.2.1.1.2 Export markets for Irish Dairy Products

Dairy is the most active and strong industry for Ireland accounting for over 47% of its exports to international market (Bord Bia, 2017). More than 80% of Irish dairy products were exported in recent years. The UK, China, the United States, the Netherlands and Germany were the top 5 export destinations for Irish dairy products (including infant formula) in 2016 (Bord Bia, 2017) with the UK accounting for around 43% of Irish dairy exports.

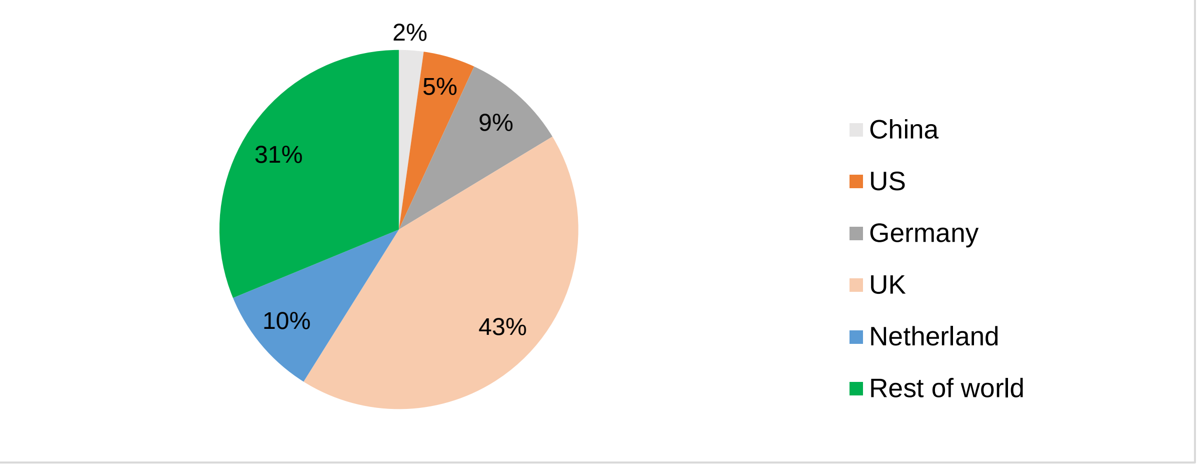
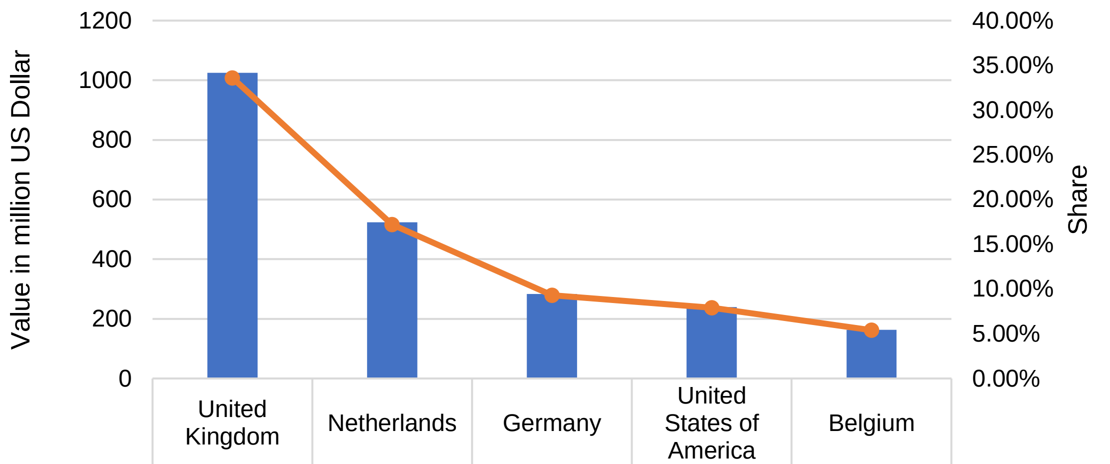


Figure 2.9: Total dairy product[25] export shares by value in 2015

Source: Author's depiction by calculating Eurostat data

In 2018, the UK, the Netherlands, Germany, the U.S. and Belgium ranked as the top 5 export destinations for Irish dairy products (HS Chapter 04) as shown in Figure 2.10. The UK is still the largest importer of Irish dairy products with import value amounting to over 1025 million US dollars and accounting for 33.6% of Irish dairy exports by value.

[25] Including products: HS 0401, HS 0402, HS 0403, HS 0404, HS 0405 and HS 0406 (see Section II.1 in Appendix II for the categorised products of these HS headings). Infant formula is excluded.



	United Kingdom	Netherlands	Germany	United States of America	Belgium
Value	1025.3	524.08	283.71	239.45	163.46
Share	33.60%	17.20%	9.30%	7.90%	5.40%

Figure 2.10: Dairy products[26] by export value and share in main export destinations for Ireland in 2018

Source: ITC Trade Map[27]

The UK has been the most important Irish dairy export destination for a long time. In 2018, the total value of dairy product[28] exports to the UK was 847 million euros accounting for around 44% of Irish intra-EU28 exports[29] and 33% of Irish global dairy exports. Liquid milk and cream (HS 0401) exporting to the UK accounts for 97.9% of the Irish intra-EU exports of liquid milk and cream, followed by Whey (HS 0403, 72.3% of Irish intra-EU exports of Whey), Cheese and curds (HS 0406, 65.1% of Irish intra-EU exports of cheese and curds), Buttermilk (HS 0404, 44.2% of Irish intra-EU exports of Buttermilk) and Butter (HS 0405, 26.7% of Irish intra-EU exports of Butter). Of Ireland's extra-EU export destinations, China, an emerging dairy import market with a booming economy, accounts for over 74.8% and 51.8% of Irish extra-EU Liquid milk and cream and Whey product exports, respectively.

[26] Categories by Harmonized System digits 2 (HS-2) product 04: Dairy produce, birds' eggs; natural honey; else
[27] Website: http://www.trademap.org/Country_SelProductCountry_TS.aspx?nvpm=1|372||||04|||2|1|1|2|2|1|2|1|1
[28] Aggregated HS headings 0401, 0402, 0403, 0404, 0405 and 0406
[29] Data source: Eurostat Database: DS-016894

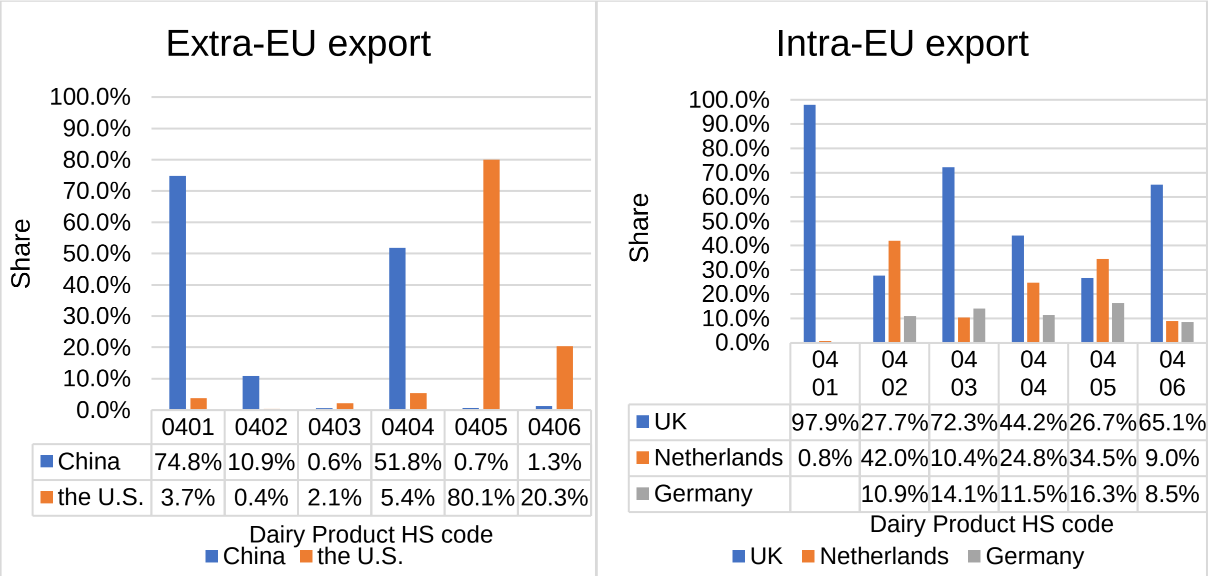


Figure 2.11: Export shares of various dairy products by value for Extra EU28 and Intra EU28 in 2018

Source: Calculated and depicted using Eurostat data by HS-4 Product codes[30]. EU trade since 1988 by HS2,4,6 and CN8 [DS-645593], accessed on 26/11/2019

Infant formula, as a premium dairy product with high nutrition and at the top of the dairy products value chain, diversifies the portfolio and increases the competitiveness of Irish dairy exports. It is a key profitable dairy product for Ireland. In 2015, infant formula exports from Ireland to the UK amounted to 172 million euros, accounting for 47.82% of Irish Intra-EU infant formula exports. Infant formula as a high value-added and premium dairy product is in great demand in China. As Figure 2.12 depicts, the export value of infant formula (HS sub-heading 190110) from Ireland to China has been surging since 2011 and exceeded exports to the UK since 2014. In 2015, its export from Ireland to China amounted to over 337 million euros, accounting for 93.65% of total infant formula export by value from Ireland to extra-EU28 countries. The Chinese market is of vital importance to Ireland and will substantially broaden and deepen dairy export trade.

[30] Dairy Product Categories by Harmonized System (HS-4) HS headings:
0401-Milk and cream; not concentrated, not containing added sugar or other sweetening matter;
0402-Milk and cream; concentrated or containing added sugar or other sweetening matter;
0403-Buttermilk, curdled milk and cream, yoghurt, kephir, fermented or acidified milk or cream, whether or not concentrated, containing added sugar, sweetening matter, flavoured or added fruit or cocoa;
0404-Whey and products consisting of natural milk constituents; whether or not containing added sugar or other sweetening matter, not elsewhere specified or included;
0405-Butter and other fats and oils derived from milk; dairy spreads;
0406-Cheese and curd.

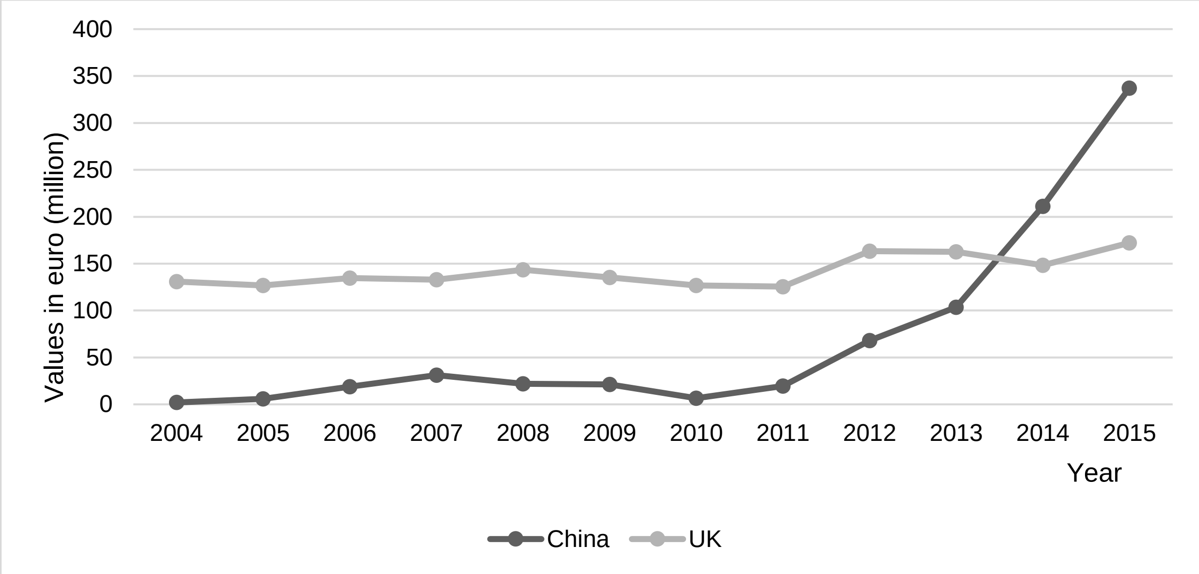


Figure 2.12: Irish Infant formula (HS 190110)[31] exports to China and the UK by value

Data Source: Eurostat database

The UK is still the most important dairy export destination for Irish companies. However, the referendum on Brexit in June 2016, and the corresponding exchange rate fluctuations and uncertainty, have had a negative impact on Irish exports to the UK. Although the shrinkage of exports to the UK hit Irish dairy exports to some extent, the total export value of Irish dairy products has been increasing over the years due to emerging new markets. For example, China emerged as a new export market for Ireland and due to a high demand for dairy products, become the second largest importer of Irish dairy products. To develop a more diversified market strategy and meet high demand from booming economies in Asia, such as China, India, Korea etc., Ireland needs to adjust its export strategy and increase the speed of shifting its export portfolio from low-margin products to high value-added products.

2.3.2 New Zealand's Dairy Export Context

New Zealand, an island nation in the south western Pacific Ocean with a similar population to Ireland of around 4.6 million, leads the world when it comes to dairy product exports, and accounts for over a third of the global dairy trade. Interestingly, New Zealand shares considerable similarities with Ireland while thriving in several aspects of its global dairy industry that Ireland could improve on. In 2013, whole milk

[31] HS Sub heading 190110-Food preparations; of flour, meal, starch, malt extract or milk products, suitable for infants or young children, put up for retail sale

powder (WMP) accounted for 42% of dairy revenue, skim milk powder accounted for 14%, butter for 16%, cheese for 12%.[32] Notably, Chinese import of dairy products is essentially dominated by New Zealand, which accounts for approximately 90% of market share, especially in the milk powder market. In 2018, the top 5 export destinations for New Zealand's dairy products (HS Chapter 04) were China (30%), Australia (5.5%), United Arab Emirates (3.9%), Malaysia (3.8%) and Japan (3.8%) with China's imports by value amounting to over 3057 million US dollar as illustrated in Figure 2.13 below.

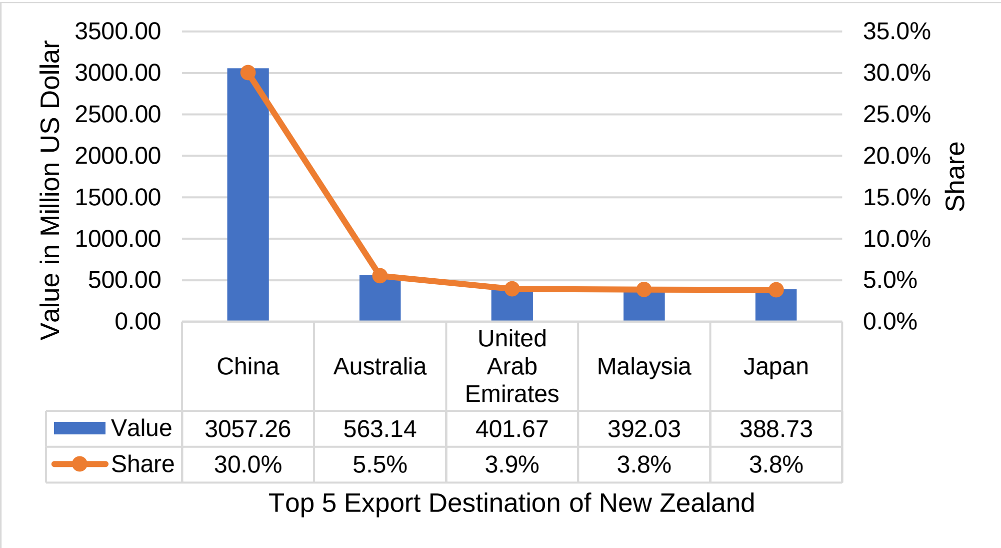


Figure 2.13: Dairy products[33] export values and shares in the top 5 export destinations of New Zealand in 2018

Source: ITC Trade Map[34]

China is the largest trading partner of New Zealand. Its sizeable and growing middle class and flourishing economy offer significant opportunities for New Zealand exporters and investors. Dairy (Milk powder, butter and cheese) is the largest sector for New Zealand exports. New Zealand entered into a free trade agreement with China in 2008, and along with the FTA came unique advantages. Currently, tariffs are eliminated for over 97% of New Zealand export of goods to China. In 2018, all exports other than dairy, and a small number of products excluded from the FTA, are eligible for tariff-free

[32] Calculated using FAOSTAT data.
[33] Categories by Harmonized System digits 2 (HS-2) product 04: Dairy produce, birds' eggs; natural honey; else
[34] Website: http://www.trademap.org/Country_SelProductCountry_TS.aspx?nvpm=1|372||||04|||2|1|1|2|2|1|2|1|1

access to China. China granted greater market access and preferential tariffs for New Zealand's dairy products and greater cooperation in areas such as sanitary and phytosanitary (SPS) measures and technical barriers to trade (TBT). In terms of dairy products, China has granted tariff-free market access for most dairy products from New Zealand (HS 0401, HS0403, HS 0404, HS 0405 and HS 0406). However, some of New Zealand's main dairy product exports, such as whole milk powder (WMP, HS 040221+HS 040229) and skim milk powder (SMP, HS 040210), remain subject to tariffs, but safeguarded with preferential tariffs of 1.7% which are much lower than the MFN tariff rate of 10%. In 2018, China's imports of SMP and WMP from New Zealand accounted for 16.08% of China's total goods imports from New Zealand but are subject to tariff rates of 1.7%. Duty-free dairy products imported from New Zealand amounted to around 1260.08 million US dollar and account for 11.37% of China's total imports from New Zealand, while around 1782.51 million US dollar New Zealand dairy products were imported by China at a preferential tariff rate of 1.7% and account for 16.09% of China's total imports from New Zealand. (Table 2.6 below)

Table 2.6: Tariffs applied at 6 digits product level by China (2017)

HS Subheading Product code	Product description	Preferential Applied Tariff[35] for New Zealand (at the HS 6-digit level)			Average of AV Duties		China Imports from New Zealand (2018)	
		Average of ad valorem (AV) Duties[36]	Max AV Duty	Duty Free Total (%)	MFN Applied Tariff[37]	Bound [38]	Value in million USD	Share of total imports from New Zealand
040110	Milk and cream of a fat content by weight of <= 1%, not concentrated nor containing added sugar or other sweetening matter	0	0	100	15.0	15	7.60	0.07%
040120	Milk and cream of a fat content by weight of > 1% but <= 6%, not concentrated nor	0	0	100	15.0	15	150.84	1.36%

[35] Applied rates: duties that are actually charged on imports. These can be below the bound rates.
[36] Ad valorem (AV): a tariff rate charged as percentage of the price.
[37] MFN (most-favoured-nation) tariff: normal non-discriminatory tariff charged on imports (excludes preferential tariffs under free trade agreements and other schemes or tariffs charged inside quotas).
[38] Bound rates (tariff binding): commitment not to increase a rate of duty beyond an agreed level. Once a rate of duty is bound, it may not be raised without compensating the affected parties.

	containing added sugar or other sweetening matter							
040140	Milk and cream of a fat content by weight of > 6% but <= 10%, not concentrated nor containing added sugar or other sweetening matter	0	0	100	15.0	15	0.02	0.00%
040150	Milk and cream of a fat content by weight of > 10%, not concentrated nor containing added sugar or other sweetening matter	0	0	100	15.0	15	216.05	1.95%
040210	Milk and cream in solid forms, of a fat content by weight of <= 1,5%	1.7	1.7	0	10.0	10	272.88	2.46%
040221	Milk and cream in solid forms, of a fat content by weight of > 1,5%, unsweetened	1.7	1.7	0	10.0	10	1501.35	13.55%
040229	Milk and cream in solid forms, of a fat content by weight of > 1,5%, sweetened	1.7	1.7	0	10.0	10	8.26	0.07%
040291	Milk and cream, concentrated but unsweetened (excl. in solid forms)	1.7	1.7	0	10.0	10	0.00	0.00%
040299	Milk and cream, concentrated and sweetened (excl. in solid forms)	0	0	100	10.0	10	0.02	0.00%
040310	Yogurt, whether or not flavoured or containing added sugar or other sweetening matter, fruits, nuts or cocoa	0	0	100	10.0	10	0.10	0.00%
040390	Buttermilk, curdled milk and cream, kephir and other fermented or acidified milk and cream, whether or not concentrated or flavoured or containing added sugar or other sweetening matter, fruits, nuts or cocoa (excl. yogurt)	0	0	100	20.0	20	5.77	0.05%
040410	Whey and modified whey, whether or not concentrated or	0	0	100	6.0	6	14.39	0.13%

	containing added sugar or other sweetening matter							
040490	Products consisting of natural milk constituents, whether or not sweetened, n.e.s.	0	0	100	20.0	20	7.53	0.07%
040510	Butter (excl. dehydrated butter and ghee)	0	0	100	10.0	10	6.86	0.06%
040520	Dairy spreads of a fat content, by weight, of >= 39% but < 80%	0	0	100	10.0	10	443.82	4.01%
040590	Fats and oils derived from milk, and dehydrated butter and ghee (excl. natural butter, recombined butter and whey butter)	0	0	100	10.0	10	159.29	1.44%
040610	Fresh cheese "unripened or uncured cheese", incl. whey cheese, and curd	0	0	100	12.0	12	108.46	0.98%
040620	Grated or powdered cheese, of all kinds	0	0	100	12.0	12	83.36	0.75%
040630	Processed cheese, not grated or powdered	0	0	100	12.0	12	24.58	0.22%
040640	Blue-veined cheese and other cheese containing veins produced by "Penicillium roqueforti"	0	0	100	15.0	15	-	-
040690	Cheese (excl. fresh cheese, incl. whey cheese, curd, processed cheese, blue-veined cheese and other cheese containing veins produced by "Penicillium roqueforti", and grated or powdered cheese)	0	0	100	12.0	12	31.42	0.28%

Source: WTO Tariff Download Facility. Website: http://tariffdata.wto.org/. The World Integrated Trade Solution (WITS), website: https://wits.worldbank.org/. Accessed on 26/11/2019.

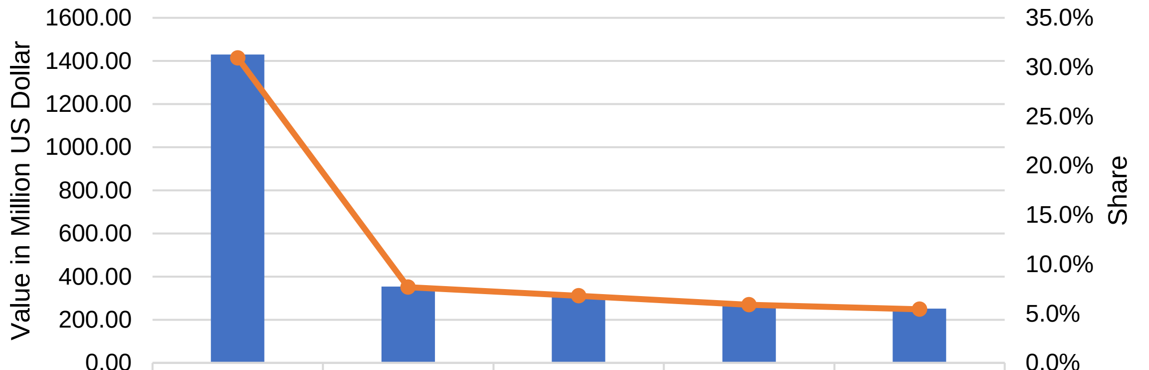
Note: For details, please check the WTO website for official definitions of the terms listed in the above table:

https://www.wto.org/english/tratop_e/tariffs_e/tao_help_e.htm.

2.3.3 U.S. Dairy Export Context

The United States of America (USA), the world's largest economy with extremely diverse climate, geography and wildlife, is a major dairy producer and consumer with unique production characteristics owing to its latitude, land scale and technologies. Unlike the pasture-based farming characteristics and seasonal production of milk in New Zealand and member states of the EU, American milk production has little seasonality, which confers an advantage on its dairy process industry.

In 2018, total dairy exports by value for the U.S. amounted to 4620 million US dollar. Mexico ranked first place for US dairy product exports worth a value of 1429 million US dollar and accounting for 30.9% of total US dairy exports. In 2018, exports to Canada, China, Korea and Japan accounted for 7.7%, 6.8%, 5.9% and 5.4% of total US dairy exports, respectively.



	Mexico	Canada	China	Korea, Republic of	Japan
Value	1429.09	353.84	314.61	272.76	251.07
Share	30.9%	7.7%	6.8%	5.9%	5.4%

Figure 2.14: Dairy product exports to main US destinations by value and share in 2018

Source: ITC Trade Map

In the case of Mexico, the North American Free Trade Agreement (NAFTA), implemented in 1994, gives U.S. dairy products great market access, with some trade restrictions on US dairy products eliminated upon its implementation and others phased out over 4-year, 9-year and 14-year periods. Currently, all US dairy products enjoy duty-free access to Mexican markets while average AV duties in Mexico for MFN countries are still quite high (see Table I.1 in Appendix I). Mexico is the largest US dairy product importer and the largest developing neighbour of the US. In 2018, imported dairy products from the United States were valued at 1.4 billion US dollar and 30.9% of Mexico’s dairy imports by value. SMP (HS 040210) ranks in first place by value in Mexico’s dairy-product imports at 657.62 million US dollar and accounting for

46.27% of total dairy imports from the US. Cheese (HS 040690) is the second-highest U.S. dairy product imported by Mexico by value. In 2018, over 183.12 million US dollar duty-free American cheese (HS 040690) was imported by Mexico accounting for around 12.88% of its total dairy imports from the US. Grated or powdered cheese (HS 040620) ranks as the third largest imported U.S. dairy product worth over 159 million US dollar by value and 11.19% of dairy imports from the US.

As the second largest American dairy importer, a developed neighbour of the US, and a member of NAFTA, the Canadian market is essential and important for the US dairy sector. US dairy products exports to Canada have increased significantly over the years. However, trade barriers and tariffs were not liberalised by NAFTA, and restrictions on US dairy products still apply as Canada excluded dairy products from NAFTA and dairy imports by Canada continue to be constrained by Tariff-Rate Quotas (TRQs), limiting export growth for US dairy products. All dairy products at HS 6-digit level imported from the U.S. are subject to the same tariff-rate quotas as MFN tariff-rate quotas. In 2018, of all Canada's import of U.S. dairy products by Canada, butter (HS 040510) was highest in terms of import value under the quota rate of the lesser of 298.5% or $4.00/kg, amounting to 67.63 million US dollar in value and accounting for 20.48% of total dairy products from the US. Specifically, 66.67% of whey products (HS 040410) imported from the US enjoy duty-free access to Canadian markets and the over-quota tariff rate is the lesser of 208% or $2.07/kg. In 2018, the import value of whey from the US by Canada amounted to 35.20 million US dollar and accounted for 10.66% of Canada's total dairy imports from the US, ranking it in second place for US dairy products imported by Canada. Cheese (HS 040690) is a third largest US dairy product imported by Canada and amounts to 26.61 million US dollar under the quota rate of the lesser of 245.5% or $4.52/kg. (See Table I.1 in Appendix I for details).

2.3.4 China's Promising Dairy Market

With rising incomes, large population, low production to consumption ratio, and preference for imported dairy products, China has become the largest importer of dairy products in recent years, especially for infant formula and milk powder. Advertising, public milk programmes, and public information on the benefits of dairy product consumption, have changed dietary habits for Chinese families towards dairy products and fostered a culture for milk and dairy product consumption. Due to serial infant milk powder scandals and dairy food safety issues, Chinese consumers have low confidence in domestic milk and dairy product quality and safety and have been deterred from purchasing them (P. Xu, Yang, & Lone, 2017).

The consumption of major dairy products has been growing more rapidly than domestic milk production in China. Increased demand for dairy products, and especially for imported dairy products, can be attributed to several factors, including a) rapid economic growth and higher incomes boost consumption capacity for higher value-added products; b) changing demographic characteristics in China boost consumption of dairy products as a high-nutrition food: the population aged 0-14 and over 65 has been increasing for years, and these are the main consumer groups for dairy products in China. An increase in urban populations and the rise of the middle class in China enhance change in diet from oriental to more western style diets that consume more dairy products.

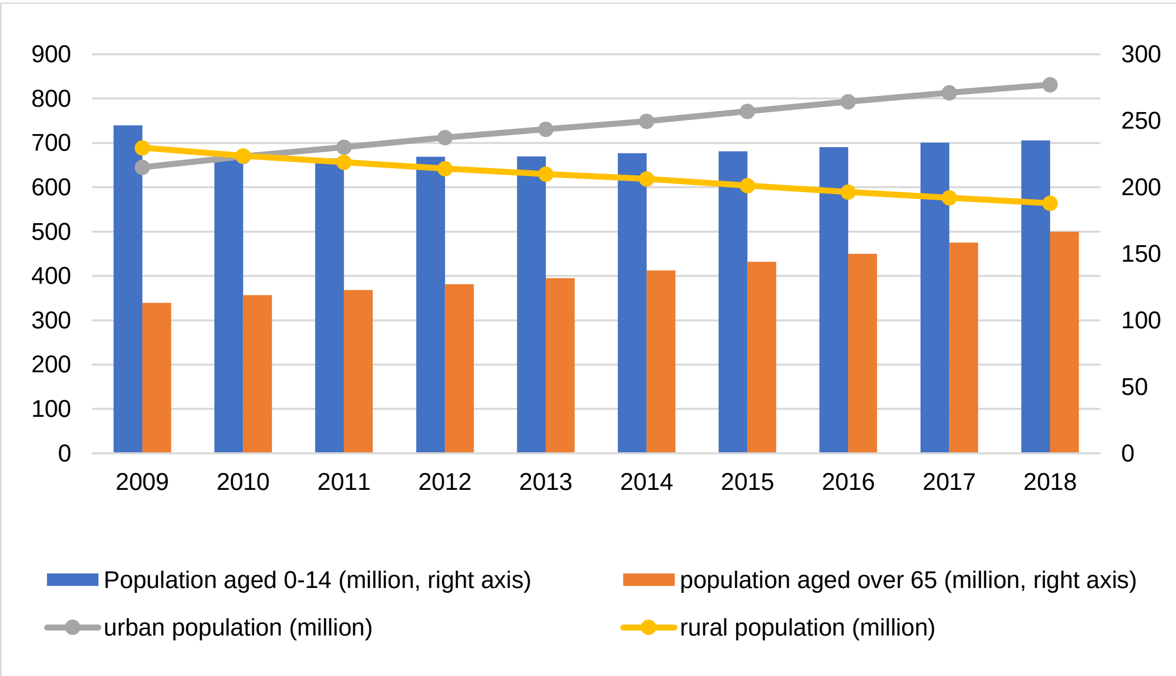


Figure 2.15: Demographic characteristics of China (2006-2018)

Source: National Bureau of Statistics of China, website: http://data.stats.gov.cn/easyquery.htm?cn=C0. Accessed on 26/11/2019.

Although demand for dairy products has been increasing in China, domestic milk production capacity remains at a comparatively low level. From 2009 to 2018, domestic milk production in China ranged from 30 million tonnes to 32 million tonnes with fluctuations around the horizontal level as illustrated in Figure 2.16 below. So, to balance the increasing demands for dairy products and a deficit in domestic supply, China imports various dairy products.

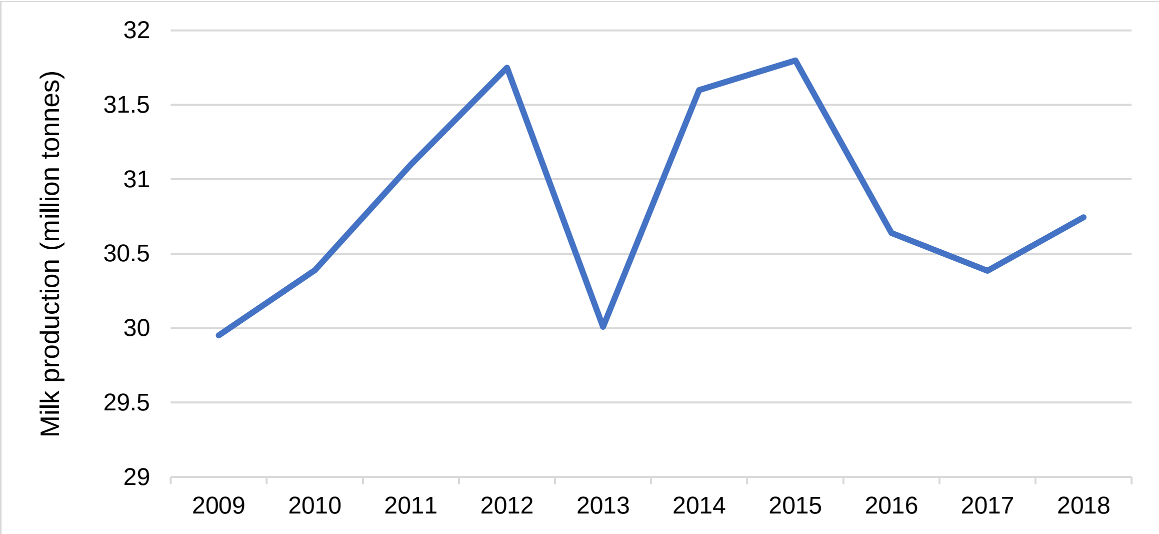


Figure 2.16: Domestic milk production in China from 2009 to 2018.

Source: National Bureau of Statistics of China.

http://data.stats.gov.cn/easyquery.htm?cn=C0. Accessed on 26/11/2019.

Figure 2.17 (a) to Figure 2.17 (d) depict China's production, consumption and imports for major dairy products from 2010 to 2018. It can be clearly seen that domestic production of butter, cheese and skim milk powder have a downward trend since 2010 and the production of whole milk powder has a slight upward trend. The import and consumption of all the major dairy products have an upward trend and display a similar pattern over the years. China has much larger consumption and import levels for whole milk powder than other dairy products.

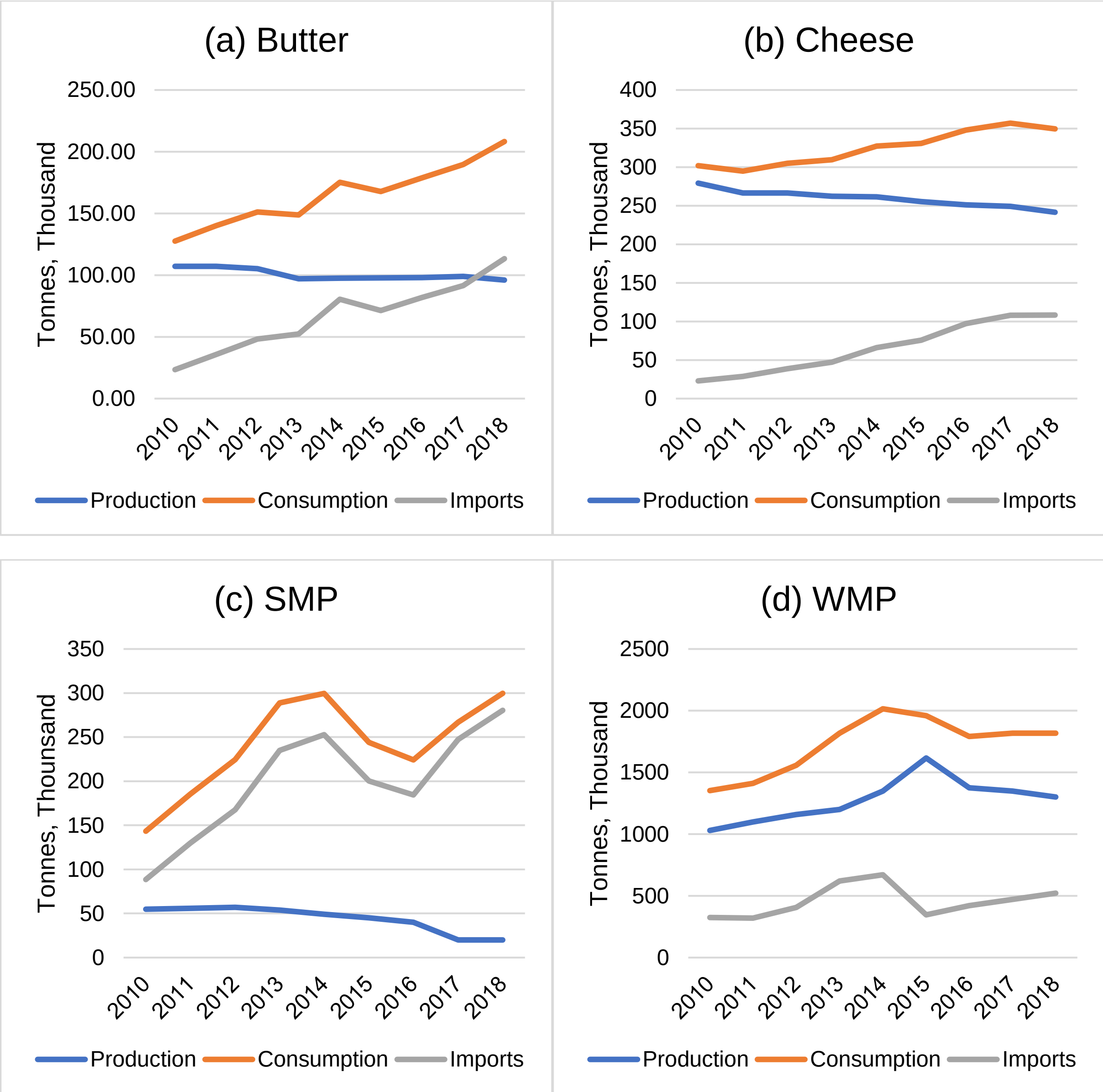


Figure 2.17: Production, consumption and imports for major dairy products in China from 2010 to 2018

Source: OECD-FAO Agricultural Outlook Database

Among all dairy products, milk powder is the one most consumed and imported in China. Whole milk powder and skim milk powder imports account for over 60% of China's total dairy imports from 2009 to 2014 (Figure 2.18). In 2018, China consumed over 1.8 million and 0.3 million tonnes, respectively, of global whole milk powder and skim milk powder, of which over 0.5 million and 0.28 million tonnes, respectively, were imported. The consumption to production ratio of skim milk powder is high at almost 15. Recently, some special dairy products such as whey and infant formula are in huge demand in China due to unique dietary habits and the significantly large number of Chinese newborns each year. Whey powder is a by-product of cheese but also a main ingredient for infant formula and is a popular and high value-added import product in China (DAFM, 2015).

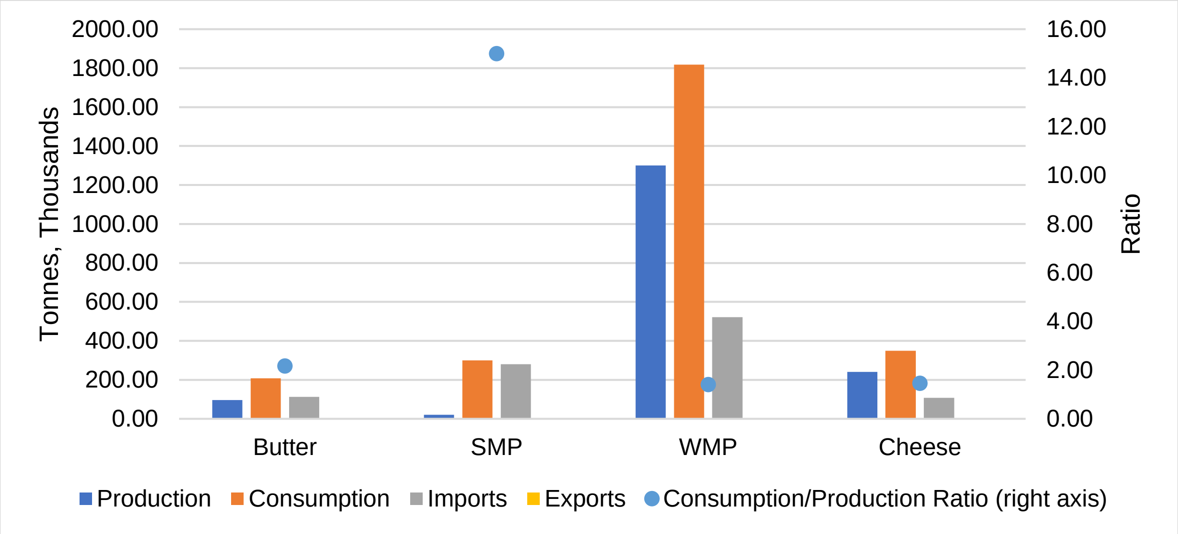


Figure 2.18: Production, consumption and trade among major dairy products in China in 2018

Source: OECD-FAO Agricultural Outlook Database

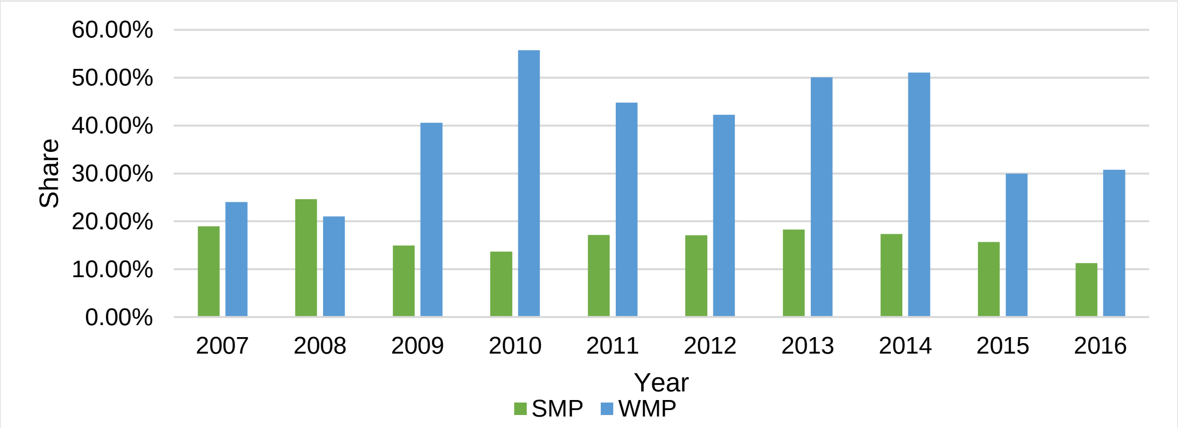


Figure 2.19: Share of SMP and WMP imports to total dairy imports in China by value

Source: UN Comtrade database

New Zealand (NZ), the EU, the U.S. and Australia are the four major countries for China's dairy product imports. In 2015, New Zealand, the EU and the U.S. accounted for around 88.5% of Chinese dairy imports as outlined in Table 2.7. New Zealand (NZ), the EU and Australia are the top 3 exporters of liquid milk and cream (HS 0401), concentrated milk and cream (HS 0402), and butter (HS 0405).

Table 2.7: Shares of Chinese imports among the Top 3 suppliers of dairy products by value in US Dollars (2015)

Rank	Liquid Milk, HS 0401	Concentrated Milk, HS 0402[39]	Buttermilk, HS 0403	Whey, HS 0404	Butter, HS 0405	Cheese, HS 0406	Aggregated dairy products
1	EU (57.1%)	NZ (78.31%)	EU (36.31%)	EU (52.03%)	NZ (80.09%)	NZ (46.46%)	NZ (53.79%)
2	NZ (23.64%)	EU (9.95%)	NZ (34.22%)	U.S. (34.63%)	EU (14.15%)	Australia (18.61%)	EU (25.36%)
3	Australia (13.35%)	Australia (7.07%)	Switzerland (12.14%)	Argentina (6.49%)	Australia (4.18%)	EU (16.32%)	U.S. (9.35%)

Source: calculated using data from UN Comtrade.

The dairy import market structure in China has remained stable for years. In 2018, New Zealand, the EU and the U.S. accounted for around 88.27% of dairy imports in China. However, market share for US products declined compared to 2015 due to US-China trade conflicts. New Zealand (NZ), the EU and Australia (AUS) are still the top 3 exporters for liquid milk and cream (HS 0401), concentrated milk and cream (HS 0402), and butter (HS 0405), and Australia increased its rank to third place for buttermilk (HS 0403) and cheese (HS 0406) in 2018.

Table 2.8: Shares of Chinese imports for Top 3 suppliers of dairy products and China's total imports by value (million US Dollar, 2018)

Rank	HS 0401	HS 0402	HS 040210, SMP	HS 0403	HS 0404	HS 0405	HS 0406	Aggregated dairy products
1	EU 47.74%	NZ 71.96%	NZ 44.80%	EU 82.51%	EU 54.17%	NZ 86.56%	NZ 48.29%	NZ 57.20%
2	NZ 41.04%	EU 12.47%	EU 28.19%	NZ 9.66%	U.S. 32.46%	EU 10.64%	EU 20.45%	EU 24.88%
3	AUS 8.84%	AUS 9.78%	AUS 16.59%	AUS 3.36%	NZ 2.27%	AUS 1.80%	AUS 16.32%	U.S. 6.19%
Total	912.57	2477.11	-	60.72	633.31	696.76	513.19	4672.78

Source: Calculated using data from WITS, website: https://wits.worldbank.org/. Accessed on 26/11/2019.

[39] Subheading HS 040210 (SMP) is under the heading HS 0402, as in this table only products denoted under the Subheading at 4-digit level are listed.

Dairy products and milk imports have experienced prominent growth in China, which provides great potential for major dairy export countries. Major EU dairy exporting member states, such as Germany, the Netherlands, Ireland and other EU member states, face weak dairy market demand due to the Russian import ban and uncertainties stemming from Brexit, and are new entrants to the Chinese market compared to New Zealand. There will be more challenges and opportunities for EU dairy export member states to expand their market share in China.

Table 2.9 outlines the duties faced by dairy exporters to China. These are different from New Zealand which has a free trade agreement with China and enjoys duty-free market access for most dairy products and preferential tariff rates, other dairy exporters, such as the EU and the U.S., have to face MFN applied duties for dairy products in the Chinese market. In the post-WTO accession, China has duty-bound all items relating to dairy in the summary of its binding commitments in the dairy sector. China's MFN applied duties are on par with the final bound duty rates on dairy products, which is 12.2% on average. The highest import is the HS heading 0402 "condensed milk" which has bound and applied MFN rate of 10% and is worth over 2,214 million US dollar, followed by the HS heading 0401 "liquid milk" where import amounts to 879 million US dollar and has bound and applied MFN rate of 15%.

Table 2.9: Tariffs and imports by product groups in 2017[40]

	Final bound duties				MFN applied duties			Import
Product groups	AVG	Duty-free in %	Max	Binding in %	AVG	Duty-free in %	Max	Value in million USD
Dairy products 04	12.2	0	20	100	12.3	0	20	-
Liquid Milk 0401	15	0	15	100	15	0	15	879.39
Condensed Milk 0402	10	0	10	100	10	0	10	2214.42
Butter Milk 0403	15	0	20	100	15	0	20	66.83
Whey 0404	13	0	20	100	13	0	20	666.12
Butter 0405	10	0	10	100	10	0	10	499.35
Cheese 0406	12.6	0	15	100	12.6	0	15	497.52

Source: WTO Tariff Download Facility and Trade Profile. Accessed on 20/11/2019

[40] AVG: Average rates; MAX: maximum rates

Recently, China focused on the recovery and growth of its domestic dairy industry which was heavily hit by the melamine scandal and consequent distrust by Chinese consumers. Taking the industry's sustainability, food security, welfare and rural development into consideration, the Chinese dairy market will not be as easy to enter in future (OECD, 2018). In September 2016, the China Food and Drug Administration, now changed to the State Administration for Market Regulation (SAMR),[41] released a draft regulation with detailed rules for online selling of products and other labelling rules taking effect on October 1st, 2016.[42] This strengthening regulation will further standardize the production and sales of infant formula milk powder and promote the sustainable and healthy development of the infant formula milk powder industry in China,[43] which, to some degree, will pose challenges for both imported and domestic infant formula producers and sellers.

In general, milk powder, including SMP, WMP and infant milk formula powder, are dominated by imports in China. However, new rules, such as a registration system, and e-commerce tax, will to some degree cool down the dominant effects of foreign suppliers. Liquid milk imports are anticipated to be strong thanks to improvements in transportation and logistics, changing purchasing habits and booming e-commerce that enables consumers outside Tier 1 cities to purchase imported milk. Therefore, future efforts should focus on market expansion beyond China's Tier-1 city markets.

2.4 Conclusion

The global dairy sector is characterised by a few major exporters and importers. On the one hand, trade patterns by different exporters exhibit unique features in terms of export destinations, export product structures, trade policies and relationships with trade partners. On the other hand, close links among geographically separated exporters via the market and dairy trade was one of the delicate issues in trade agreement negotiations globally, and remains influenced by bilateral trade history, specific interests of countries, previous trade agreements, and so on. Recently, there

[41] "formula registration management measures on Infant formula milk powder product", No. 26 Order of the State Administration for Market Regulation, SAMR: http://gkml.samr.gov.cn/nsjg/tssps/201903/t20190329_292466.html. Accessed on 20/12/2019.
[42] Previous links via CFDA (invalid now): http://www.sda.gov.cn/WS01/CL1197/155260.html
[43] Official interpretation on "formula registration management measures on Infant formula milk powder product": http://gkml.samr.gov.cn/nsjg/tssps/201903/t20190311_291859.html. Accessed on 20/12/2019

is considerably increased fluctuation and volatility in dairy prices and price volatility creates uncertainty for the dairy market. This inhibits investment, impedes market integration, and harms the welfare of different stakeholders in the sector. In fast-changing global markets context with shocks probably occurring at any time, it is essential to delve deeply into the market mechanisms and spatial price transmission of dairy trade markets and consider the complexity of inherited features and external trading environments.

In conclusion, three major dairy exporters, the EU, New Zealand and the U.S., are significant and representative players in global dairy markets and each have symbolic characteristics: (a) The EU has experienced a series of CAP reforms to make its dairy sector more market oriented. It has a free, dynamic and vibrant internal market facilitated by the EU single market strategy, and also has common custom tariffs to protect its internal market. Over half of dairy products are traded among EU member states. (b) New Zealand is known as the country with the least subsidised agricultural sector in the world and has no subsidies for its dairy sector, which results in "a dramatic reduction in market distortions" according to the OECD (CATO, 2002[44]). Its number one export destination is China accounting for 30% of New Zealand's total dairy exports and both countries are heavily reliant on each other. There is a sharp contrast between New Zealand and other major exporters (such as the EU and the US) where 95 percent of total dairy production is for domestic consumption. (IUF, 2011[45]). (c) The US dairy sector has encountered substantial adjustments in marketing and policies to make itself a more reliable dairy product supplier and to successfully evolve into one of the top players in global dairy markets (Vitaliano, 2016). It is both an important player in international trade and consumer markets, with Canada and Mexico as the main export destinations for its dairy products. (d) New Zealand has dominated the Chinese dairy import market over the last decade and China is the largest dairy importer globally. However, thanks to the continuously increasing demand for imported dairy products, China still provides opportunities and space for market expansion for new entrants.

[44] CATO (2002). https://www.cato.org/publications/commentary/save-farms-end-subsidies
[45] IUF (2011). http://cms.iuf.org/sites/cms.iuf.org/files/New%20Zealand%20Dairy%20Industry.pdf

Chapter 3 Literature Review

3.1 Introduction

Price is a fundamental part of economic theory. Prices drive production, consumption and distribution mixed decisions, welfare of stakeholders (e.g. producers, processers, retailers, exporters, consumers and policy makers, etc), resource allocation, etc. Price transmission integrates markets vertically along the supply chain and horizontally among geographically separated locations or cross products. In the context of an ongoing process of globalization, multilateral trade corporation, and challenges of rising trade protectionism and economic policy uncertainties, international commodity prices linkages and volatility have become the centrepiece of many policy debates and economic discussions. Price transmission and price leadership are examined in theoretical and empirical studies to understand price dynamics and market mechanism. Trade policy regimes, macroeconomic factors, demand and supply sides shocks, substitute prices and other influencing factors may have impacts on price transmission mechanisms in international commodity markets and along global supply chains. In particular, the literature pays considerable attention to two main directions in price transmission analyses, that is Asymmetric Price Transmission (APT) and Horizontal Price Transmission (HPT). The former deciphers different price transmission patterns when prices are increasing and decreasing, and the latter provides information on the performance of geographically separated markets or the price relations across different commodity markets.

In this chapter, an extensive review of the rapidly growing agri-food related spatial price transmission literature is conducted. The main model techniques used, the variables focused on, the questions answered, the main findings of the literature and their policy implications are discussed. Gaps in the literature and future research directions are also highlighted.

3.2 Horizontal Price Transmission: Theory and Model Development

3.2.1 Features of Horizontal Price Transmission

Horizontal price transmission usually refers to Spatial Price Transmission (SPT) that price linkages across geographically separated markets, however, it can also apply to the transmission across different agricultural commodities (cross-commodity price transmission) (Esposti & Listorti, 2013; Listorti & Esposti, 2012). Spatial price transmission analysis could shed light on the market patterns (integration or segmentation). Different concepts and aspects are explored and applied to the spatial price analysis, including spatial arbitrage (Ardeni, 1989), the Law of One Price (LOP) derived by Marshall in 1890 (Baffes, 1991), spatial market integration that was defined as the degree of co-movement of prices in different locations earlier, specifically as measured by the correlation between the prices (Faminow & Benson, 1990; Goodwin & Piggott, 2001; Ravallion, 1986; Sexton, Kling, & Carman, 1991), and spatial market efficiency (see P. L. Fackler and B. K. Goodwin (2001) for a comprehensive summary). At the spatial level, LOP and predictions for market integration in standard spatial price determination models (Enke, 1951; Samuelson, 1952), following the Enke-Samuelson-Takayama-Judge tradition, imply that markets where information is fully and rapidly conveyed through prices are perfectly integrated and efficient. Predictions by these models imply that supply and demand sides changes in one market affect trade and thereafter restore price equilibrium in other markets through spatial arbitrage (Georege Rapsomanikis et al., 2006). However, Barrett and Li (2002) distinguish market integration from market equilibrium and define it as tradability or contestability between markets, implying the transfer of excess demand from one market to another that manifests in the physical flow of commodities, and the transmission of price shocks from one market to another, or both.

Spatial price transmission studies evaluating the validation of LOP and exploring market integration and their levels of efficiency offer meaningful insights for economic welfare. The absence of market integration or incomplete price transmission from one market to another caused either by trade or other policies or transaction costs, or by poor transport, communication and/or information infrastructure, provides incomplete information to economic decision makers, and this can lead to incorrect or irrational decisions and ineffective economic outcomes (Georege Rapsomanikis et al., 2006).

Spatial price transmission and linkages normally cover aspects of magnitude, speed and nature of price adjustments to shocks in geographically separated markets (Vavra & Goodwin, 2005). Generally spatial price analysis addresses the following four questions:

(a) To what degree will price in one market respond to prices on other markets when there is a shock of a certain size? (magnitude)
(b) How long will it take prices to converge to long-run equilibrium following shocks to prices in geographically separated markets? (speed)
(c) Are adjustments asymmetric after positive and negative shocks to prices in other markets? (nature)
(d) Is there a significant difference when shocks transmit to prices from central (global) markets to local (regional) markets or from local (regional) markets to central (global) markets? (direction)

3.2.2 Reasons for Asymmetry in Price Transmission

Asymmetries can occur within any aspect of the adjustment process, and these are prominent in recent research on the price transmission process. The speed and magnitude of price transmission might be asymmetric, as price information transmits differently when facing positive or negative shocks, or when transmitting from central to peripheral markets or from peripheral to central markets. Bailey and Brorsen (1989) find that asymmetries in spatial price transmission may be due to asymmetric adjustment costs, asymmetric information, market concentration and asymmetric price reporting. Spatial APT could exist if firms with local market power compete for market share in a region: a firm in one location might swiftly respond to a decrease in its competitors' price to avoid loss of market share, yet might regard competitors' price increases as a chance to boost sales, leading to a slower response to a price increase (Meyer & Von Cramon-Taubadel, 2004). The spatial APT might also be due to asymmetric flows of information between central and peripheral areas: a central market of a larger size and at the hub of information has more market power. So, prices in central maize markets are estimated to be less responsive to price changes in peripheral markets than vice versa (Abdulai, 2000).

3.2.3 Development of Methodology on Horizontal Price Transmission

In the context of agriculture and food, earlier empirical studies on price transmission and market mechanisms are mainly concerned with static models and the main focus is the elasticity of price pass-through. Recently, the dynamic and long-term analysis of spatial price transmission focuses on the application of time series econometric models and analysis techniques. Time series models have little data requirements and pre-assumption of model structure, and rely on price series or time series only. Time series analysis can signal market dynamics and direction, magnitude and distribution of price dynamics, thus contributing to policy assessment and implications. Time series methodology is the standard tool for analyzing spatial market relationships and provides useful insights into issues of market integration and price transmission. However, there are some criticisms of, and doubts on, the reliability and effectiveness of time series analysis (Barrett & Li, 2002; Baulch, 1997).

Time series models are widely used to analyse spatial price transmission, with price as the primary variable. Vector autoregressive (VAR) models attracted the attention of economists and were first introduced and made popular by Sims (1980), after which considerable research has been done using VAR models and extended linear and non-linear VAR models.

Bivariate and multivariate models are commonly applied in spatial price relationship analysis to explore relationship between different regional or dimensional price pairs and global linkages of prices, respectively. Various methodologies are employed to evaluate long-run price relationships. As agricultural commodity price transmission could be affected by domestic policies, market structure, and trade policy scenarios (for international markets) (Sharma, 2003), price transmission may be non-linear. Non-linearity price transmission could also result from market arbitrage, non-stationary transfer cost, and discontinuous trade and price cycle asynchronization, which may make linear models inaccurate and not appropriate. Therefore, applications of models that can deal with non-linear estimations are prominently featured in current price transmission research.

3.2.4 Linear Cointegration Models

The Granger-Engle cointegration model named after Engle and Granger (1987) is a two-step procedure for cointegration analysis to solve the problem of spurious regression. The way to detect the cointegrating relationship is to first establish a long-run equilibrium equation and then to test stationarity using unit root tests such as the Augmented Dicken-Fuller (ADF) test (Dickey & Fuller, 1979) of residuals derived from the acquired equation. After these two steps, a long-run error correction model can be established.

3.2.5 Threshold Cointegration Models

The threshold Autoregressive (TAR) model proposed by Tong (1983) facilitates the capture of “deep” movements in a series and an investigation of whether troughs in the series are more persistent than peaks or vice versa. Asymmetries in the manner of price adjustments, in terms of positive or negative deviations, can be obtained through a TAR model. Alternatively, an M-TAR model could capture attempts to mitigate or eliminate large changes in a series. The specification of TAR and MTAR is shown as Eq. (1). If $|\rho_1| < |\rho_2|$, a negative realization of $\widehat{\Delta\varepsilon_{t-1}}$ decays faster than a positive one. Increases tend to persist, whereas decreases are sharper and more significant, thereby tending to revert rapidly towards equilibrium. This pattern would be reversed if $|\rho_1| > |\rho_2|$.(Enders & Granger, 1998; Enders & Siklos, 2001).

The model specifications of the residuals for TAR and MTAR are as follows:

$$\Delta\widehat{\varepsilon_t} = \rho_1 \mathrm{I}_t \widehat{\varepsilon_{t-1}} + \rho_2(1 - \mathrm{I}_t)\widehat{\varepsilon_{t-1}} + \sum_{i=1}^{p} \varphi_i \, \Delta\widehat{\varepsilon_{t-\iota}} + \mu_t \quad (1)$$

where I_t is the Heaviside indicator function that can be set as following equations:

$$I_t = 1 \; if \; \widehat{\varepsilon_{t-1}} \geq \tau \,, 0 \; otherwise; or \quad (2a)$$

$$I_t = 1 \; if \; \widehat{\Delta\varepsilon_{t-1}} \geq \tau, 0 \; otherwise \quad (2b)$$

and τ is the value of the threshold, μ_t is the identical and independently distributed white noise with mean zero and constant variance. If the Heaviside indicator depends on the level of $\widehat{\varepsilon_{t-1}}$ as indicated in Equation (2a), then Equation (1) is the representation form of Threshold Autoregressive Model (TAR). If the Heaviside indicator relies on the previous period's change in $\widehat{\varepsilon_{t-1}}$ as Equation (2b), then Equation (1) is the representation form of Momentum-Threshold Autoregressive Model (M-TAR).

3.2.6 Different Varieties of VAR Models (VECMs)

As econometric and time series models developed and evolved, various models have been applied to price transmission such as Vector Auto Regressive Model (VARM)/Vector Error Correction Model (VECM), Threshold VARM/VECM (TVECM), Global VARM/VECM (GVECM), Asymmetric VARM/VECM (AVECM), Panel VARM/VECM (P-VECM) and more recently many other forms of VARM/VECM have emerged.

In summary, based on the characteristics of prices and the research questions to be studied, different time series models can be applied to conduct the dynamic price transmission analyses. The general steps when dealing with time series models are depicted in Figure 3.1 below.

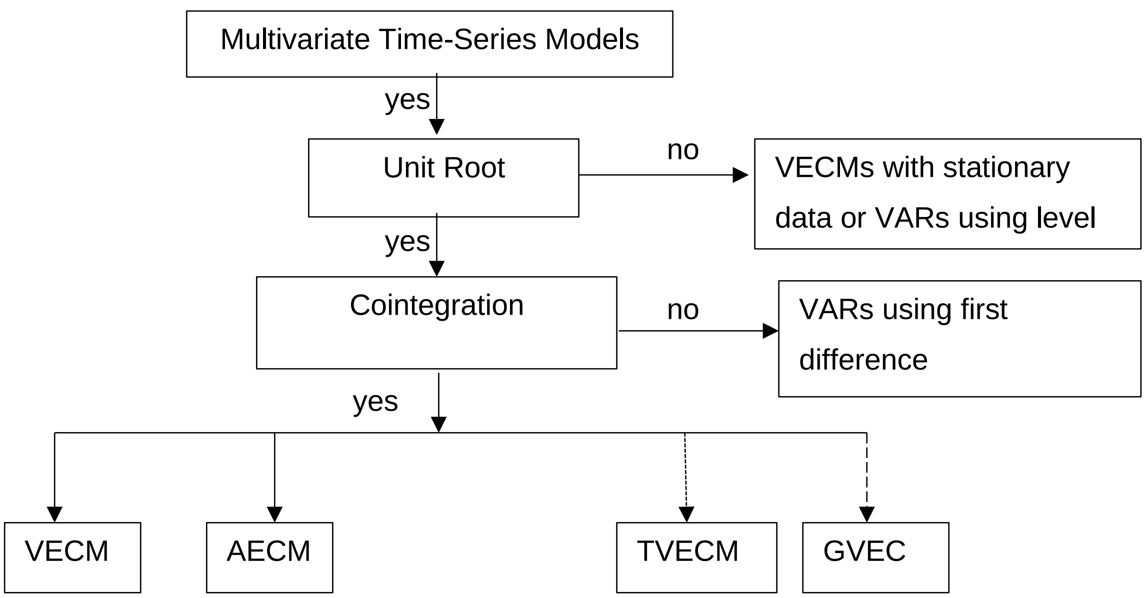


Figure 3.1: Flowchart of steps in conducting time series analysis

3.3 Empirical Analysis of Spatial Price Transmission for Agri-Food Commodities

This section discusses extensive empirical studies on spatial price transmission for agri-food commodities. A summary of the papers reviewed, their modelling approaches, data and main variables is set out in Table I.2 and Table I.3 in Appendix I.

3.3.1 Spatial Price Transmission for Maize

Spatial price transmission in regional and international grain commodity markets, especially for maize, have been widely explored using various approaches. Abdulai (2000) explores price linkages between two local maize markets (Accra and Bolgatanga) and one central maize (Techiman) market in Ghana by adopting threshold cointegration models including Threshold Autoregression (TAR), consistent TAR, Momentum TAR, and consistent MTAR that allows for asymmetric adjustment. He finds that the major maize markets in Ghana are well integrated, that wholesale maize prices in local markets respond more rapidly to price increases in central market, and that different local markets react at different rates to price changes in the central market. Using Markov-switching VAR models, Ihle, von Cramon-Taubadel, and Zorya (2009) estimate maize price transmission between Tanzania and Kenya over the period when export bans were in place and find the existence of two distinct regimes in price margins. They also identify “high” margin episodes with unknown determinants. Myers and Jayne (2011) analyse maize price transmission between South Africa and Zambia by developing a framework that allows multiple equilibria and speeds of adjustment with regime partition based on the magnitude of trade flows between regions. They find no maize price transmission during periods of high imports with government intervention, but higher transmission during periods of low imports when the government was not involved. Abidoye and Labuschagne (2014) compare nested and non-nested models by Bayes factor to explore the co-movement and transmission relationship between South Africa domestic maize prices and global maize prices and find nonlinearity in price transmission with three regimes induced by previous price spreads. They also estimate large long-run deviations in price transmission to South

African maize markets and find that changes in global price transmit to South African export prices at a slower speed than to country’s import prices.

3.3.2 Spatial Price Transmission for Maize Compared to Other Commodities

Studies have compared the spatial transmission of maize prices to price transmission for other commodities, such as wheat, rice, and teff. Threshold cointegration models are employed by Cudjoe, Breisinger, and Diao (2010) to analyse food price transmission between regional markets during a global food crisis in 2007-2008. Their results show that in Ghana import-dependent products such as rice and self-sufficient products such as maize are all highly linked to global prices. They suggest that high levels of transmission exist between regional producer markets and markets in the largest cities which could be explained by distance between producer-consumer markets and the size of consumer markets. Furthermore, an analysis of the impact of price surges on the welfare of different household groups (i.e. consumers) indicates that while the impact appears modest for the country as a whole, the poorest groups are hit hardest due to different consumption patterns. Burke and Myers (2014) employ the threshold single equation error correction model (SEECM) to assess market performance for informal products without regulations with informal trade volumes determining threshold regimes and to understand the mutual influence of maize trade policies and uncertainty of private sector performance in Southern Africa (SA). They explore the long-run relationship between informal maize trade volumes and prices, diesel fuel prices and exchange rates. This reveals that high transfer costs may occasionally hinder informal trade flows. However, the impacts of potential trade constraints is not disruptive and price transmission is swift. Baquedano and Liefert (2014)’s analysis of over 60 country/commodity pairings using a single equation error correction model (SEECM) indicates that consumer markets for wheat, rice, maize, and sorghum in urban centres of the developing countries are co-integrated with world markets. They also estimate that changes in both world prices and real exchange rates are not rapidly transmitted to domestic consumer prices, and if there are shocks to exchange rates, convergence towards equilibrium between domestic and world prices is slow. George Rapsomanikis and Mugera (2011) employ a bivariate Vector Error Correction model (VECM) along with a Generalized Conditional Autoregressive Heteroscedasticity (GARCH) model to figure out the volatility effect of price transmission for selected international food markets (wheat, rice and maize) to

Ethiopia’s domestic wheat market, India’s rice market and Malawi’s maize market. They estimate that prices in Ethiopia and Malawi do not adjust completely to world price changes, while volatility spill-overs are significant only when the world market is extremely volatile. In India, they estimate that prices adjust relatively rapidly, and volatility spill-overs are dampened due to domestic policies. Rashid (2011) examines price relationships across three major cereals (maize, wheat and teff) to assess the relative importance of them in generating price volatility, using a dynamic econometric model. The author finds that markets are well integrated in major grain producing regions, moreover, and maize is the most significant in aggregating price variability regarding persistence of price shocks to itself, wheat and teff. This implies that a focus on maize price is useful to facilitate and reduce the cost of price stabilization. Another finding was that shocks to maize and wheat have long-run effects on each other that are significant at a conventional level, however, these do not transmit to teff markets. Esposti and Listorti (2013) use cointegration and error correction models (ECM) to analyse the cereal prices transmission across different markets and different commodities (i.e., wheat and corn) using Italian and International spot price over a period of agricultural market turbulence. Results from the estimated VECM imply that the price bubble only slightly influences the price spreads, and temporary trade-policy measure, when effective, limits this impact. Zakari, Ying, and Song (2014) assess the degree of price transmission from international and regional markets to Niger domestic grain markets. They find that maize and rice prices in Niger domestic markets adjust faster to world prices than millet and sorghum and respond asymmetrically to negative and positive shocks in regional and international prices.

3.3.3 Spatial Price Transmission for Wheat

Wheat is another commodity extensively investigated in empirical spatial transmission research. Brosig, Glauben, Götz, Weitzel, and Bayaner (2011) use a bivariate threshold vector error correction model (TVECM) with two symmetric thresholds to symbolise transaction costs in their analysis of spatial price transmission in 28 provincial wheat markets in Turkey. The probit regressions show that minimum transaction costs are more likely hinder full market integration in smaller markets, that is, market size is a driving force in market integration and transaction costs. Moreover, they find an inner cluster of highly integrated provinces that can be regarded as one large market and that market integration in peripheral provinces is lower. Ghoshray

(2010) uses a nonlinear exponential smooth transition autoregressive error correction model (ESTAV-ECM) approach to test international price transmission for wheat including export prices for ATP, ASW, U.S. HRW, U.S. SRW, U.S. DNS, CWRS and EU. This study estimates the international wheat market to be highly integrated with all price data analysed in cointegrated pairs. They imply that transaction costs could induce a greater possibility of arbitrage and more deviation in prices, however, large deviations can still be corrected. Qiu and Rude (2016) combine conventional price transmission analysis with copula-based dynamic tail dependence, to examine Ukrainian and global wheat price relationships during periods when markets experienced both export restrictions and price surges. They find that there is no upper or lower tail dependence between global and Ukrainian wheat markets, which indicates that Ukrainian domestic prices are not impacted by large world price shocks. However, the asymmetric price co-movement relationship between domestic flour and wheat prices might change depending on the extent of restrictions on exports.

3.3.4 Spatial Price Transmission for Other Staple Foods

Additionally, spatial price transmissions for other staple foods such as rice, teff and barley have been investigated in recent years. Getnet, Verbeke, and Viaene (2005) utilize an autoregressive distributed lag (ARDL) model to analyse the spatial price relationship between producer and the wholesale prices for a major Ethiopian staple cereal, namely white teff. They find prices in the central market had an impact on local prices in both the short-run and the long-run. However, the adjustment of disequilibrium is relatively slow due to the uncompetitive market structure. Using cointegration tests and error correction models, Hassanzoy, Ito, Isoda, and Amekawa (2015) find the degree of price transmission appears larger in global prices of low-quality rice while the speed of convergence to the long term equilibrium is faster for domestic prices of high quality rice. They also find that a shock to the global prices of low-quality rice might impact domestic prices of low-quality rice for a longer period than for high quality rice. Ganneval (2016) estimates the impact of volatility on market linkages for a homogenous commodity, in a study of rapeseed, corn, feed barley and protein pea French markets. Ganneval finds that in a high volatility regime, price deviations converge to the long-term equilibrium at a faster pace than that in a low volatility regime. Besides, when there are increases in volatility, information in the reference price is more important for commodities with a futures market. Lee and Valera (2016) investigate world rice price transmission and volatility spill-overs in six major Asian rice markets. A panel GARCH framework was utilized to estimate the spill-over effects considering heterogeneity and interdependence among countries. They estimate that both the price levels in domestic rice markets and their conditional variances are influenced by changes in world rice prices. Spill-over of price shocks in one country to another within that region is strong due to linkages among rice markets.

3.3.5 Spatial Price Transmission for Meat

For meat commodities, the pork and lamb markets in the European Union (EU) single market scenario have been studied to analyse the degree of market integration in the EU. Sanjuán and Gil (2001) use VECM with impulse-response functions (IRF) and the forecast error variance (FEV) decomposition to study spatial price relationships for pork and lamb in the EU over the period 1988 to 1995. In the EU, pork and lamb markets are integrated in both the short- run and in the long-run, despite the more efficient price transmission in pork markets. They conclude that removal of trade barriers to achieve a Single European Market by 1993 triggered intense trade flows for pork within the EU, resulting in a high efficiency and degree of integration in pork markets. Later, Serra, Gil, and Goodwin (2006) use both non-parametric regressions and non-linear threshold models for data on weekly pork prices in four leading EU pork producer and trading countries (i.e. Germany, Spain, France and Denmark) over the period of 1994 to 2004, and find that pork prices are transmitted in separate EU markets but adjusted asymmetrically following introduction of the EU single market in 1993. A range of price differentials where equilibrating price adjustments are less intense is also implied by both methods. They compare the results from non-parametric techniques (LLR) and parametric threshold models (TAR), with LLR implying a stronger linkage of pork prices either through information or trade flows and find LLR is better in capturing the true speed of price changes for out-of-band price differentials.

3.3.6 Spatial Price Transmission for Vegetables

Spatial price transmissions for vegetables, especially those traded frequently, have also been explored. Stephens, Mabaya, Cramon-Taubadel, and Barrett (2012) employ generalized reduced rank regression (GRRR) techniques with semi-weekly price and trade flow data to study the spatial price transmission of tomato markets in Zimbabwe in trade and non-trade. They find that the adjustments are larger and more rapid in non-trade periods, and markets are efficient in transmitting market signals spatially via price adjustment dynamics. Santeramo (2015) uses asymmetric threshold autoregressive econometric model to study the characteristics of spatial price movement for tomato and cauliflower and estimate transaction costs and speed of spatial price transmission. The author finds that prices are asymmetrically transmitted in most of the European country pairs studied and concludes that tomato and cauliflower markets are not efficient.

3.3.7 Spatial Price Transmission for Agricultural Commodity Price Indexes

Recently, agricultural commodity price indexes have become the main variables to examine the essence of spatial price transmission. Ianchovichina, Loening, and Wood (2014) utilize threshold regressions to analyse international and domestic price index movement transmission for 18 countries in the Middle East and North Africa. Price transmission from international to domestic markets is mostly asymmetric and increases in international prices would be transmitted to domestic prices. However, declines in international prices were merely transmitted. McLaren (2015) constructs OLS and 2SLS models with instrumental variables (IVs) including a count variable of the number of climatological or meteorological events in other countries to explore asymmetries in price transmission from international to local markets, using unbalanced panel export and producer price data for 161 items, and from 117 countries. Mclaren estimates that there is stronger price transmission when international prices decline than when they rise due to demand-side market powder. García-Germán, Bardají, and Garrido (2016) use error correction models (ECM) to estimate the degree and speed of impact on world agricultural commodity prices (IMF index, Import-weighted ECB index, and Use-weighted ECB index) movements in consumer food prices (unprocessed food harmonized index of consumer prices (HICP)) in European Union member states and find a long-run relationship between world agricultural commodity and consumer food prices in over half of EU member states . Because the empirical analysis reveals different responses to specific world price indices in different member states and to the different corresponding categories, they conclude that the structure and the efficiency of food markets vary in different categories of member states with lower transmission elasticities in general among eurozone founding countries.

3.3.8 Price Transmission Analysis in the Dairy Industry

The external policy and market environment facing the global dairy industry is constrained by various factors, such as a changing market structure following the removal of EU milk production quotas, CAP reforms, and WTO negotiations to facilitate and promote free multilateral and global trade; increasing global demand for milk and dairy products due to changing dietary pattern s and economic growth in emerging countries; domestic and external economic policy uncertainties; and a changing global industry structure for major dairy exporters and importers. Spatial patterns in the dairy market can be entangled with price behaviour and determination (P. L. Fackler & B. K. Goodwin, 2001), and analysing spatial price transmission can provide insights into market performance, which in turn has implications for policy and market development.

Although extensive empirical studies were conducted on spatial price transmission for various agri-food commodities, spatial price transmission analysis for dairy commodities is relatively rare. Using Asymmetric Error Correction Models (AECM) to analyse price dynamics between global and domestic milk markets, Acosta, Ihle, and Robles (2014) find that price fluctuations in global markets are transmitted to domestic markets in Panama at a lower magnitude and is asymmetric that the transmission speed is faster when there are increases in global prices than deceases. Fousekis and Trachanas (2016) explore asymmetric spatial price linkages at monthly wholesale levels in skimmed milk powder markets of three major exporters (the U.S.A., the EU and Oceania) using nonlinear autoregressive distributed lag model. Also, nonparametric kernel-based and time-varying copulas are employed to assess the level of integration of the international skim milk powder (SMP) market and the co-movement of monthly SMP prices among the US, EU and Oceania markets (Fousekis, Emmanouilides, & Grigoriadis, 2017). Bergmann, O’Connor, and Thümmel (2016) apply vector autoregression models combined with a multivariate GARCH model to capture price transmission effects, and find strong price and volatility transmission effects between EU and global butter prices, further spill-over of EU butter shocks to palm oil volatility, as well as evidence indicating spill-over of oil prices to global butter prices and volatility. These studies are solely concerned with prices for a single product in different countries to investigate market integration or solely concerned with prices in a single country (region) to investigate price transmission from international to domestic markets.

Much attention has been paid to price transmission along the supply chain in the dairy sector, to identify welfare issues for producers and consumers, and market power. Kinnucan and Forker (1987) were the first to estimate four major dairy products, namely fluid milk, butter, cheese, and ice cream, and find that retail dairy product prices adjust more rapidly and more fully to increases in the farm price of milk than to decreases. Serra and Goodwin (2003) analyse a variety of dairy products in Spain using Asymmetric threshold vector error correction models and find asymmetries affect a noticeable share of raw milk processed in Spain. Bonnet, Corre, and Réquillart (2015) use a flexible demand model, a random coefficients logit model, and several models for vertical relationships within the industry to study static price transmission in vertically related markets and assess the effect of changes in input prices on consumer prices using data on pricing strategies of manufacturers and retailers in the food supply chain. Using state space structural time series models, Nicholson and Stephenson (2015) assess the nature of cyclical behaviour on the quarterly U.S. all-milk price and identify a period of 3.3-year price cycles with feed costs as an exogenous regressor.

However, as major dairy exporters such as European Union member states (including Ireland, Germany, and the Netherlands), or the U.S and New Zealand adjust their strategies and targeted dairy export markets, the global dairy market has become more interactive, competitive and complex. Moreover, a large share of dairy products production in these major dairy producing countries are aimed at export. Therefore, understanding spatial price dynamics, such as the interlinkage between domestic and export prices between different exporters and their interaction with other factors, is vitally important for the effective development of relevant policies, for the welfare of producers and industry practitioners. It is also important for the prosperity and future development of the dairy industry and trade.

3.4 Empirical Application of Global Vector Autoregressive Model

Although there is voluminous research on price transmission in the food industry, or more specifically, in the dairy industry, little of this research is concerned with commodity price transmission and dynamic interactions with other influencing factors such as energy prices, substitutes prices, input prices, macroeconomic factors such as CPI, exchange rates, etc, in international trade markets, particularly relating to the dairy export market. One of the main reason for gap in the research is the restrictions of economic theoretical models and difficulty with large numbers of parameter estimations. The Global Vector Autoregressive (GVAR) model proposed by M. Hashem Pesaran, Schuermann, and Weiner (2004) provide a relatively simple but effective way to analyse interactions in a high-dimensional system that can study time series variable interlinkages across sections and over time. Since then GVAR models have been widely applied in various economic areas (see Chudik and Pesaran (2016) for comprehensive surveys), for example: studying factors and shocks affecting global inflation (Anderton, Galesi, Lombardi, & Mauro, 2010; Lombardi, 2009), global imbalance (Bettendorf, 2017; Matthieu, Alexander, & Arnaud, 2013), impact of EMU membership (Dubois, Hericourt, & Mignon, 2009; Hashem Pesaran, Vanessa Smith, & Smith, 2007; L. V. Smith & A. Galesi, 2014), house price and crisis (Jannsen, 2010; Vansteenkiste & Hiebert, 2011), effects of fiscal and monetary policy (Favero, Giavazzi, & Perego, 2011; Feldkircher & Huber, 2016; G. Georgiadis, 2015; G. Georgiadis, 2016; Hebous & Zimmermann, 2013) credit supply shock (Eickmeier & Ng, 2015; Konstantakis & Michaelides, 2014; Xu & T.T, 2012), spillovers in the labour market (Hiebert & Vansteenkiste, 2010) and business cycle synchronization and the rising role of China in the world economy (Boschi & Girardi, 2011; Cashin, Mohaddes, & Raissi, 2012; Cesa-Bianchi, Pesaran, Rebucci, & Xu, 2012; Dreger & Wolters, 2011; Feldkircher, 2015; Feldkircher & Korhonen, 2014; Greenwood-Nimmo, Nguyen, & Shin, 2012; Y. Sun, Heinz, & Ho, 2013), etc. In the agri-food economic area, Gutierrez, Piras, and Paolo Roggero (2015) establish a GVAR model for global wheat export prices to analyse the linkage between food commodity prices, energy prices and financial sectors in major wheat exporting countries. Research by Gruss (2014) using a GVAR model to analyse output growth in phenomena that commodity prices have been stable since mid-2011 after incredible booming, suggests growth in future years for the average commodity exporter in the region could be significantly lower than during the commodity booms in Latin America and the Caribbean. Moreover, there have been an increasing number of studies on oil prices as an import factor influencing global commodity prices. Chudik and Fidora (2012) and Cashin, Mohaddes, Raissi, and Raissi (2014) construct the identification of global oil shocks and sign restriction for identification, also identify totally different consequences from two types of shock. Besides oil prices, weather shocks are also explored to examine the exogenous impacts on economic performance. They find that different countries responded in an opposite manner to El Nino weather shocks with the US and the EU experiencing growth-enhancing effects while countries such as Australia, Chile, Japan and South Africa experienced a short-run decline in economic activity.

Therefore, the GVAR model as a high-dimensional cross-sectional time series model with little reliance on economic theory and restrictions is a good model to analyse spatial commodity price transmission and to identify the impacts of various shocks and determinants in a visual way.

3.5 Trade Patterns and Determinants in Global Agri-Food Commodity Prices

Considerable research and theory have been developed to explain and predict the co-movement of global commodity prices. Research on market integration and price transmission has applied different methodologies and highlights several factors hindering the passing on of price signals and affecting price transmission in agricultural commodities. Major factors widely investigated include: exchange rate policies that insulate international and domestic markets and exchange rate fluctuations that hinder price transmission, energy price volatility that affects agricultural commodity prices through cost-effects and supply-effects, food inflation, agricultural policy instruments and interventions, such as price support schemes that distort market mechanisms, import tariffs, tariff rate quotas, and export subsidies or taxes.

3.5.1 Macroeconomic Factors

Exchange rate changes are an important factor influencing export prices of agricultural commodities with Schuh (1974) referring to exchange rates as major determinants of agricultural trade flows. Considerable research has been conducted since then to explore the relationships between exchange rates and export flows and prices. Naseem, Tan, and Hamizah (2008) empirically investigate the effects of real exchange rate misalignment and volatility and find they had an important role on Malaysian flows of exports especially during the 1997 Asian financial crisis. While Serenis and Tsounis (2014) use VECM to find a significant negative relationship between aggregate exports and exchange rate volatility in three South American countries. Arize, Malindretos, and

Kasibhatla (2003) find that increases in exchange-rate volatility exert a significant negative effect on export demand in both the short-run and the long-run in most of the LDC countries studied. These effects may result in significant reallocation of resources by market participants. Pino, Tas, and Sharma (2016) study emerging economies in Asia including Indonesia, Malaysia, Republic of Korea, Singapore, Thailand and the Philippines and find the effect of exchange rate volatility on export flows is predominantly negative in the long run, while the effect in the short run is mixed. This implies that reducing volatility is beneficial for increasing exports. Davidson, Halunga, Lloyd, McCorriston, and Morgan (2016) employ a seven variable co-integrated vector autoregressive (C-VAR) framework that accounts for a wider range of factors to determine domestic food inflation. By using impulse response functions and a variance decomposition approach, they find that not only world agricultural prices, but also exchange rates and oil prices are important determinants of food prices, with the latter two emerging only in long run. They also find that dynamic characteristics of both the level and duration of “spike” affect inflationary effects.

3.5.2 Energy Commodity Prices

Energy commodities increasingly connected to the agricultural commodities are recognized as a key factor affecting agri-food commodity trade flows and prices. From supply side cost channels, including inputs such as transportation and production, the prices of energy commodities such as gasoline, electricity and so on will affect costs in agri-food commodities, and thus to a large degree will destabilize their prices. Another channel is the more recent biofuel production boom, based on food crops, which tightens the relationship between agri-food commodities and energy prices. As Piesse and Thirtle (2009) suggest, with fixed farmland supply, producing more products for biofuel will reduce land available for other commodities. Considerable research has been conducted to analyse price transmission and interlinkages in biofuel-related markets and mainly found that energy prices drive long-run agricultural price levels, while some studies of price volatility conclude that instability in energy markets is transferred to food markets, with more intensive spill-overs since the start of biofuel production in the 2000s (See Serra and Zilberman (2013) for a comprehensive literature review). While Dillon and Barrett (2015) empirically investigate oil price impact on local maize prices and conclude that global oil prices transmit much more rapidly to local maize prices than do global maize prices, implying that immediate effects of correlated commodity price shocks on local food prices are driven more by transport costs.

3.5.3 Agricultural Supply and Demand Shocks

The price of a commodity is determined as a function of its market as a whole, by the interaction of market demand and market supply. Policy imposed on the industry can greatly influence both the supply- and demand-side, especially for commodities that are traded domestically and internationally. In earlier studies, pricing-to-market models (Dornbusch, 1987; Froot & Klemperer, 1988; Krugman, 1986) suggest that non-competitive behaviour can hinder market integration. The models assume that to maintain market share in their export markets, firms will alter export prices, measured in local domestic currency, to absorb some of the fluctuation in exchange rates. Besides, differences between international and domestic prices might remain at higher levels than those determined by transfer costs because of oligopolistic behaviours and collusion among domestic traders. Recently, research on the removal of the EU CAP milk quota and other CAP reforms have shed light on demand and supply side of dairy products. Lips and Rieder (2005) find that abolition of dairy quotas and the removal of dairy product price support in the EU has a relatively minor effects on the EU and the Rest of the World. The output changes for raw milk are heterogeneous within EU member countries, with Ireland increasing dramatically, less expansion of Denmark, Italy, Luxembourg, the Netherlands and Spain, and declines for Germany, Greece, Portugal and Sweden, and a small quantity of change for all other member countries. Bouamra-Mechemache et al. (2008) find that, by 2014–2015, the market effects of abolishing quotas are similar to a 2 per cent gradual quota increase. Starting in 2009 they analyse the impact of gradual but significant increases in EU milk quotas and discuss the implications of different changes in allocation of milk quotas, compared with the status quotas agreed in the 2003 Common Agricultural Policy reform. Kempen, Witzke, Domínguez, Jansson, and Sckokai (2011) compare the results of a milk quota reform scenario (year 2020) and a baseline situation (2020 with quotas in place) with simulation. Their results indicate that the abolition of the milk quota regime is likely to increase milk production on average by 4.4% in the EU27, and to a decline in raw milk prices of -10%. Agricultural income would decline on average by 1.6% since increasing production cannot compensate for lower milk prices.

3.6 Summary, Discussion and Proposals for Future Work

Price transmission characteristics such as co-movement, dynamics of price adjustment, asymmetry in transmission speed, magnitude and direction could shed light on the degree of market integration, welfare of stakeholders and evaluation of policy reforms. Understanding the essence of dairy price transmission is a vital cornerstone to provide policy prescriptions and market strategy adjustments for development and international trade in the dairy sector. Although spatial price analysis has a history of over a hundred years, the study of dairy price transmission among geographically separated markets and the underlying determinants is still young and limited compared to price transmission analysis for other agricultural commodities. Some gaps are found in this literature review and it is worth exploring spatial price transmission in more depth for different spatial levels. These gaps and future research direction are summarized as follows:

(a) In the international dairy market, especially at the disaggregated product level, dynamics of export prices and their responses to market shocks haven’t been explored yet, especially shocks to external factors such as energy prices, exchange rates, substitutes prices and domestic economic contexts.

(b) Although price transmission between major players for some dairy products, such as skim milk powder, have been studied to explore market integration, comparative analyses of performance and price transmission for different dairy exporters in major dairy export destination markets, such as China, haven’t been researched yet. The focus of existing research is mainly on one country or on the prices for one product across several countries, with limited implication for the literature, policy and markets.

(c) Milk price transmission along the supply chains in different countries has been relatively widely studied recently. However, many countries that have a large quantity of milk production are export-oriented and most of their produced raw milk is processed to make other dairy products such as milk powder, butter and cheese. So, analysing price transmission along the supply chain with only farm-gate, wholesale and retail prices may not accurately estimate the welfare loss for suppliers and consumers or decipher market power and price leadership. So, the existing literature cannot provide much insightful information and guidance for the international trade of dairy products. Export prices should be incorporated into price transmission analysis, to better understand market mechanisms and evaluate policy for the dairy sector.

The current global dairy market has encountered a phase of transformation, structural change, and policy shocks, especially in European countries. The global demand for dairy products, especially milk powers such as skim milk powder, whole milk powder and infant formula, has soared and will continue to increase in the future. Export markets will be more vibrant, competitive and strongly connected. The current global dairy market is dominated by a few major exporters. In international dairy trade, imperfect competition exists and there is an oligopoly market structure or even a monopoly market structure in specific import markets. It is necessary to conduct comprehensive analyses on the spatial price transmission and investigate the influencing factors on price dynamics. Understanding the pattern of prices will facilitate an understanding of dairy market mechanisms, and therefore provide policy advice for exporters to enhance their performance in global dairy market.

Chapter 4 Spatial Price Dynamics and Asymmetric Price Transmission in Skim Milk Powder (SMP) International Trade: Evidence from New Zealand and Ireland

4.1 Introduction

In recent years, policy changes and market volatility in dairy markets in the European Union (EU) have brought greater challenges, as well as incentives, for EU policymakers and dairy exporters to expand to broader international markets (DAFM, 2015; European Commission, 2014).[46] Meanwhile, China has increasingly become a key international market destination for dairy exporters across the globe, attributing to its discontinuation of the universal “one-child” policy, rising demand from the middle class, embracing of westernized food consumption patterns, and issues of consumers’ trust for domestic dairy safety post major infant milk powder scandals (Fuller, Beghin, & Rozelle, 2007; He, Yang, Xia, Zhao, & Yang, 2016; Rae, 1997; Rutherford, 1999; Shono, Suzuki, & Kaiser, 2000; Zhou & Wang, 2011). As a result, in the last five years, rapid expansion has been seen from major EU dairy exporting countries to the Chinese market.[47]

However, competing for the Chinese market is no easy task for EU dairy exporters facing strong competition from other international players. In particular, New Zealand (NZ), a major dairy exporter in the Southern Hemisphere, has been a dominant player in China’s dairy market accounting for 57.3% of its total dairy imports, thanks to its strong export orientation, close geographic proximity, and its free-trade agreement with the Chinese government.[48] The intensification of the trade facilitation strategies is expected to further stimulate the price transmission and market integrations. However, in increasingly integrated world markets, intensified market competition heightened price volatility, causing further risks for the dairy industry (RA Jongeneel et al., 2010). While at the same time, Irish dairy export is facing uncertainties with new opportunities

[46] Some major policy changes and market volatility include the abortion of the EU milk quota, the Russia ban on the EU’s dairy products, Brexit, and the Euro exchange rate fluctuations, etc.

[47] Denmark and the Netherland experienced 133% and 26% increases in the export of condensed milk [The Harmonized Commodity Description and Coding System (HS code): 0402] to China, respectively. Data source: OEC.

[48] Data source: OEC. HS Code: 0401, 0402, 0403, 0404, 0405 and 0406.

and challenges due to the Brexit and dairy quota abolition: (1) the possible Non-Tarif Barriers to trade (NTBs) and market loss for the UK market; (2) the increasing of milk production and the intensive milk powder investment would cause the product surplus that needs to be exported to new markets. In the near future, the Chinese market for SMP will become more important and competitive with the anticipation of the SMP market integration that would be determined by several factors. Firstly, the deepening and the ongoing bilateral and multilateral trade agreements. For instance, the China-New Zealand Free Trade Agreement, the Asia-Pacific Economic Cooperation (APEC) and WTO negotiations. Secondly, the efforts of the major SMP importers such as China to boost the domestic dairy industry and build up the consumer confidence in domestic milk powder products. Thirdly, the predictable and strategic market extensions for EU dairy exporters after milk production quota abolition. For example, Ireland has turned its focus on the Chinese markets and try to establish an Irish dairy products image named as Origin Green (e.g., healthy, “green”, sustainable that inherent to Irish dairy sector) to Chinese consumers who have increasing demand for dairy food but are still affected by the trauma of domestic milk powder safety disasters thereby enhancing the premium milk powder products export to China (DAFM, 2015). Thus, for dairy exporters, policymakers and economists, a better understanding of the price dynamics and linkages among geographically separated markets (aka, spatial price transmission) is of crucial importance to facilitate trade policies, investment decisions, and export management.

Spatial price dynamics and transmissions of food commodities have been extensively explored in the literature over the years. According to the Law of One Price (LOP), the price for commodities in efficient and undistorted international trade markets acts as the primary mechanism to link various regions, subject to the costs associated with space, time and various marketing activities (Asensio, González, García, & Martín, 2008; P. Fackler & B. Goodwin, 2001). In reality, the LOP may no longer hold due to the presence of various factors (such as transaction costs, trade policies, and market power) that constrain the pass-through of price signals from one market to another.[49] Therefore, different econometric models have been developed and applied to study the asymmetric spatial price transmissions to explore market integrations and price dynamics. Despite the amount of literature available on spatial price transmission,

[49] see Meyer and von Cramon-Taubadel (2004) for a comprehensive review on this topic.

timely studies that incorporate the increasing scales of international market integration and capture the changing price dynamics for key export commodities in specific markets are much needed. In particular, there has been no empirical study that explicitly explores the asymmetries in price transmission of two competitors in a special market, such as the Chinese market. The proposed study aims to fill this literature gap.

The objective of the chapter is to investigate the spatial price transmission relevant to international dairy competitors in China, aiming to decipher the underlining dynamics and potential interactions of the price movements. Given New Zealand (NZ)'s dominant position and the changing market landscapes following the fast growth from EU dairy exporters, this investigation on the price dynamics between the dominant player (NZ) and the newer player is focused on identifying the price leadership. Ireland is chosen as the representative new market entrant in this study, due to the fact that the Irish dairy industry is highly export-oriented (with more than 80% of its dairy products exported and consumed overseas every year) and China has become its second largest export market since 2014 (Bord Bia, 2018; DAFM, 2015).[50] The study also examined the asymmetry in the export prices transmission for New Zealand and Ireland in the world and in the Chinese markets, thus to identify the market integrations and market power of central market. The empirical analysis of the price dynamics will provide insights and policy implications to other EU and international dairy exports facing relevant situations.

Among various dairy products, SMP is chosen as the product in this study for the following reasons: (a) The vital export position of SMP in the world. [51] (b) China is heavily dependent on imported SMP and has been a key importer of SMP in the global market. [52] (c) In principle, the price dynamics of SMP formed by different exporters

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[50] To some extent, New Zealand and Ireland share similar natural endowments for dairy but with distinctive operations and trade patterns.

[51] SMP has remained the third largest internationally traded dairy commodity (after whole milk powder and cheese) in recent years in terms of trade weight and also the highest traded commodities in terms of share of net exports in total production (OECD-FAO, 2015). It is a vital commodity besides butter that is sustained by stocks and interventional price policies in major dairy exporters such as the EU and the United States (US). Substantial amounts have been invested in the European dairy sector to powder drying facilities for export markets, and the SMP production in 2024 is expected to reach 1.6 million tonnes, driven by strong global demand (European Commission, 2014). In addition, heightened trade frictions between the US and China at the current stage may lead to greater opportunities for the EU exporters in the Chinese market.

[52] See section 4.2 for more details on this.

could be linked to each other because of the market integration and the substitution effect between two homogenous products (Keane & O'Connor, 2009; Phlips, 1962).

The rest of the chapter is organized as follows. Section 4.2 detailed China's SMP imports, with a special focus on the export situation of New Zealand and Ireland. Section 4.3 presents the methodology and the empirical models for spatial price relationships. Section 4.4 reports the empirical results on the export prices dynamics of New Zealand and Ireland. Section 4.5 presents additional evidence and interpretation on export prices linkages and volatilities. Lastly, Section 4.6 concludes and discusses the study.

4.2 Imported SMP Market in China

In this section, an overview of China's SMP market and its potential growth is present. The growth and development of the SMP export of New Zealand and Ireland in recent years is explained, with a special focus on the expansions in their export of the SMP in the Chinese markets.

China as a key importer of several dairy products has become the arena of major dairy exporters, especially for SMP. In 2018, imported skim milk powder accounted for approximately 93.34%, while domestic production accounted for only 6.66% (OECD-FAO, 2018[53]).

The future perspective of China's SMP imports is promising for the following reasons: (a) The main consumer groups for skim milk powder in China (children and senior citizen in urban areas) have been growing. The population group aged between 0-14 has increased by 5.68% between 2010 and 2018, and the population group aged over 65 has increased by 40.05% between 2010 and 2018. In China, skim milk powder which contains low fat has been promoted to add nutrition and keep healthy for older populations and is a base product for production of infant milk formula. In 2016, the Chinese government announced the abortion of "one-child" policy (allowing two children), and the country has seen a surge of newborn babies in the last two years.[54] (b) The increase in milk demand is greater than the growth of the domestic milk

[53] Dataset: OECD-FAO Agricultural Outlook 2019-2028
[54] Estimated by using the data from National Bureau of Statistics of China

production (Elizabeth Gooch, 2017). As China's national statistics illustrates, the milk production has increased by 17.58%, while the urban population experienced an increase of 32.30% from 2006 to 2015. (c) E-commerce platforms in China such as Alibaba Tmall, and JD.com with oversea shopping channels have facilitated the change in the shopping habits of Chinese consumers and enabled households in every part of China to buy imported products online, which has greatly boomed foreign milk powder imports (Wang, 2014; Zhou & Wang, 2011), and (d) Shattered consumer confidence following the severe food safety incidents (such as the 2008 milk scandal incident) has resulted in a tendency for Chinese consumers (especially urban consumers) to prefer imported products (Jia, Huang, Luan, Rozelle, & Swinnen, 2012; Pei et al., 2011; Zhou & Wang, 2011).

New Zealand is the dominant player in the Chinese SMP market accounting for 57.3% of China's total dairy import in 2014. [55]The dairy sector has been the largest goods export sector in New Zealand and its export has been trended upward over the past two decades (John & Daniel, 2017). The 2008 bilateral China-New Zealand Free Trade Agreement (FTA) gradually reduces tariffs on dairy products to zero with milk powders phased out by 2019. Favourable trade policies, ongoing development of a global network of New Zealand Dairy Board, and Fonterra subsidiaries overseas make New Zealand's dairy sector more competitive in its export markets (DCANZ, 2018). Recently, the SMP imports of China from New Zealand have grown rapidly since 2008 and has reached the peaks in 2014, following which the imports quantity had dropped mainly due to high SMP stocks in China.

Compared to New Zealand, Ireland is a much smaller player in the Chinese SMP market. The market share of Irish SMP in the Chinese market accounts for 2.26% of China's total SMP import value in 2016. [56] As a member of the European Union having access to the corresponding favourable trade policies, traditionally Irish dairy export commodities were mainly destined for the UK and other European markets. In 2016, Ireland's SMP export value to China only accounts for 5.72% of its total SMP exports. However, with the abolition of EU milk production quota in 2015, Ireland is expected to

[55] NZIER. (2014). QuickStats about Dairying-NEW ZEALAND. New Zealand Institute of Economic Research, New Zealand.
[56] Estimated by using the data from UN Comtrade

see a 50% milk production increase by the year of 2020.[57] Meanwhile, Brexit imposed great level of uncertainty and risks to the UK market. As an export-oriented country with more than 80% of its dairy products exported overseas, fast expanding to alternative international market destinations is crucial to the Irish dairy industry. Under such situation, China has become an increasingly important strategic market for Ireland with fast growth of market share since 2012 (Bord Bia, 2018; DAFM, 2015).

Nowadays, New Zealand's dominant position in China's dairy import market is likely to be challenged by the dairy exporters from the European Union (EU) through intensified market competition. The fast-changing international market landscape has demanded better understanding of the spatial price dynamics in this key international market.

4.3 Methodology, Empirical Models, and Data

Price dynamics and transmission between two geographically separated exporters in a specific market can display various patterns due to the different market integration level (Fousekis et al., 2017; Fousekis & Grigoriadis, 2017; Goodwin & Piggott, 2001), market scenarios (Abdulai, 2000), and policy uncertainty (Listorti & Esposti, 2012). Over the years spatial price dynamics and transmissions of food commodities have been extensively explored in the literature, with different econometric models being developed and applied to empirical studies: Abdulai (2000) utilizes the threshold cointegrating models to reveal the asymmetric market signals transmission and responses between central and local maize markets. The switching regime VECM model employed by Goodwin and Piggott (2001) investigates the price linkages among different corn and soybean regional markets in North Carolina. The non-parametric regressions and non-linear threshold models have been compared to estimate the asymmetric price adjustments in spatially separate pig markets within EU (Serra et al., 2006). Nonlinear autoregressive distributed lag model, as well as nonparametric kernel-based and time-varying copulas, are employed to assess the asymmetric spatial price linkages and market integration and co-movement of monthly skimmed

[57] Food Harvest 2020: A Vision for Irish Agri-food and Fisheries. Department of Agriculture, Fisheries & Food, Ireland, 2010. Accessed at: https://www.agriculture.gov.ie/publications/2011/annualreviewandoutlookforagriculturefisheriesandfood20102011/nationaldevelopments/foodharvest2020/

milk powder (SMP) prices among the US, the EU and Oceania markets (Fousekis et al., 2017; Fousekis & Trachanas, 2016).

This section explained relevant methodologies including both the linear and non-linear cointegration models, including Error Correction Model, and four types of Threshold models (Enders & Siklos, 2001; Engle & Granger, 1987; Tong, 1983), and how they can be employed in our study to empirically address the SMP export price transmissions dynamics for Ireland and New Zealand.

4.3.1 Linear Cointegration Analysis

The Granger-Engle cointegration model named after Engle and Granger (1987) is a two-step procedure for cointegration analysis to solve the problem of spurious regression. The way of detecting the cointegrating relationship is to first establish a long-run equilibrium equation first and then to test the stationarity of the residuals derived from the acquired equation.

Step 1: The Granger-Engle long-run equilibrium equation for two variables could be constructed as Equation (1), whose parameters can be estimated by Ordinary Least Squares (OLS) regression.

$$Y_t = \alpha_0 + \alpha_1 X_t + \varepsilon_t \qquad (1)$$

Where α_0 and α_1 are coefficients, ε_t is the error term.

Step 2: An Augmented Dicken-Fuller (ADF) test (Dickey & Fuller, 1979) was performed on the residuals $\widehat{\varepsilon_t}$ to determine whether the residuals are stationary. If so, then the two nonstationary variables of I (1) can be regarded as cointegrated. To be more specifically, the number of lags was selected by Akaike Information Criterion (AIC), Bayesian Information Criterion (BIC), or Ljung–Box Q test to ensure that there is no serial correlation in the regression residuals, that is, the residuals μ_t in Equation (2) could be considered as a white noise. Therefore, if the null hypothesis of ρ = 0 is rejected, it can be concluded that Y_t and X_t are integrated.

$\Delta\widehat{\varepsilon_t} = \rho\widehat{\varepsilon_{t-1}} + \sum_{i=1}^{p}\Phi_i\Delta\widehat{\varepsilon_{t-\iota}} + \mu_t$ (2)

Where ρ and Φ_i are coefficients, μ_t is a white noise with zero mean and constant variance, which is identically and independently distributed, Δ is the first difference indicator, $\widehat{\varepsilon_t}$ is the estimated residuals and p represents the lag orders.

4.3.2 Non-Linear Cointegration Analysis

The threshold autoregressive (TAR) model proposed by Tong (1983) facilitates the capture of the "deep" movements in a series and to investigate whether the troughs in the series are more persistent than the peaks or vice versa. Therefore, the TAR approach was employed to uncover the SMP export price relationships among the average global markets and regional market, or among the different exporters in the same market, in the assumption that exporters only act to move back to an equilibrium when the deviation from the equilibrium exceeds a critical threshold. That is, only when the benefits of this adjustment exceed the costs will the prices adjust. Besides, the asymmetries in the price adjustments manner to positive or negative deviations can be obtained through the TAR model.

Alternatively, Momentum-Threshold Autoregressive (M-TAR) Model could capture the attempting to mitigate or eliminate large changes in a series. If $|\rho_1| < |\rho_2|$, a negative realization of $\widehat{\Delta\varepsilon_{t-1}}$ decays faster than the positive one, then the increases tend to persist, whereas decreases are sharper and more significant, thereby tending to converge rapidly towards the equilibrium. This pattern would be reversed if $|\rho_1| > |\rho_2|$.(Enders & Granger, 1998; Enders & Siklos, 2001)

Equation (2) can be written in an alternative specification as

$\Delta\widehat{\varepsilon_t} = \rho_1 \mathrm{I}_t\widehat{\varepsilon_{t-1}} + \rho_2(1-\mathrm{I}_t)\widehat{\varepsilon_{t-1}} + \sum_{i=1}^{p}\varphi_i\,\Delta\widehat{\varepsilon_{t-\iota}} + \mu_t$ (3)

where I_t is the Heaviside indicator function that can be set as following equations:

$I_t = 1\ if\ \widehat{\varepsilon_{t-1}} \geq\ \tau\ , 0\ otherwise; or$ (4a);

$I_t = 1\ if\ \widehat{\Delta\varepsilon_{t-1}} \geq \tau, 0\ otherwise$ (4b)

and τ is the value of the threshold, μ_t is the identically and independently distributed white noise with mean zero and constant variance. If the Heaviside indicator depends on the level of $\widehat{\varepsilon_{t-1}}$ as indicated in Equation (4a), then Equation (3) is the representation form of the Threshold Autoregressive Model (TAR). If the Heaviside indicator relies on the previous period's change in $\widehat{\varepsilon_{t-1}}$ as Equation (4b), then Equation (3) is the representation form M-TAR Model.

4.3.3 Asymmetric Error Correction Model with Threshold Cointegration

Provided that there is only one cointegrating relationship in the form of Equation (1), the Asymmetric Error-correction Models with Threshold cointegration can be constructed as the following specifications.

$$\Delta X_t = \theta_X + \delta_X^+ \mathrm{E}_{t-1}^+ + \delta_X^- E_{t-1}^- + \sum_{j=1}^{J} \alpha_{X_j}^+ \Delta X_{t-j}^+ + \sum_{j=1}^{J} \alpha_{X_j}^- \Delta X_{t-j}^- + \sum_{j=1}^{J} \beta_{X_j}^+ \Delta Y_{t-j}^+ + \sum_{j=1}^{J} \beta_{X_j}^- \Delta Y_{t-j}^- + \vartheta_{X_t} \quad (5a)$$

$$\Delta Y_t = \theta_Y + \delta_Y^+ \mathrm{E}_{t-1}^+ + \delta_Y^- E_{t-1}^- + \sum_{j=1}^{J} \alpha_{Y_j}^+ \Delta X_{t-j}^+ + \sum_{j=1}^{J} \alpha_{Y_j}^- \Delta X_{t-j}^- + \sum_{j=1}^{J} \beta_{Y_j}^+ \Delta Y_{t-j}^+ + \sum_{j=1}^{J} \beta_{Y_j}^- \Delta Y_{t-j}^- + \vartheta_{Y_t} \quad (5b)$$

Where ΔX and ΔY are driving price and dependent price in first difference respectively, α, β, δ are coefficients, and ϑ is the error term. The subscribes t and j indicate time and lags, respectively. In Equations (5a) and (5b), the positive and the negative variables were subjects to the following example Equations:

$$\Delta X_{t-j}^+ = \begin{cases} X_{t-j} - X_{t-j-1}, & if\ X_{t-j} > X_{t-j-1} \\ 0, & if\ X_{t-j} \leq X_{t-j-1} \end{cases}$$

$$\Delta X_{t-j}^- = \begin{cases} X_{t-j} - X_{t-j-1}, & if\ X_{t-j} < X_{t-j-1} \\ 0, & if\ X_{t-j} \geq X_{t-j-1} \end{cases}$$

The error correction term *E* defined as $E_{t-1}^+ = I_t \widehat{\varepsilon_{t-1}}$ and $E_{t-1}^- = (1 - I_t)\widehat{\varepsilon_{t-1}}$, reveals the possible asymmetric prices in response to positive and negative deviations from the long-term equilibrium, along with the impact of threshold cointegration. I_t is the

Heaviside indicator in Eq. (4a) and (4b) and $\widehat{\varepsilon_{t-1}}$ is represented as the following equation:

$$\widehat{\varepsilon_{t-1}} = Y_{t-1} - a_0 - a_1 X_{t-1}$$

As X represents the driving force and the long-term disequilibrium is measured as the difference between X and Y, thus the signs of the coefficients for error correction terms should be $\delta_X^+ > 0$, $\delta_X^- > 0$ and $\delta_Y^+ < 0$, $\delta_Y^- < 0$. The maximum lags j is selected by AIC statistics and Ljung-Box Q test.

4.3.4 Empirical Models and Hypothesis

Considering that China had been a leading milk powder importer in the world, especially from New Zealand, with Ireland trying to expand its dairy market share and returns in China, three relationships based on our assumptions of export prices were studied in this chapter.

First, the relationship between the export price of Ireland in the global market, p_{ie}^{w} , and price in the Chinese market, p_{ie}^{c} , with the latter as the driving force was analysed, namely $Y_t = p_{ie}^{w}$ and $X_t = p_{ie}^{c}$. The correlation of the two prices series was estimated to be 0.75.

Second, the export price of New Zealand in the Chinese market, p_{nz}^{c}, was assumed to be the driving force of New Zealand's export price in the global market, p_{nz}^{w}. Therefore, in this case: $Y_t = p_{nz}^{w}$ and $X_t = p_{nz}^{c}$. The correlation of the two prices series was estimated as 0.52.

Finally, the third relationship was estimated between the export price in the Chinese market from New Zealand, p_{nz}^{c}, and from Ireland, p_{ie}^{c} , in which, the price of New Zealand was made as the driving force, i.e., $Y_t = p_{ie}^{c}$ and $X_t = p_{nz}^{c}$. The correlation of the two prices series was 0.87.

The first two relationship were to identify the market integration between the key market and the global market, and the third relationship was estimated to identify price leadership between dominant player (New Zealand) and new player (Ireland) in the Chinese market.

4.3.5 Data and Software

As mentioned above, three pairs of SMP export price relationships were explored in the study, including the prices of Ireland in the Chinese market and in the global market, the prices of New Zealand in the Chinese market and in the global market, and the prices of Ireland and New Zealand in the Chinese market. The trade data of New Zealand was extracted from the UN Comtrade and the trade data of Ireland was extracted from Eurostat due to a large amount of missing data for Ireland in the UN Comtrade dataset. The commodity of the Skim Milk Powder (SMP) was classified according to the Harmonises System classification at 6 digits of details (HS-6) as HS 040210[58]. The export values are free-on-board (FOB) type value. It means the amount would be paid in the event of sale or purchase at the time and place the goods cross the national border of the exporting countries. It includes only incidental expenses (freight, insurance) incurred on the part of the journey located on the territory of the exporting countries. It does not include taxes on import or export, such as customs and excise duties or VAT. Quantity is expressed in kilograms. It reflects the net mass, i.e. the weight of the goods without any packaging.

Monthly data from January 2010 to December 2016 was used for this study.[59] The export price of New Zealand in the US dollars was calculated using the equation: $p_{nz}^{h} = \frac{V_{nz}^{h}}{Q_{nz}^{h}}$, where V_{nz}^{h} is the total export value in US dollars and Q_{nz}^{h} is the total export weight in kilogram. While the export prices of Ireland in US dollars was calculated using the equation: $p_{ie}^{h} = \frac{V_{ie}^{h}}{Q_{ie}^{h}} * er_{euro}$[60] , where V_{ie}^{h} is the total export value in euro, Q_{ie}^{h} is the total export weight in kilogram, and er_{euro} is the exchange rate for the conversion of one euro to the US dollars extracted from International Financial Statistics (IFS), h symbolizes the destinations for export, namely, China and the world. The spatial price transmission for FOB export prices will directly reflects the prices responses and

[58] Milk and Cream in Solid Forms, of A Fat Content by Weight ≤1.5%. UN Comtrade, export data at monthly interval are retrieved at: https://comtrade.un.org/data/ in 2017.

[59] The monthly export data of New Zealand at 6-digit level are only covered by UN Comtrade from Jan 2010, yet New Zealand is very important in the dairy international trade. The model running and data processing was mainly conducted in 2017 and 2018, so all the dataset in this Chapter only covered data from Jan 2010 to Dec 2016. Similar choice of periods is selected in the next two chapters.

[60] Irish export price in US dollar calculated by EUROSTAT data is the similar to the one that calculated using UN Comtrade data with an accuracy of three decimal places with respect to the dollar.

leadership of exporting countries and rule out other factors such as tariffs and transportation costs that would cause asymmetries in price transmission.

In this study, the software R studio was used for statistical analysis and for the depiction of figures. Specifically, the R package *apt* created by C. Sun (2016) was applied for the analysis.

4.3.6 Descriptive Statistics and The Unit Root Test Results for The Price Series

The descriptive statistics of price series used in this study are outlined in Table 4.1 and the time series are plotted in Figure 4.1.

Table 4.1: Descriptive statistics for the export prices of Ireland and New Zealand

Statistic	Ireland World Level	Ireland China Level	New Zealand World Level	New Zealand China Level
Mean	2.927	3.340	2.861	3.217
Minimum	1.359	1.921	1.760	1.760
Maximum	4.599	7.097	5.055	5.164
Std. Dev.	0.785	0.887	0.821	0.850

From January 2010 to December 2016, the average export prices of Ireland in the world and in the Chinese markets were 2.927 US dollar per kilogram and 3.3 40 US dollar per kilogram, respectively; while the average export prices of New Zealand in the world and Chinese markets were 2.861 US dollar per kilogram and 3.217 US dollar per kilogram, respectively. Generally according to the descriptive statistics, the export price in the Chinese market is higher than that in the “world” market, also the export price of Ireland is higher than that of New Zealand. It is probably because that the New Zealand and China has free trade agreement which greatly lower the tariffs duty rates to 1.7%, while China’s most favored nation (MFN) tariffs for SMP is 10%.[61]

[61] Data source: WTO Tariff Download Facility.

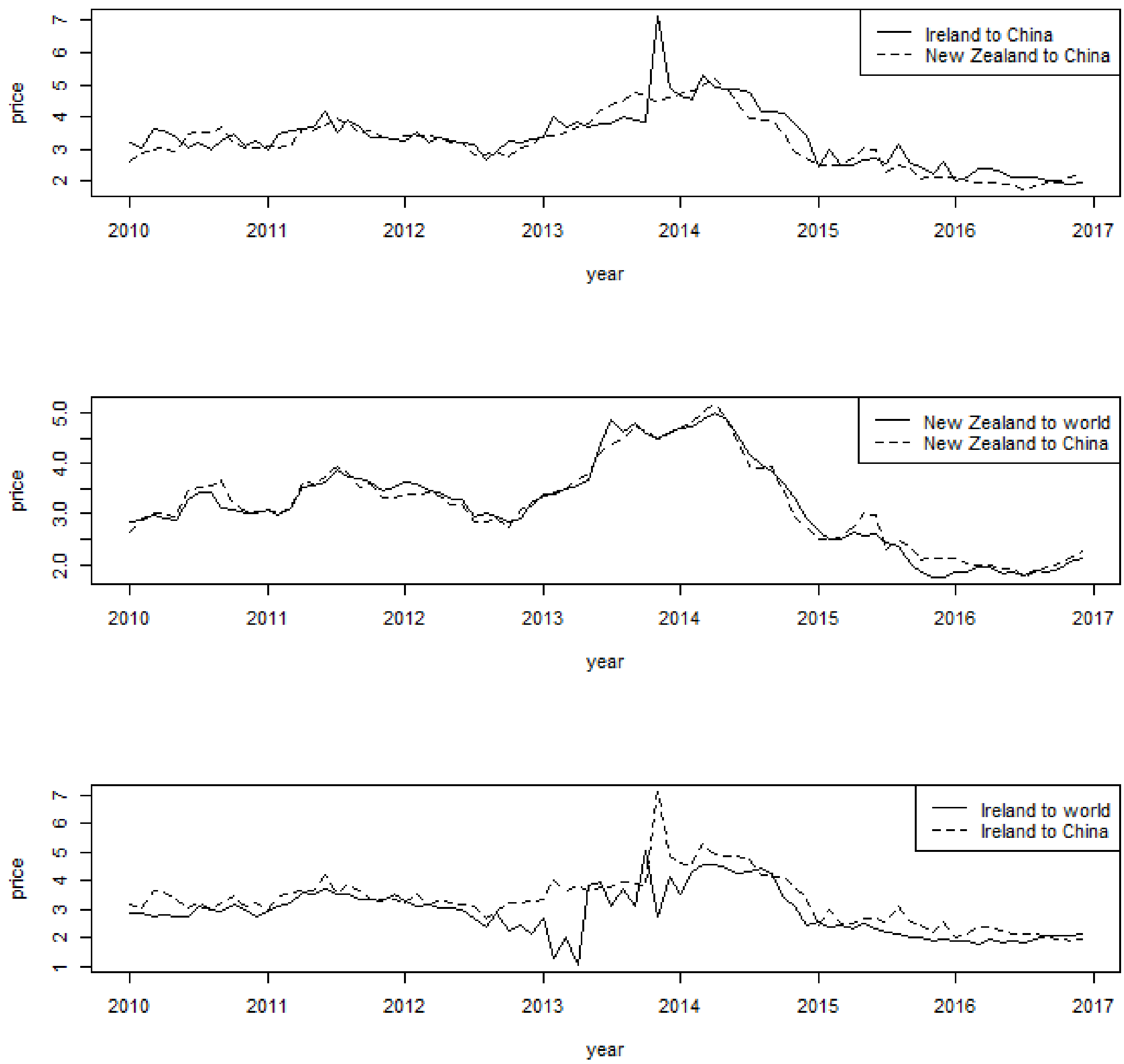

Figure 4.1: Monthly SMP export prices of Ireland and New Zealand in the Chinese market and in the global market from 2010 to 2017

As depicted in Figure 4.1, the export prices of both countries were much more stable before 2013 and displayed a co-movement pattern over time, after which they have obvious spikes and troughs with large fluctuations in between the years of 2013 to 2015. The main reasons behind the price fluctuations are: (a) The cold wet spring in Europe and worst drought in New Zealand for 75 years, along with the weak production in China resulted in the low dairy supply in 2013 (Bord Bia, 2014). (b) The demand from China remained high in 2013, thus resulted in the intensive stock building in 2013 and early 2014 (Bord Bia, 2014, 2015). (c) In 2014, the domestic production was higher than expected while China's economic growth slowed down. (d) High retail prices in the late 2013 and early 2014 reduced import demand both in the Chinese market and global market and the oil price fell (Bord Bia, 2015). However, the fluctuations have died down since 2015 with the prices dropped to low levels. Overall, as illustrated in the Figure 4.1, the export prices of Ireland and New Zealand appears to have a co-movement pattern and the export price of Ireland follows the price change of New Zealand with greater fluctuations. Thus, New Zealand, to a certain degree, may have been the leading country for Skim Milk Powder (SMP) export price both in the world and in the Chinese markets.

The Augmented Dicken-Fuller (ADF) united root tests were conducted for price series at original and at first differenced levels outlined in Table 4.2.

Table 4.2: The ADF unit root test results for the export prices of Ireland and New Zealand

Statistic	Ireland World		Ireland China		New Zealand World		New Zealand China	
	Level	1st Diff	Level	1st Diff	Level	1st Diff	Level	1st Diff
ADF test	-2.288 [0.458]	-4.082 [0.01]	-1.346 [0.844]	-4.111 [0.01]	-2.757 [0.265]	-4.220 [0.01]	-2.053 [0.554]	-3.664 [0.033]

Note: p-value in brackets.

The hypothesis of nonstationarity couldn't be rejected at the 10% level, while it could be rejected at the 1% level for the first-differenced form. All the price series are nonstationary and are one-order integrated. Therefore, it is very likely that the four series have cointegration relationships, which means the two countries' prices could have long run relationships.

4.4 Empirical Results for Own-Country Price Relationships

4.4.1 Relationship of Irish SMP Export Prices in the Chinese and Global markets

Table 4.3 outlines the results for the Engle-Granger and threshold cointegration tests results for world-China SMP export prices pairing model of Ireland.

Table 4.3: Engle-Granger and threshold cointegration tests results for Irish SMP export prices

Item	Engle-Granger	TAR	Consistent TAR	MTAR	Consistent MTAR
Estimate					
Threshold	-	0	-0.36	0	0.098
ρ1	-0.4241***	-0.361*	-0.275.	-0.402**	-0.176
	(-3.538)	(-1.978)	(-1.662)	(-2.346)	(-0.928)
ρ2	-	-0.624***	-0.719***	-0.629***	-0.681***
	-	(-4.386)	(-4.947)	(-4.179)	(-5.035)
Diagnostics					
AIC	134.339	107.17	103.441	107.627	102.832
BIC	141.632	119.142	115.413	119.599	114.804
R^2	0.5567	0.4641	0.4882	0.461	0.492
$Q_{LB}(4)$	0.2595	0.513	0.431	0.452	0.495
$Q_{LB}(8)$	0.03954	0.086	0.096	0.078	0.166
$Q_{LB}(12)$	0.01474	0.027	0.049	0.037	0.131
Hypotheses					
Φ(H0:ρ1=ρ2=0)	-	10.04	12.328	9.767	12.711
	-	[0.000133]	[2.267×10^{-05}]	[0.00017]	[1.697×10^{-05}]
F(H0:ρ1=ρ2)	-	1.712	5.421	1.269	6.042
	-	[0.195]	[0.023]	[0.263]	[0.016]

Note: 0.001 '***' 0.01 '**' 0.05 '*' 0.1 '.'. P-value in the brackets.

4.4.1.1 Engle-Granger cointegration analysis

The linear cointegration analysis was conducted through the Engle-Granger cointegration test which consisted of two steps. First, the linear relationship of the Irish SMP export prices in the world and in the Chinese markets was estimated with results shown in Eq. (6a). The coefficient was 0.66 and is significant at the 1% significant level. Secondly, the Augmented Dicken-Fuller (ADF) unit root test was performed on the residuals with lags equalling to 1 selected by AIC statistic. Therefore, the Irish SMP export prices in the world and in the Chinese markets have a cointegrating relationship when tested using the Engle-Granger approach. As reported in Table 4.3, the statistic value was estimated to be -3.54 with estimated coefficient of -0.4241, which is significant at the 1% level.

$$p_{ie}^{w} = \underset{(0.00189)}{0.72186} + \underset{(3.82*10^{-16})}{0.66049} p_{ie}^{c} + \varepsilon_t \text{ (6a)}$$

4.4.1.2 Non-linear threshold cointegration analysis

The threshold autoregressive models were applied to study the nonlinear cointegration analysis. The method proposed by Chan (1993) was applied to determine the threshold estimate (Enders & Granger, 1998). Different lags ranging from 1 to 12 were performed to select the best lag. According to the AIC statistics, the best lag for the models was lag 2. In Table 4.3, the four models (i.e., TAR, MTAR, Consistent TAR and Consistent MTAR) estimated with the selected lag 2 has been reported.

In the case of Ireland, the consistent MTAR model was the best fit for the relationship between the export price in the Chinese market and the export price in global market, because both AIC statistic of 102.832 and BIC statistic of 114.804 for consistent MTAR model were the lowest in the four threshold models. Moreover, the hypotheses of no cointegration and the symmetric transmission were rejected at 1% and 2% significance levels, respectively. Therefore, the adjustment process was asymmetric when the export prices in the global market and in the Chinese market adjust to achieve the long-run equilibrium. The point estimate of coefficients for the price adjustment in this consistent MTAR was − 0.176 for positive shocks but was – 0.681 for negative shocks. So, if there was an above-threshold deviation from the long-term equilibrium caused by increases in the world price or decreases in the Chinese price ($\widehat{\varepsilon_{t-1}} \geq 0.098$), this deviation would have been corrected at the speed of 17.6% per month. While if there was a below-threshold deviation due to decreases in the world price or increases in the Chinese price ($\widehat{\varepsilon_{t-1}} \leq 0.098$), this deviation would have been corrected at a speed of 68.1% per month. Thus, the convergence for the above-threshold deviations from the long-run equilibrium is almost 4.2 months (1/0.176-1/0.681=4.2 months) slower than the below-threshold deviations. Moreover, the result that the transmission is asymmetric indicated by the consistent MTAR model is in accordance with the results of the other three models.

4.4.1.3 Error correction model results analysis

Table 4.4 outlines the results of the asymmetric error correction model with threshold cointegration for Irish SMP export prices in global market and in the Chinese market.

Table 4.4: Results of the asymmetric error correction model with threshold cointegration for Ireland

	Ireland China		Ireland World	
	Estimation	t-ratio	Estimation	t-ratio
(Intercept)	-0.016	-0.215	0.003	0.051
α_1^+	-0.672***	-4.056	-0.043	-0.308
α_2^+	-0.066	-0.28	-0.069	-0.351
α_1^-	0.062	0.223	-0.043	-0.183
α_2^-	0.126	0.755	-0.102	-0.728
β_1^+	-0.222	-0.931	-0.229	-1.146
β_2^+	0.36.	1.798	0.219	1.305
β_1^-	0.318	1.348	0.04	0.203
β_2^-	-1.022***	-4.584	0.26	1.393
δ^+	0.151	0.746	-0.201	-1.181
δ^-	-0.014	-0.088	-0.528***	-4.027
R^2	0.479	-	0.444	-
AIC	97.892	-	69.327	-
BIC	126.625	-	98.060	-
Q_{LB} (4)	0.839	-	0.641	-
Q_{LB} (8)	0.320	-	0.156	-
F-statistics	6.44 [5.959×10^{-7}]		10.61 [9.917×10^{-8}]	

Note: 0.001 '***' 0.01 '**' 0.05 '*' 0.1 '.'. P-value in the brackets.

In the case of Ireland, the consistent MTAR model seemed to be the best-fit for World-China prices relationship. Therefore, the asymmetric error correction model with consistent MTAR was estimated and the results obtained have been outlined in Table 4.4. Three coefficients (i.e., α_1^+ , β_2^+ and β_2^-) were significant at the level of 10% in the Chinese market price equation, while only one coefficient δ^- was significant at the significance level of 10% in the world market price equation. Besides, the squared R statistic was 0.479 for China equation and was 0.444 for world equation. However, the

AIC and BIC statistics for world equation were lower than that of China equation. The F statistics for the overall fitness of the AECM-C-MTAR models were significant at the level of 1% for both China and world equations.

For Ireland's world equation, the estimate of positive error correction term was -0.201 and the estimate of the negative term was -0.528. In the short run, the export price of Ireland in the world market adjusted at different speed when there were positive and negative deviations. Therefore, the price in the world market has a slower correction speed to positive deviations than that to negative deviations from the long-run equilibrium. In the China equation, the estimates for the coefficient of the positive error correction term was 0.151 and the coefficient of negative error correction term was -0.014. Neither of the coefficients is significant at the level of 10%, although the coefficients indicate Ireland export price in the Chinese market responds faster for positive deviation than negative deviation from long-run equilibrium. Therefore, the export price of Ireland in the Chinese market might converge to the long-run equilibrium symmetrically regardless of the positive or negative deviations.

4.4.2 Relationship of NZ's SMP Export Prices in the Chinese and World Markets

Table 4.5 outlines the results for the Engle-Granger and threshold cointegration tests results for world-China SMP export prices pairing model of New Zealand.

Table 4.5: Results of Engle-Granger and threshold cointegration tests for New Zealand SMP export prices

Item	Engle-Granger	TAR	Consistent TAR	MTAR	Consistent MTAR
Estimate					
Threshold	-	0	0.404	0	-0.122
ρ1	-0.06709	-0.115**	-0.149***	-0.066	-0.065.
	(-2.071)	(-2.557)	(-3.266)	(-1.378)	(-1.655)
ρ2	-	-0.039	-0.011	-0.091*	-0.112*
	-	(-0.813)	(-0.24)	(-1.954)	(-1.814)
Diagnostics					
AIC	-	-22.288	-25.691	-20.97	-21.252

BIC	-	-10.316	-13.718	-8.997	-9.279
R^2	0.2686	0.1998	0.2327	0.1867	0.1895
Q_{LB} (4)	0.636	0.998	0.99	0.995	0.991
Q_{LB} (8)	0.6807	0.946	0.872	0.943	0.936
Q_{LB} (12)	0.8969	0.994	0.976	0.995	0.99
Hypotheses					
Φ (H0: ρ1=ρ2=0)	-	3.541	5.345	2.862	3.007
	-	[0.03379 *]	[0.0067 **]	[0.06323 .]	[0.0553 .]
F (H0: ρ1=ρ2)	-	1.397	4.76	0.131	0.401
	-	[0.241]	[0.032]	[0.718]	[0.529]

Note: 0.001 '***' 0.01 '**' 0.05 '*' 0.1 '.'. P-value in the brackets.

4.4.2.1 Engle-Granger cointegration analysis

The relationship between the export price of New Zealand in global market and in the Chinese markets was also estimated to be cointegrated. The linear relationship of the New Zealand's SMP export prices in the global and in the Chinese markets was estimated with results shown in Eq. (6b), the linear regression coefficient was 0.50 and significant at the level of 1%. The statistic value of -2.07 was reported in Table 4.5 and is significant at the 5% level, which indicates that the export prices of New Zealand in the global and in the Chinese markets are well cointegrated in the long run.

$$p_{nz}^{w} = \underset{(8.69*10^{-5})}{1.25221} + \underset{(4.43*10^{-7})}{0.50017}\, p_{nz}^{c} + \varepsilon_t \quad (6b)$$

4.4.2.2 Non-linear threshold cointegration analysis

In the case of New Zealand, the consistent TAR model fits the relationship between the export price in the Chinese market and the export price in global market best with the lowest AIC statistic of -25.691 and BIC statistic of -12.718. The hypothesis for no cointegration was rejected at the significance level of 1% in all models. Based on the estimations obtained from the consistent TAR, the adjustment process was asymmetric when the export prices adjusted to achieve the long-term equilibrium because the hypothesis for symmetric adjustment was rejected at the significance level of 5%. The point estimate of the consistent TVAR for the price adjustment was − 0.149 when facing positive shocks and − 0.011 when facing negative shocks. Therefore, the above-threshold deviations ($\widehat{\varepsilon_{t-1}} \geq 0.404$) take around 7 months (1/0.149 = 6.71 months) to be fully adjusted to the long-run equilibrium, while below-threshold deviations ($\widehat{\varepsilon_{t-1}} \leq 0.404$) take 91 months (almost 7.58 years) to return to the equilibrium. So, the SMP export prices of New Zealand in the world and in China are much slower to adjust to equilibrium than that of Ireland when there are shocks to the prices, regardless of negative shocks or positive shocks. Moreover, New Zealand is very slow to adjust its global prices when the negative price spreads between China and the world increase dramatically. However, the estimated results in the four models were not substantially consistent and R^2 for all models were quite low.

4.4.2.3 Error correction model results analysis

Table 4.6 outlines the results of the asymmetric error correction model with consistent TAR for New Zealand's SMP export prices.

Table 4.6: Results of the asymmetric error correction model with threshold cointegration for New Zealand

	New Zealand China		New Zealand World	
	Estimation	t-ratio	Estimation	t-ratio
(Intercept)	0.039	0.829	0.042	0.89
α_1^+	0.155	0.624	0.016	0.066
α_2^+	-0.211	-0.867	0.214	0.874
α_1^-	0.154	0.799	-0.184	-0.952
α_2^-	0.167	0.863	0.011	0.057
β_1^+	-0.061	-0.368	0.318*	1.902
β_2^+	0.036	0.201	0.267.	1.504
β_1^-	0.123	0.453	0.372	1.366
β_2^-	-0.257	-0.985	0.216	0.825
δ^+	0.033	0.47	-0.217***	-3.045
δ^-	0.142**	2.385	0.114*	1.905
R^2	0.164	-	0.268	-
AIC	-7.132	-	-6.639	-
BIC	21.602	-	22.094	-
Q_{LB} (4)	0.602	-	0.963	-
Q_{LB} (8)	0.790	-	0.683	-
F-statistics	1.372 [0.2115]		2.559 [0.01072]	

Note: 0.001 '***' 0.01 '**' 0.05 '*' 0.1 '.'. P-value in the brackets.

There was only one coefficient δ^- significant in the China equation, while there were four coefficients (i.e., β_1^+, β_2^+, δ^+, δ^-) significant at the level of 10% in the world equation. The R^2 statistic was 0.164 for China equation and 0.268 for world equation, while the AIC and BIC statistics are lower for China equation. The F statistic for the overall fitness of the AECM-C-TAR model of China was 1.372, which was not significant at the level of 10%, while the F statistic for the world model was 2.559, which shows that the model was significantly fit at the level of 1%. The estimate for the coefficients of the correction term in the case of New Zealand world model was -0.217 for the positive error correction term and was 0.114 for the negative error correction term. New Zealand export price in the global market responds faster to positive deviations than negative deviations from long-run equilibrium. So, it is concluded that the adjustment path for the price in the world market facing positive and negative deviations was asymmetric in the case of New Zealand price in the global market. In the China equation, the estimate for the coefficient of positive error correction term was 0.033 and was 0.142 for the coefficient of the negative term. Thus, the adjustment of export price in Chinese market converged to the long-run equilibrium at a much slower speed when there were positive deviations than facing negative shocks.

To sum up, in the short term, the price adjustment paths for both Ireland and New Zealand were asymmetric in the global market. However, when it comes to the case in the Chinese market, the price adjustment path was symmetric for Ireland and was asymmetric for New Zealand, respectively.

4.5 Empirical Results of The Cross-Country Price Relationship in the Chinese Market

Table 4.7 outlines the results for the Engle-Granger and threshold cointegration tests results for the Ireland-New Zealand price relationship in the Chinese Market.

Table 4.7: Results of Engle-Granger and threshold cointegration tests on SMP export prices of New Zealand and Ireland in Chinese market

Item	Engle-Granger	TAR	Consistent TAR	MTAR	Consistent MTAR
Estimate					
Threshold	-	0	-0.432	0	-0.005
ρ1	-0.8538	-0.82***	-0.799***	-0.951***	-0.951***
	(-5.894)	(-6.155)	(-6.406)	(-7.406)	(-7.415)

ρ2	-	-0.821***	-0.893***	-0.492**	-0.49**
	-	(-4.262)	(-3.902)	(-2.446)	(-2.425)
Diagnostics					
AIC	-	103.358	103.225	99.443	99.426
BIC	-	110.614	110.482	106.663	106.646
R^2	0.7496	0.409	0.4099	0.4319	0.4321
Q_{LB} (4)	0.9994	0.989	0.994	0.784	0.792
Q_{LB} (8)	0.7253	0.688	0.72	0.472	0.472
Q_{LB} (12)	0.9246	0.906	0.919	0.731	0.734
Hypothesis					
Φ(H0:ρ1=ρ2=0)	-	28.024	28.133	30.415	30.429
	-	[5.6×10^{-10}***]	[5.3×10^{-10}***]	[1.5×10^{-10}***]	[1.5×10^{-10}***]
F (H0: ρ1=ρ2)	-	0	0.129	3.688	3.705
	-	[0.997]	[0.72]	[0.058]	[0.058]

Note: 0.001 '***' 0.01 '**' 0.05 '*' 0.1 '.'. P-value in the brackets.

4.5.1 Engle-Granger Cointegration Analysis for New Zealand-Ireland Export Price Relationship

The linear relationship of export prices of Ireland and New Zealand in the Chinese market was estimated. The coefficient was 0.90 which was significant at the level of 1%. The relationship was shown in Eq. (7). After, the statistic for the ADF test was -0.85, implying that the hypothesis for the stationarity was rejected at the significance level of 1%. Therefore, the export prices of New Zealand and Ireland are cointegrated.

$$p_{ie}^{c} = \underset{(0.0266)}{0.43305} + \underset{(<2*10^{-16})}{0.90336}\, p_{nz}^{c} + \varepsilon_t \quad (7)$$

4.5.2 Non-Linear Threshold Cointegration Analysis for New Zealand-Ireland Export Price Relationship

The nonlinear cointegration is also estimated using the above mentioned four threshold models. In the relationship of export prices of New Zealand and Ireland in the Chinese market, the consistent MTAR is the best-fit with the lowest AIC and BIC statistics for the four models. Focusing on the results of consistent MTAR estimation, the hypothesis of symmetric adjustment can be rejected at the 10% significance level.

Moreover, the two prices have a cointegrating relationship because no cointegration hypothesis can be rejected at the significance level of 1%. The estimates of coefficients of adjustments to positive and negative shocks are -0.951 and -0.49 respectively. Both estimates are significant at the level of 5%. Therefore, the positive deviations from long-run equilibrium due to the increases in the price of Ireland or decreases in the price of New Zealand could be corrected at the rate of 95.1% per month, while negative deviations because of decreases in the price of Ireland or increases in the price of New Zealand could be corrected at the rate of 49% per month. The convergence for above-threshold deviations is very fast with only 1 month to return to long-run equilibrium, while it would take 2 months for below-threshold deviations to converge to long-run equilibrium.

4.5.3 Error Correction Model Results Analysis

The consistent MTAR model was the best-fit for export prices relationship between New Zealand and Ireland. The estimated results of asymmetric error correction model with consistent MTAR was reported in Table 4.8.

Table 4.8: Results of the asymmetric error correction model with consistent MTAR

	New Zealand		Ireland	
	Estimation	t-ratio	Estimation	t-ratio
(Intercept)	0.02	0.472	-0.016	-0.206
α_1^+	0.128	0.545	-0.141	-0.321
α_1^-	0.465**	2.314	-0.39	-1.038
β_1^+	-0.108	-0.946	0.151	0.712
β_1^-	0	0.002	-0.02	-0.133
δ^+	0.208*	1.674	-1.09***	-4.693
δ^-	0.02	0.168	-0.596***	-2.654
R^2	0.100	-	0.472	-
AIB	-10.192	-	92.412	-
BIC	9.062	-	111.666	-
Q_{LB} (4)	0.198	-	0.947	-
Q_{LB} (8)	0.478	-	0.326	-
F-statistics	1.392 [0.2291]		11.19 [6.98×10^{-9}]	

Note: 0.001 ‘***’ 0.01 ‘**’ 0.05 ‘*’ 0.1 ‘.’. P-value in the brackets.

In the ECM-C-MTAR estimations, two coefficients (i.e., α_1^- and δ^+) were significant at the level of 10% for the Ireland equation, and two coefficients (i.e., δ^+ and δ^-) were significant at the significance level of 1% for the New Zealand price equation. The squared R statistic was only 0.1 for New Zealand equation and was 0.472 for the Ireland equation. The F statistics of the model fitness were 1.392 and 11.19 for New Zealand and Ireland equations, respectively. The AIC and BIC statistics of New Zealand equation are much lower than that of Ireland. To sum up, the AECM-C-MTAR fits better for Ireland.

The coefficients of the error correction terms in the equation of Ireland were significant for positive and negative deviations, and the point estimations are -1.09 and -0.596, respectively. Thus, it could be concluded that the price of Ireland adjusts faster to positive deviations than negative deviations from long-run equilibrium. In the equation of New Zealand, the point estimate for the coefficient of the positive error correction term is 0.208 and is significant at the level of 5%. The point estimate of negative error correction term was 0.02, however, it was not significant at 10% level. It indicated that the price of New Zealand responds to a positive, not a negative deviation from long-run equilibrium. It could still be concluded that the price of New Zealand converges faster to long-run equilibrium for positive deviations. The results from AECM-C-MVAR models of Ireland and New Zealand is consistent with the findings of positive asymmetry in most spatial price transmission studies (Frey & Manera, 2007).

4.6 Price Volatility in Three Relationships

Price volatility results from the supply and demand characteristics of the market and can increase the market risks. Dairy markets especially SMP export markets have been characterized as high volatile markets. Food price volatility is an issue for producers and consumers that would raise the market risk and cause loss of welfare, but also for governments that require wise intervene tools. However, policies that aim to reduce short-run price fluctuations to some degree result in distortions in agri-food markets (Anderson, Rausser, & Swinnen, 2013).

Autoregressive conditional heteroskedastic regression (ARCH) model is applied to test the hypotheses that the four different export prices volatilities are invariant to price changes. The residuals in Eq. (1) are modelled respectively. The best-fit estimates of the models are given in Eq. (8a) for New Zealand export prices in the Chinese and in global markets, Eq. (8b) for Ireland export prices in the Chinese and in global markets, and Eq. (8c) for export prices of Ireland and New Zealand in the Chinese market (p-value in parentheses).

$$p_{nz}^{w} = 1.25221(8.69 * 10^{-5}) + 0.50017(4.43 * 10^{-7})p_{nz}^{c} + 0.05056(0.28573) + 0.97281(0.00929)\, \mu_{t-1}^{2} \quad \text{(8a)}$$

$$p_{ie}^{w} = 0.72186(0.00189) + 0.66049(3.82 * 10^{-16})p_{ie}^{c} + 0.05244(0.008604) + 0.03920(0.832062)\mu_{t-1}^{2} + 0.47461(0.002958)\mu_{t-2}^{2} + 0.49009(0.000472)\mu_{t-3}^{2} \quad \text{(8b)}$$

$$p_{ie}^{c} = 0.43305(0.0266) + 0.90336(< 2 * 10^{-16})p_{nz}^{c} + 0.05318(0.000715) + 0.87501(6.84 * 10^{-7})\mu_{t-1}^{2} \quad \text{(8c)}$$

The results indicate that: firstly, for both Ireland and New Zealand, increases in the export prices volatility in the Chinese market will cause higher export price variability in global market. Nevertheless, the price volatility effects for export prices of Ireland in the Chinese market and in global market last longer and stronger because the previous three-period variations still affect present price variations as shown in Equation (8b). This finding is consistent with the view in a recent report by Irish Department of Agriculture Food and the Marine (DAFM) that extreme price volatility is a threat faced by Irish dairy industry (DAFM, 2015). Secondly, the coefficients for the lagged variance terms are significantly different from zero, implying that the sizes of current and previous period residuals are strongly correlated and influenced the price volatility altogether. Thirdly, the volatility of New Zealand in the Chinese market will cause higher price variability of Ireland in the Chinese market, although the spill-over effect of volatility is not as strong as the one from the price volatility in the world market.

4.7 Conclusion and Discussion

4.7.1 Conclusion

In this study, the price dynamics of Ireland and New Zealand including three price transmission relationships were explored. There were several meaningful conclusions drawn from this research.

Firstly, in terms of the transmission relationships between the own-country prices in the world and in the Chinese market, Ireland and New Zealand display distinctive price transmission patterns from each other. The spatial price transmission from Chinese market to global market is asymmetric for both Ireland and New Zealand. Market integration between Chinese market and global market for SMP exports is weak. The SMP export price of Ireland and New Zealand in the Chinese market might converge to the long-run equilibrium symmetrically regardless of the positive or negative deviations as its estimated coefficients are not statistically significant.

In the case of Ireland, the convergence for the above-threshold deviations from the long-run equilibrium is slower than the below-threshold deviations. In the short-run, the export price of Ireland in the Chinese market might converge to the long-run equilibrium symmetrically regardless of the positive or negative deviations as estimated coefficients are not statistically significant. SMP export price of Ireland in global market has a slower correction speed to positive deviations than to negative deviations from the long-run equilibrium between global price and Chinese price: when the price series encounters shocks, the adjustment of the price series in global market exhibits more “momentum” in the direction of rising prices in global market or decreasing price in the Chinese market than the direction of decreasing price in global market or increasing price in the Chinese market. The factors behind this spatial transmission pattern may be due to the CAP policy of the SMP stocks and intervention prices from the EU to stabilize price if global price decreases. Also, it could because that the market share in the Chinese market is relatively small, Ireland has more freedom to adjust its export prices to make arbitrage in the Chinese market and to avoid a high volatility of its overall export prices.

In case of New Zealand, the spatial price transmission from Chinese market to global market is asymmetric for New Zealand. Convergence for the above-threshold deviations from the long-run equilibrium is faster than the below-threshold deviations. The SMP export price of New Zealand in the Chinese market might converge to the long-run equilibrium symmetrically regardless of the positive or negative deviations as its estimated coefficients are not statistically significant. Opposite from Ireland, SMP export price of New Zealand in global market responds faster to positive deviations than negative deviations from long-run equilibrium between global price and Chinese price: If there were negative deviations of price from long-run equilibrium, which may be an indication of an price increase in the Chinese market or price decrease in the global market, the adjustment of its global prices was very slow. If there were positive deviations such that the price in the Chinese market was decreasing or price in global market was increasing, the adjustment was faster. Therefore, the global export price of New Zealand is subjected to the export price movements in the Chinese market, which could be explained by the large market share and New Zealand's SMP export dependence on the demand of China. New Zealand had put almost all its eggs (i.e., SMP export market share) in the same basket (i.e., China), thus the export market in the Chinese market is of vital importance to New Zealand. Therefore, the price changes or deviations from long-run equilibrium would greatly change the overall export prices of New Zealand, especially if there is a drop in the prices in the Chinese market. Although New Zealand has dominated the Chinese SMP imported market, the Chinese market, to a great degree, has vital deciding effects on the SMP export prices fluctuation of New Zealand.

Secondly, the export price transmission of New Zealand and Ireland in the Chinese SMP market was asymmetric. The price of Ireland adjusts faster to positive deviations than negative deviations from long-run equilibrium between export prices of Ireland and New Zealand in the Chinese market. While export price of New Zealand responds to a positive, not a negative deviation from long-run equilibrium. In the long term, the price spreads between Ireland and New Zealand in the Chinese market could rapidly converge for above-threshold deviations within a period of 1 month in order to return to long-run equilibrium, while it would take 2 months for below-threshold deviations to converge to the long-run equilibrium. Therefore, the SMP export of two geographically separated countries are well integrated, and the adjustments of price changes are rapid yet a bit asymmetric. New Zealand has been the price leader in the Chinese SMP imported market, and the export prices of Ireland response more rapidly to decreases than to increases of the export prices of New Zealand. The reason behind the asymmetric price adjustment could be that New Zealand has been dominating China's SMP import market and has obtained a large SMP market share in China thereby greatly influencing SMP imported prices in the Chinese market. Ireland, as a small player with no price advantage in China's SMP import market, could be greatly constrained by the price pressure from New Zealand. Therefore, the price of Ireland was forced to reduce its price quickly when the price of New Zealand decreases, and couldn't keep up with the increases in the export price of New Zealand in the Chinese market, implying that Irish SMP may lack competitiveness in terms of price in the Chinese market due to the homogeneous attributes of SMP commodity. Besides, Irish exporters' lack of tracking the price movement of New Zealand' s export prices and clear understanding of the price relationship between the export prices of New Zealand and Ireland in the Chinese market might explain the inferior position of Irish SMP export price as well.

In sum, the asymmetries exist in the price transmission of the three price pairs, namely, export prices of Ireland in the world and in the Chinese markets, export prices of New Zealand in the world and in the Chinese markets and export prices of New Zealand and Ireland in the Chinese market, though displayed in different patterns. The SMP export of two geographically separated countries in the Chinese market are well integrated as the adjustments of price changes are rapid. New Zealand has been the price leader in the Chinese SMP imported market, and the export prices of Ireland responds more rapidly to decreases than to increases of the export prices of New Zealand.

4.7.2 Discussion

The conclusions drawing from the empirical analysis could give policy implication on dairy sector of Ireland, or other similar new entrants to the Chinese market. The export of skim milk powder is of vital importance to both New Zealand and Ireland, although in comparison, the SMP export volumes and values differ greatly. New Zealand has dominated the import SMP market of China over the past decade thanks to its large production scale, early access to the Chinese market, superior trade policies and a strong brand image based on the country of origin of milk and dairy products.

Nevertheless, the booming of imported milk powder has threatened the domestic dairy industry in China which triggers some ongoing negotiation on new cooperation mode and policies (such as multinational cooperation of domestic “star” dairy brands, raise of taxes on online imported products, stricter labelling requirements, etc.) between domestic milk powder brands and foreign exporters. Therefore, the Irish SMP exports sector could explore new selling points and cooperation modes to turn the challenges into new opportunities to expand the scale of SMP exports to China, and market returns, the following advices are proposed: (1) instead of competing directly in the SMP export with New Zealand in the Chinese market, Ireland should focus more on high value-added and high-end products, such as infant milk formula, sports nutritious products and packaged dairy products. (2) it is necessary to closer cooperation with Chinese companies to provide ingredients to China’s domestic dairy producing companies to expand market share. (3) Ireland should continue to build image for its sustainable, high-end and unique dairy sector in the Chinese market to create differentiation to its dairy products. (4) the export price of New Zealand could be an effective price signal for Ireland to adjust its SMP price and export pattern in advance.

Chapter 5 Global Vector Error Correction Model Application on the Dynamics and Drivers of the Global Butter Export Prices

5.1 Introduction

Recently, the global economy has experienced profound market and policy changes as trade protectionism and economic policy uncertainty increases in the major economies, leading to a risk of global economic downturn, disruption in global value chain and further economic uncertainties (Gozgor, 2019; Steinberg, 2019; Tam, 2018). As an indispensable part of the global value chain, the global dairy trade would be affected from both the demand side and supply side, thus triggering price fluctuations and corresponding welfare loss among stakeholders. Price fluctuations to some extent are inevitable in all types of markets in that they signal changing preferences from the demand side and changing cost and competitive positions from the supply side. The pattern of spatial price transmission among geographically separated countries and the price interaction with inputs, macroeconomic drivers and energy prices may offer useful information about market integration (globalization) or segmentation (regionalization or localization), as well as the solution to monitoring and stabilizing export prices (Fousekis et al., 2017; Fousekis & Trachanas, 2016).

Although extensive studies have been done on spatial price transmission in the dairy sector and factors affecting commodity prices, the causes of the dairy price rises and falls and market integration dynamics remain important for policy makers, for stakeholders involved in international dairy trade supply chains and for scholars. Several causes have been identified in studies on the rises in commodity prices that might also influence dairy prices, including: (1) growth in demand in emerging economies such as China and India due to changes in diets, population growth, and higher per capita income (Pingali, Aiyar, Abraham, & Rahman, 2019); (2) rising energy prices affecting costs of production inputs and distribution (Sands et al., 2011; Sato & Dechezleprêtre, 2015; Taghizadeh-Hesary, Rasoulinezhad, & Yoshino, 2019; Zilberman, Sproul, Rajagopal, Sexton, & Hellegers, 2008); (3) US dollar devaluation and exchange rate fluctuations; (4) increase in export controls and tariff and non-tariff measures due to trade protectionism (Felbermayr, Kinzius, & Yalcin, 2017).

Previous studies have examined spatial price transmission among geographically separated countries to investigate the market integration for a single dairy product, for example, studies on market integration for skim milk powder (SMP) of the U.S., the EU and New Zealand by analysing SMP price transmission among these three countries (Fousekis et al., 2017; Fousekis & Grigoriadis, 2016; Fousekis & Trachanas, 2016). Some studies have just examined different factors influencing a single commodity price in one country or region. Other studies have considered the impact of one factor isolation (such as the relationship between crude oil price and agri-food commodity prices). However, the international dairy market is dynamic and complex and the prices in geographically separated countries will interact with and be affected by both country-specific and external shocks as well as by global factors. To the best of my knowledge, there is no study that examines spatial price transmission and price interactions with factors that influence this among geographically separated countries or regions for the global dairy trade. Therefore, the Global Vector Autoregressive (GVAR) model proposed by M. Hashem Pesaran et al. (2004) is applied to study the spatial price transmission of butter export prices and the links between each of the key factors (macroeconomic factors, energy price, inputs, and substitution price), to better understand the global dairy market and its price mechanisms. The GVAR model provides a relatively simple but effective way to analyse interactions in a high-dimensional cross-section system with much less structural assumptions.

In this study, butter is chosen from various dairy products for the following reasons: (a) The vital export position of butter in the world.[62] (b) Of all dairy products, the U.S. and the EU have tried to regulate dairy markets primarily through interventions in butter markets. This suggests that butter is representative of the dairy industry in general in terms of studying the links between export prices and macroeconomic and policy factors. (c) Butter is a homogeneous dairy product, so its trade patterns are not distorted by product differentiation that circumvent the negative effects of intensive global competition.

[62] Butter has remained the fourth largest internationally traded dairy commodity (after whole milk powder, cheese and skim milk powder) in recent years, in terms of trade weight (OECD-FAO, 2015. OECD-FAO Agricultural Outlook 2015-2024.) It is a vital commodity that is sustained and regulated by stocks and interventional price policies in major dairy exporters such as the EU and the United States (US). The changing diet pattern and nutrition suggestion would cause the increase in the global demand for butter exports.
See section two for more details on this.

The overall objective of this empirical study is to understand global butter price transmission and how this is linked to macroeconomic factors, energy prices, input prices and substitute product prices in the short-run and long-run, and how butter export prices of different exporting countries react to shocks to these influencing factors. This should provide policy makers, producers, manufacturers and exporters with relevant information that has implications for decision making

This study contributes to the literature as follows: First, it addresses a gap in spatial price transmission research that focuses on the prices without considering other influencing factors. Second, studying the transmission effects on butter export prices, the crude oil and other macroeconomic factors, fits with current research trends towards potential links between energy, agriculture commodities, and macroeconomic uncertainties. Third, this chapter expands the application of the GVAR model to the dairy sector for the first time and validates its effectiveness in analysing spatial price dynamics with various factors across geographically separated countries (region). Besides, this study on the macroeconomic impact on dairy industry in light of a more market-oriented EU dairy policy and rising global trade protectionism might also provide policy makers with a basis for the development of timely butter export strategy adjustments and policy-making processes. Finally, panel data approaches provide more useful information by deriving information from both time and cross-country dimensions, than simple time series methods. This study could provide dairy producers and exporters with more useful information on price mechanisms to stabilize butter export prices.

The rest of the chapter is organized as follows: Section 5.2 provides an overview of the global butter export market, with a special focus on the U.S., the EU28 and New Zealand. Section 5.3 presents the conceptual framework and explains the economic rationale behind the hypotheses. Section 5.4 presents the methodology, empirical models and data sources for spatial butter export prices and related influencing factors. Section 5.5 reports the empirical results to understand the short-term relationships. Section 5.6 presents the dynamic analysis using general impulse response functions to understand the price linkages and dynamics in the long run. Finally, Section 5.7 sets out the conclusion and discussion of this chapter.

5.2 Overview of Global Butter Trade Markets

An overview of the global butter export market and its potential growth are presented in this section. The growth and evolution of butter exports by the U.S., the EU28 and New Zealand in recent years is explained.

The international dairy market is highly concentrated and dominated by a limited number of major exporters, and this concentration is expected to increase in the future. The United States of America (U.S.), the 28-member states of the European Union (EU28) and New Zealand are the three major dairy product exporters in the world[63] covering over 80% of global dairy products exports by value (e.g. butter, skim milk powder (SMP), whole milk powder (WMP), cheese, and whey powder). The dairy industry is increasingly important in international markets due to substantial growth in demand from developing countries for the following reasons: (a) agriculture commodity trade liberalization; (b) innovations and investment in milk processing and storage; (c) rising per capita incomes of major dairy importers; (d) urbanization, changing demographics and dietary patterns in non-traditional dairy-consuming countries. These have all led to a more robust demand for butter imports and less price sensitivity, especially in Asia (OECD, 2018). Butter is the fourth most traded, and second most produced and consumed dairy product, and the price of butter is used as the reference price for milk fat. As illustrated in Figure 5.1 below, 10% of production was exported across the world, and the ratio is lower as India is the largest producer of butter, yet it exports very little of this.

[63] In 2018, New Zealand, the EU28 and the U.S. ranked at first, second and fourth place, respectively, in butter exports (Belarus is in third place). However, the data of Belarus for the variables studied in this chapter are not fully available and its share of global butter exports is relatively negligible compared with New Zealand and the EU. Source: European Commission from USDA - PS&D reports

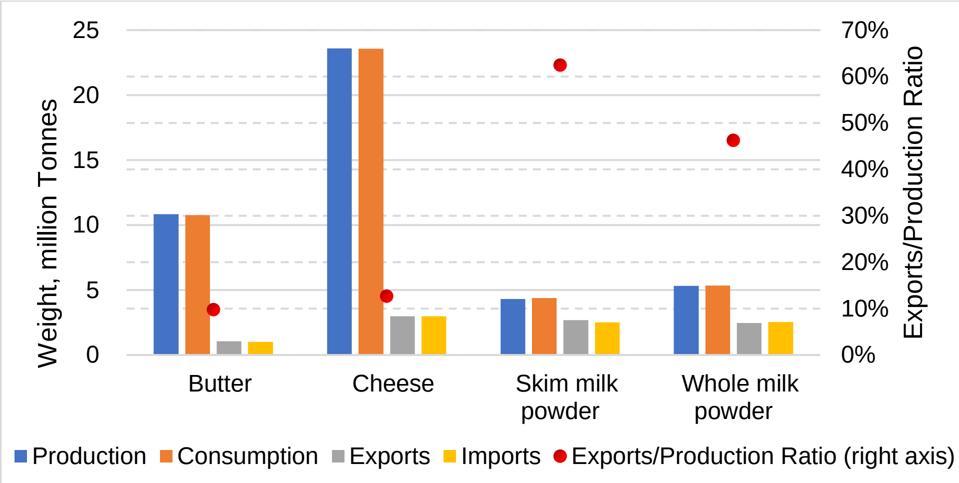

Figure 5.1: Global production, consumption and trade for the major dairy products in 2018

Source: OECD-FAO Agricultural Outlook dataset. https://stats.oecd.org Accessed on 11/09/2019.

Figure 5.2 below illustrates the butter market (production, consumption, exports and imports) in the EU, New Zealand, the U.S. and the world total in 2018. Production and consumption levels and consumption and production ratios of the EU and the U.S. are both high in global terms. In 2018, production levels in the EU28 and the U.S. were 2152 and 866 thousand tonnes, respectively, while the consumption and production ratios in the EU28 and the U.S. were 90.47% and 99.04%, respectively. However, export levels in New Zealand are the highest among the major exporters.

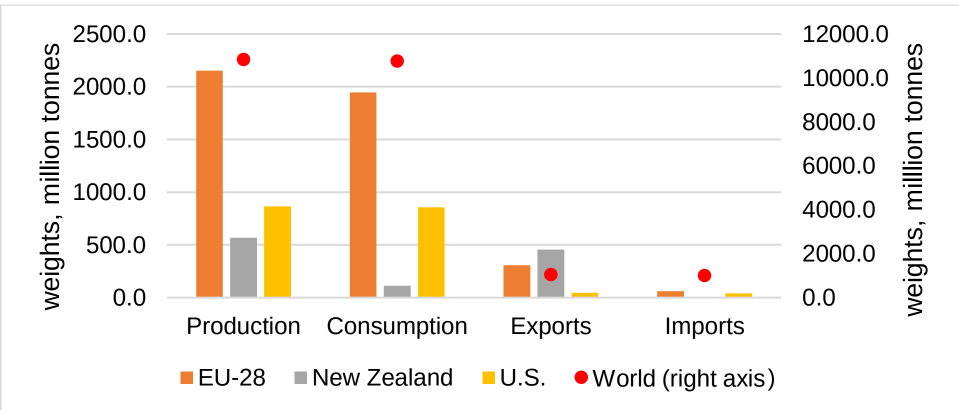

Figure 5.2: Butter production, consumption and trade of the EU[64], New Zealand, the U.S. and the world in 2018

Source: OECD-FAO Agricultural Outlook dataset. Accessed on 11/09/2019 at https://stats.oecd.org

[64] Exports and Imports for the EU is EU-27 without the UK.

Although the EU28, New Zealand and the U.S. are geographically separated with different topographical characteristics and dairy industry structures. The three studied major butter exporters have been interacted with one another via different channels, and price links in the international butter markets will be stronger because of the trade intensification: (a) EU28 is both a butter importer and exporter thanks to trade agreements and duty-free access for inward processing. In 2018, over 84% of Extra-EU butter imports in the EU came from New Zealand and the share has remined at levels between 70% and 90% over the period of this study.[65] Therefore, the EU28 and New Zealand interact with each other not only by competing for markets in export destinations but by direct (uni-directional) trade. (b) Compared to the American dairy industry, the dairy industries of New Zealand and the EU are more subject to the climate and environmental constraints because of their pasture-based production. (c) New Zealand doesn't give any subsidy to the dairy industry and supports free trade since the elimination of agricultural subsidies in 1984, while dairy sectors in the EU[66] and the U.S. are still protected under trade-distorting policy instruments, subsidies, and private storage aid for butter. (d) There are fundamental regional structural differences within the EU and after the abolition of milk production quotas the northern members of the EU's milk production will grow at the expense of southern EU member states, thus causing long-lasting effects as the EU dairy industry is exposed more to the global markets (R. A. Jongeneel & van Berkum, 2015).

Of all dairy products, butter has been characterized as a highly concentrated commodity, with a limited number of major exporters and numerous importers. New Zealand is the leading exporter for butter, followed by the EU. As depicted in Figure 5.3, the U.S., the EU28 and New Zealand accounted for 3.95%, 14.60% and 60.94% of global butter exports in 2018, respectively, accounting for almost 80% [67] of world total butter exports in trade value.

[65] Calculated using data from UN Comtrade
[66] The EU dairy sector is subject to the Common agricultural Policy (CAP).
[67] Estimated from FAOSTAT.

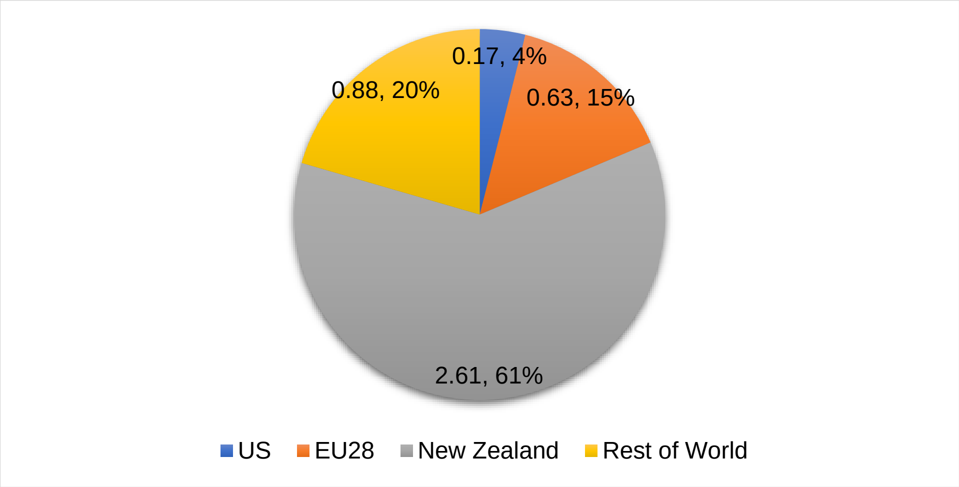

Figure 5.3: Butter export value and US, EU and New Zealand shares of the global market in 2018 (Billon USD)

Source: Calculated using data from UN Comtrade, intra EU export excluded from the EU's export.

The U.S., the EU and New Zealand have different export destinations and targets as outlined in Table 5.1. Destinations for U.S. butter exports are mainly to its two neighbours. Canada is the largest importer of the U.S. butter, accounting for almost 42% of U.S. butter exports, followed by Mexico (19.37%), Saudi Arabia (7.30%), Denmark (4.61%), and Honduras (3.71%). Most butter exports in the EU are among EU member states, while the top non-EU export destinations are the US, China and Middle Eastern countries. The U.S. is the top destination accounting for 4.49% of EU's exports (including both intra-EU and extra-EU exports), followed by Saudi Arabia, China, the Lebanon, United Arab Emirates. New Zealand is the biggest butter exporter globally with China accounting for 21.14% of its total butter export, followed by Australia, the Philippines, Saudi Arabia and Mexico. In general, New Zealand and the U.S. have more export markets overlaps in terms of top 5 destinations, i.e. Mexico and Saudi Arabia, with different market shares for each. If taking the 28 member states of the EU as a single exporter, the three studied countries have destination markets overlap (i.e. Saudi Arabia), and the EU and New Zealand also have China as a common export destination market.

Table 5.1: Top 5 butter export destinations of the U.S., the EU28 and New Zealand in 2018 (million USD)

Rank	The U.S.		The EU28				New Zealand	
	Partners	Value (Share)	Intra-EU Partners Ranking	Value (Share)	Extra-EU Partners ranking	Value (Share)	Partners	Value (Share)
1	Canada	70.60 (41.7%)	Netherlands	970.26 (21.1%)	United States	205.98 (4.5%)	China	551.68 (21.1%)
2	Mexico	32.76 (19.4%)	France	724.26 (15.8%)	Saudi Arabia	68.62 (1.5%)	Australia	196.20 (7.5%)
3	Saudi Arabia	12.35 (7.3%)	Germany	461.30 (10.1%)	China	24.46 (0.5%)	Philippines	170.78 (6.6%)
4	Denmark	7.8 (4.6%)	United Kingdom	390.58 (8.5%)	Lebanon	21.4 (0.5%)	Saudi Arabia	115.45 (4.4%)
5	Honduras	6.27 (3.7%)	Belgium	381.96 (8.3%)	United Arab Emirates	20.45 (0.5%)	Mexico	115.44 (4.4%)
Total	129.77 (76.72%)		2928.36 (63.79%)		340.91 (7.44%)		1149.55 (44.06%)	

Note: Shares in country global exports are outlined in parentheses

Source: Calculated using data from UN Comtrade

According to the OECD-FAO report (2019)[68], international reference prices for dairy refer to processed products (mainly for butter and skim milk powder) of the main exporters in Oceania (New Zealand contributing the most) and Europe. Since 2015, the price of butter is considerably higher than the price of skim milk powder prices because of stronger demand for milk fat globally and is expected to remain a structural feature in future.

Figure 5.4 depicts butter export prices for the U.S., the EU and New Zealand. The U.S. and New Zealand's butter export prices display a similar pattern prior to 2017 with the price cycle less obvious compared to the EU. Butter export prices for these three countries spiked in mid-2011 and early 2014, with the peak and trough of EU cycles exhibiting a wider range than those of the U.S. and New Zealand. Unbalanced supply and demand raised export prices to a historic high in the global markets during 2013 and early 2014. Demand from China increased through acquisition of substantial

[68] OECD-FAO Agricultural Outlook 2019-2028, accessed at http://www.fao.org/3/ca4076en/ca4076en.pdf

stocks due to a significant shortfall in its growing domestic supply while the productions of the U.S., the EU and New Zealand didn't expand at the same rate as demand in China. However, prices immediately fell in early 2014 due to a fall in purchasing demand in China, while production among exporters increased, together with an import ban imposed by the Russian Federation, led to price remaining at the lower levels until early 2017. Since mid-2017, prices have been rising for exports from the EU and New Zealand.

In general, the price evolves with similar patterns but at different price levels. U.S. and New Zealand prices have been relatively lower than the EU's price. The reasons for this could be that, first, the EU has a price support mechanism (intervention) which could set a price floor for butter, and second, differences in consumer preferences and geographical proximity to markets.[69] Although some simple patterns can be seen from Figure 5.4, more rigorous econometric analysis is required to reveal factors behind global market integration and hidden price dynamics among the three major players.

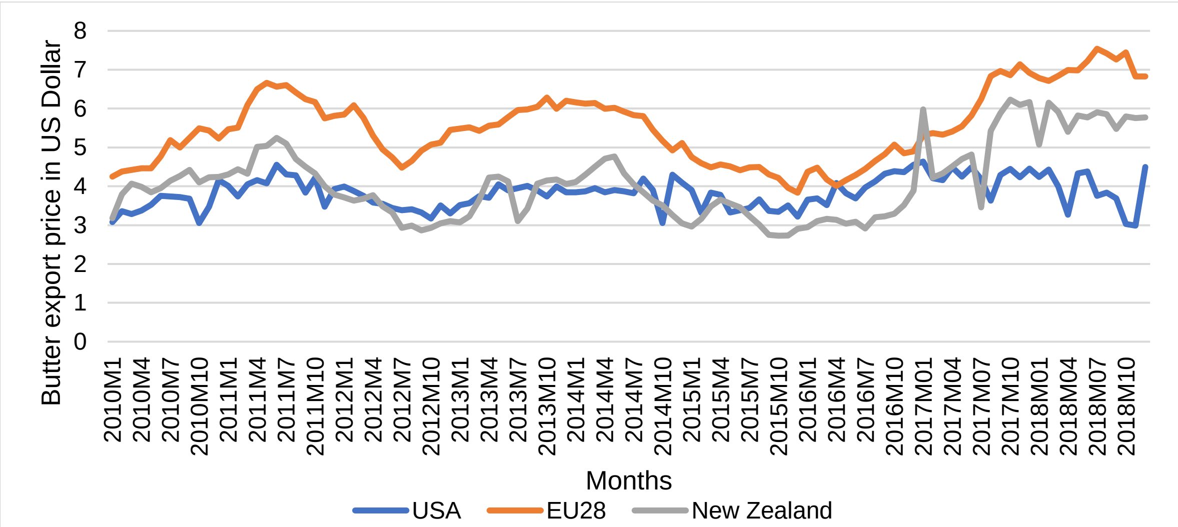

Figure 5.4: Butter export price of the U.S., the EU and New Zealand from 2010 to 2018

5.3 Conceptional Framework

Figure 5.5 illustrates the proposed framework for this study. It is assumed that butter export prices are driven by shocks to a) macroeconomic factors (food inflation and exchange rate); b) input cost (fertilizer price); c) energy price (crude oil price); d)

[69] Several butter major importers such as North African and Middle East countries have preferences towards European butter (Thiele, Richarts, & Burchardi, 2013)

substitute production price (palm oil price); and e) butter export prices of other major exporters.

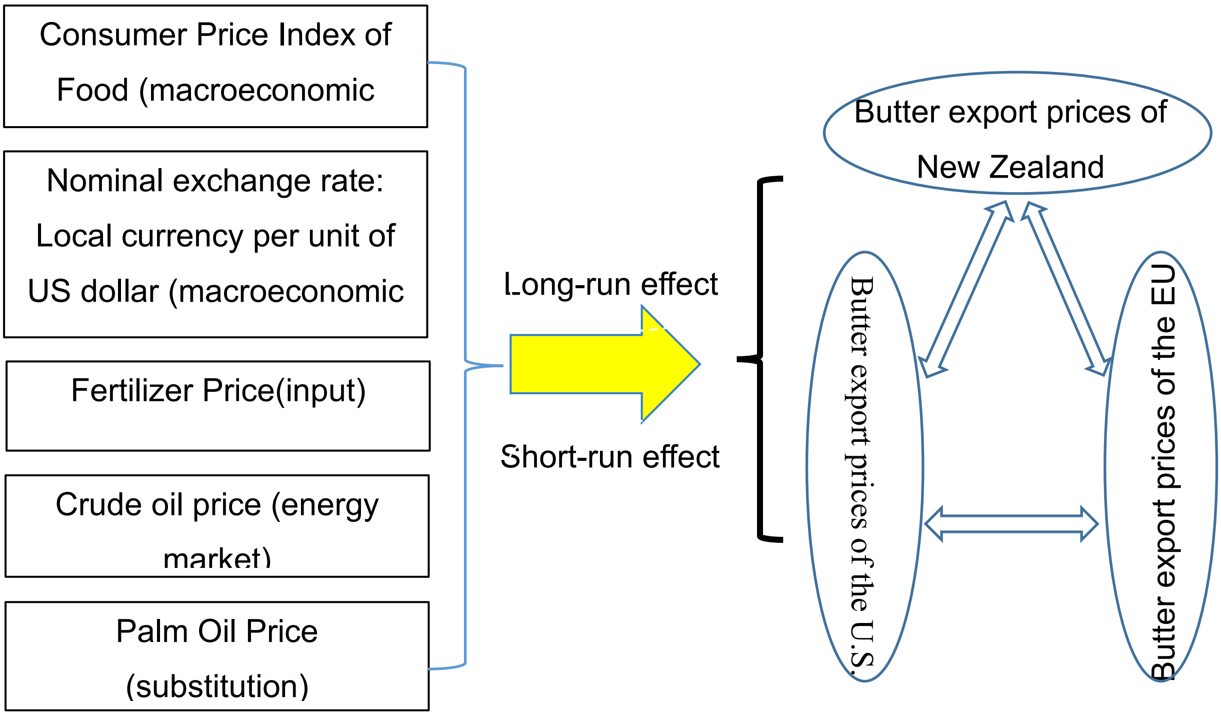

Figure 5.5: Flow Chart of influencing factors and butter export prices

As depicted in the flow chart, five drivers including CPI for food, nominal exchange rate, fertilizer price, crude oil price and palm oil price are incorporated into the analysis along with butter export prices for the U.S., the EU and New Zealand. It is assumed that increases in crude oil price, palm oil price, fertilizer price, U.S. dollar depreciation and CPI for food would cause increases in butter export prices, and the global butter market is well-integrated. The following hypotheses will be examined through this empirical analysis:

(1) A positive shock to global crude oil price will cause increases in long-run butter export prices for the US, the EU and New Zealand.

(2) A positive shock to the palm oil price will cause increases in long-run butter export prices for the US, the EU and New Zealand.

(3) Domestic food inflation and US dollar depreciation will cause increases in the butter export prices for the US, the EU and New Zealand, and the macroeconomic factors in one country will affect that country's export prices most, but also have an impact on the other countries' export prices.

(4) The substitute product price (e.g. palm oil price) inflation will cause increases in butter export prices for the US, the EU and New Zealand.

(5) The global butter export market is well-integrated so that a shock to butter export prices in one country will swiftly transmit, on a similar scale, to butter export prices for the other countries.

The domestic consumer price index for food indicates a country's food price inflation and deflation status. The inflation of domestic food prices might affect choice of domestic consumption and export ratios, thus influencing export prices. Butter is a typical agricultural product that is not only tradeable but also suitable for storage. The direction of impact of CPI for food on butter export prices might be reversed given the countries' CPI for food basket and the ratio between its butter's domestic consumption and export. If the share of butter in a country's CPI for food basket is very small, the change in CPI for food may not have any impact on butter export prices. Also, for a high domestic consumption country, the increase in CPI for food might lead to decreases in export volumes and therefore increases in the export prices; while for the export-oriented country, an increase in the CPI for food may not affect the exports directly. However, inputs such as feed price might increase leading to a rise in costs which in turn lead to increases thus increase in export prices.

Fluctuations in exchange rates are regarded as a major influencing factor that affects the relative prices of exported commodities, thus causing price fluctuations. The US dollar devaluation has been regarded, and empirically studied, as one of the main reasons behind the soaring commodity prices (Abbott, Hurt, & Tyner, 2008). However, there is little agreement on the impacts of US dollar depreciation on commodity prices (Piesse & Thirtle, 2009).

Linkages between crude oil prices and commodity prices have been extensively studied in recent years, though the results vary for different categories of commodities.

Most studies of energy-agricultural price have found positive relationships between crude oil price levels and agricultural commodity prices, especially maize, wheat, soybean and those related to the biofuel oil production (see Serra and Zilberman (2013) for a comprehensive survey). In terms of dairy products, Huchet-Bourdon (2011) found that the correlation for butter (0.46) and whole milk powder (0.47) prices with crude oil prices are the highest when compared with other commodities in the 2000s; Bergmann et al. (2016) studied the price transmission of crude oil price to Oceania and EU butter prices, and found an estimated 0.0904 coefficient at a 10% significance level between Oceania butter prices and crude oil prices, yet no significant price transmission from crude oil prices to EU butter prices. The global oil price influences agricultural commodity price in two main ways: (1) oil price increases may result in higher agricultural commodity prices through cost effects because production and distribution consume crude oil; (2) high crude oil prices may push up production and consumption of biofuels, thus first increasing prices of grain and other oil prices, and then input prices of dairy inputs such as feeds.

Palm oil, a resource used in processing margarine, is a good substitute for butter. Over the years, global palm oil production has increased while butter production has remained relatively stable. Moreover, many dairy import countries, such as China, India and Japan, are not traditional butter consumption countries and are quite price sensitive to butter. Palm oil is also used as a main fat source due to its lower price, making butter less competitive in these countries. Dairy demand may decline due to replacement with other cheaper substitutes in food manufacturing when dairy product prices are high (OECD-FAO, 2011). Therefore, price transmission might exist between butter and its substitutes, such as palm oil, in different countries (Bergmann et al., 2016; O'Connor, Keane, & Barnes, 2009).

Market integration describes market mechanism in which demand and supply shocks are transmitted , rapidly and smoothly, from one region (market) to another or among different regions (markets) with prices in these regions (markets) moving together in the long run (P. Fackler & B. Goodwin, 2001). An analysis of price transmissions in butter export prices among the three major exporters indicates market integration and price sensitivity to global shocks.

5.4 Methodology, Empirical Model and Data

5.4.1 GVAR Model Specification

The Global Vector Autoregressive (GVAR) model connects country-specific models through multiple channels of international linkages, deciphering the size and speed of price transmission upon shocks from domestic and foreign countries or from the global market. The GVAR model was first proposed by M. Hashem Pesaran et al. (2004). As a high-dimensional cross-sectional time series model seldom relying on economic theory and restrictions, the GVAR model is effective in analysing the spatial commodity price transmission and in identifying the impacts of various shocks and determinants in a visual way. By construction, the GVAR model allows for interaction among different economies through two channels, namely: a) the contemporaneous interrelation of domestic variables with foreign-specific variables; and b) the contemporaneous correlation of shocks across countries.

The GVAR model has been applied extensively in macroeconomics, including but not limited to (see Chudik and Pesaran (2016) for comprehensive surveys) studying the factors and shocks affecting global inflation (Lombardi, 2009), global imbalance (Bettendorf, 2017; Matthieu et al., 2013), effects of fiscal and monetary policy (Favero et al., 2011; Feldkircher & Huber, 2016; G. Georgiadis, 2015; G. Georgiadis, 2016; Hebous & Zimmermann, 2013) credit supply shock (Eickmeier & Ng, 2015; Konstantakis & Michaelides, 2014; Xu & T.T, 2012), spillovers in the labour market (Hiebert & Vansteenkiste, 2010), etc.

So far, the GVAR model has been applied to agricultural markets twice. Gutierrez et al. (2015) demonstrated the possibility of establishing a GVAR model for global wheat export prices to analyse linkages among food commodity prices, energy prices and financial sectors in the major wheat export countries, and found that a reduction of US stock-to-use ratio, an increase of oil price, and a devaluation of the U.S. dollar will increase global wheat export prices. Pierre and Kaminski (2019) studied short-run food price shock propagation in Sub-Saharan Africa (SSA) using GVAR model. Significant between-country market contagion and rapid regional price shock propagation were found when trade connections exist. They also found that market integration of maize within SSA and with global markets are weak. However, only two papers have applied the GVAR model for agriculture commodity price transmission and explored their dynamics with other influencing factors.

To the best of my knowledge, there is no empirical research on the dairy industry that thoroughly analyses spatial price transmission and interaction with macroeconomic influencing factors. Using GVAR models, price transmission and market dynamics could be addressed and effectively studied with less economic theoretical constraints. This chapter follows a similar approach to Gutierrez et al. (2015) and Pierre and Kaminski (2019) and proceeds as follows.

The GVAR model comprises two steps: the first step is the construction of the individual unit (countries and regions) models VARX and the second step is to stack the estimated country models together to form one large Global VAR model.

It is assumed 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×1 vector of variables specific to unit i in time period t. $x_t = (x_{1t}', x_{2t}', \dots, x_{nt}')'$ denotes the k×1 vector of all the variables, where $\mathrm{k} = \sum_{i=1}^{N} k_i$. For the empirical model in this chapter, the cross-section units refer to the specific countries and regions defined (i.e., the U.S., the EU, New Zealand and the Rest of World) for research purposes.

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*×1 vector

Equation (1)

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

for i=1, 2, 3, …, N, where $\widetilde{W}_i$ is k×k$*$ matrix of country-specific weights, typically constructed using data on bilateral foreign trade or capital flows. 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 country-specific vector of cross-section averages of the foreign variables, the model will be represented as Equation (2b).

Equation (2a)

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

Equation (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 $k_i \times 1$ error vectors.

For simplicity, it is assumed that $\Psi_{il} = 0$ for $l = 0, 1, 2, \ldots, s_i$ in the following derivation. Therefore, let $Z_{it} = (x_{it}', x_{it}^{*'})'$ be $k_i + k^*$ dimensional vector, thus equation (2a) can be rewritten as

Equation (3)

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

Where

$\mathrm{A}_{i0} = (\mathrm{I}_{ki} - \Lambda_{i0})$, $\mathrm{A}_{it} = (\Phi_{il}, \Lambda_{il})$ for l=1, 2, …, p.

The estimation of country models GVARX as Equation (3), which allows for cointegration within and across countries (via the star variables), is the first step of the GVAR approach.

Then the deduction is made to get Error-Correction representation (2c): minus $x_{i,t-1}$ on both side of Equation (2a), then getting

Equation (2a.1)

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

Then Equation (2a.2)

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

Then Equation (2a.3)

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

Therefore, by rearranging terms, the error-correction representation of equation (2a) as follows are constructed.

Equation (2c)

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

Where $\Pi_{i0} = -(\mathrm{A}_{i0} - \sum_{l=1}^{p}\mathrm{A}_{il})$, $H_{il} = -\sum_{l=1}^{p-1}\mathrm{A}_{i,l+1}$, $\Delta = 1 - \mathrm{L}$ 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 $W_i = (\mathrm{E}_i', \widetilde{W}_i')$, where E_i is $k \times k_i$ -dimensional selection matrix that select x_{it}, namely $x_{it} = \mathrm{E}_i' x_t$, and $\widetilde{W}_i'$ is the weight matrix introduced in Equation (1) to define country-specific foreign star variables.

Then Equation (4)

$$Z_{it} = \left(x_{it}', x_{it}^{*\prime}\right)' = W_i x_t$$

Then Equation (3) can be written as Equation (5)

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

Then Equation (6) is

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

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

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

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

Equation (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 analysing the impulse responses, or to compute the forecast error decompositions, or to forecast the x_t variables.

5.4.2 Empirical Models and Data

The world dairy industry has experienced a series of external shocks and policy changes. Understanding the mechanism of butter export price transmission and the interactions with macroeconomic indicators (e.g. exchange rate, CPI for food), the input materials prices (e.g. fertilizer and crude oil price) and substitute is of vital importance. The development of Global Vector Autoregressive (GAVR) Models with an application on butter markets is quite effective and timely. Combining the economic analysis with statistical estimation, this chapter shows the results from a new global dynamic model that illustrates butter export prices' responses to different sorts of shocks in the short run and in the long run as well as highlights the global butter market integration.

Four VARX models are constructed in this chapter, one for each of the main export regions: the U.S., the EU and New Zealand. Also, the Rest of the World (RoW) regional

VARX model is specified to represent the effects from all the other countries.[70] These four countries (regions) are estimated from January 2010 to December 2016 at monthly intervals. Besides, the 28 member states of the EU, which share agriculture and trade policies under the Common Agricultural Policy (CAP), are regarded as a single exporter, and so butter export prices of the EU exporting to countries outside of the EU 28 member states are constructed and put into analysis.

The country-specific variables[71] include: 1) the index of export prices in U.S. Dollars denoted as p_{it}^{e}, 2) the index of fertilizer price in the local currency as p_{it}^{f}, 3) the bilateral exchange rate against the US dollar denoted as e_{it}, 4) the consumer food price index, CPI_{it}, which reflects food inflation in each country.

The foreign-specific variables are established as a geometric average of the country-specific variables. The weights 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,$CPI_{it}^{*} = \sum_{j \neq i} w_j CPI_{jt}$.

In GVAR model analysis, the global variables are defined as ones that are set to be endogenous in one country, and could impact the system of each country, and are of vital importance to all countries. The dairy industry depends on energy in that oil and energy are necessary for the production of milk and dairy products and transportation of the products, thus directly influencing butter export prices. Therefore, the dairy market can be affected by changes in 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 the most produced vegetable oil (USDA, 2014). Both butter and palm oil are sources of fat. Margarine which can be produced using

[70] China, India, Japan, Mexico, Russian Federation and Ukraine are aggregated as the Rest of World. Although Belarus and Australia are also major butter exporters, they are excluded from this analysis due to the data insufficiency such as the lack of or low quality of data.
[71] Variables related to production are not included 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.

palm oil is a good substitute for butter and it is much cheaper than butter as cooking oil. So, international butter export prices are influenced by palm oil prices, p_t^p. In the constructed GVAR model, the crude oil price is set to be endogenous in the U.S. VECX model following most of the GVAR empirical studies (Gruss, 2014; Gutierrez et al., 2015) and palm oil price is set to be endogenous in the RoW VECX model.[72] Therefore, the variable vectors are as following:

The domestic variables vectors for the EU and New Zealand VARMs (VECMs):

$x_{it} = (p_{it}^e, e_{it}, p_{it}^f, CPI_{it})$, where $i = 1 \text{ and } 2$

The domestic variables vectors for the U.S. VARM (VECM):

$x_{0t} = (p_{0t}^e, p_{0t}^f, CPI_{0t})$,

The domestic variables vector for rest of the world VARM (VECM):

$x_{3t} = (e_{3t}, p_{3t}^f, CPI_{3t})$,

The foreign variables vectors for the U.S., the EU, New Zealand and rest of the world VARMs (VECMs):

$x_{it}^* = (p_{it}^{e*}, e_{it}^*, CPI_{it}^*)$[73], where $i = 0, \dots, 3$

The global variables vectors for VARMs (VECMs):

$d_t = \left(p_{it}^{co}, p_{it}^{po}\right)$.

Put the above-mentioned variables vectors into the following model specification:

[72] The palm oil import for the RoW countries in this study is over 10 billion US dollar, accounting for almost 40% of world total import value.
[73] The local fertilizer prices were converted by exchange rates from world fertilizer prices, so foreign counterpart fertilizer variable was excluded from the model to avoid multicollinearity problems.

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

for i = 0, 1, 2, 3 which represent the U.S., the EU, New Zealand and RoW, respectively; 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 $k_i \times 1$ error vectors.

The variables used, the data sources and descriptions for each variable in this model are outlined in Table 5.2 below. Monthly data from January 2010 to December 2016 was used for this study. The butter export price of New Zealand, the EU28 and the U.S. in US dollars was calculated using the equation: $p_{it}^e = \frac{V_{it}^e}{Q_{it}^e}$, where V_{it}^e is the total export value in US dollars and Q_{it}^e is the total export weight in kilogram, *i* symbolizes the exporters, namely, the EU28, New Zealand, the U.S. and the Rest of the World (RoW). All the variables used in this chapter are transformed to their indexes using the average value of period Jan/2010 to Dec/2010 as the base year, with the exception of crude oil price and palm oil price which already in the form of indexes. The data information is detailed in the Section 2.1 Appendix II. Agri-food commodities usually have strong seasonality, yet butter is a product that has a long shelf-life and could be stored for future use. So, in this study, the GVAR model is constructed using the unadjusted butter export price index series.

Table 5.2: Data description: domestic and global data series[74]

		Description	Source	URL	Data of retrieval
Global Variables	Crude oil price, p_{it}^{co}	Average spot price of Brent, Dubai and West Texas Intermediate, equally weighed; Nominal US	World Bank Commodity Price Data database (unavailable now) Now: The World Bank Commodity Markets “pink sheet” data commodity prices	https://www.worldbank.org/en/research/commodity-markets	2017

[74] The data source and construction are detailed in the appendix.

		dollar per barrel			
	Palm oil price, p_{it}^{po}	Nominal US dollar per Metric Ton (MT)			
Domestic variables	Butter export prices, p_{it}^{e},	United States	USDA Foreign Agricultural Services-GATS database	https://apps.fas.usda.gov/gats/default.aspx	
		European Union-28	Eurostat database	https://ec.europa.eu/eurostat/data/database	
		New Zealand	UN Comtrade database	https://comtrade.un.org/data/	
	bilateral exchange rate, e_{it}	Nominal exchange rate: Local currency per unit of US dollar	FRED Economic Data	NZ: https://fred.stlouisfed.org/series/CCUSMA02NZM618N EU: https://fred.stlouisfed.org/series/CCUSMA02EZM618N	
	Fertilizer price index, p_{it}^{f}	Fertilizers index includes natural phosphate rock, phosphate, potassium and	The World Bank Commodity Markets "pink sheet" data commodity prices	https://www.worldbank.org/en/research/commodity-markets	

		nitrogenous products.			
	Consumer food price index, CPI_{it}	United States	OECD database	https://stats.oecd.org/	
		European Union-28	Eurostat database-HICP	https://ec.europa.eu/eurostat/data/database	
		New Zealand	Stats NZ-infoshar-Economic Indicator-Consumers Price Index	http://archive.stats.govt.nz/infoshare/	

In this analysis, the software MATLAB 2019(a) is used for statistical analysis and Microsoft Excel and R are used for the depiction of figures. Specifically, the GVAR Toolbox 2.0 developed by L. Smith and A. Galesi (2014) was applied for the GVAR model estimation and analysis.

Table 5.3 on the next page lists the descriptive statistics of domestic and global variables in this study. As all the variables are in their index's forms. The mean values for butter export price series of the U.S., the EU and New Zealand are 106.93, 107.73 and 92.47, respectively, with standard deviations of 9.90, 15.26 and 15.61, respectively. The mean values for exchange rate of the EU, New Zealand and the rest of world are 105.32, 94.59 and 126.50, respectively, with standard deviations of 9.83, 7.90 and 24.65, respectively. Palm oil price and crude oil price series have mean values of 96.54 and 108.52, respectively, and have standard deviations of 20.54 and 31.42, respectively.

Table 5.3: Descriptive statistics of domestic and global data series

Variables	Countries	Mean	Median	Maximum	Minimum	Standard Deviation
Butter Export Price	The U.S.	106.93	107.13	129.44	86.75	9.90
	The EU 28	107.73	107.14	137.08	78.88	15.26
	New Zealand	92.47	91.24	130.61	67.89	15.61
Exchange Rate	The EU 28	105.32	101.91	125.67	91.65	9.83
	New Zealand	94.59	92.98	113.78	83.02	7.90
	Rest of World	126.50	121.62	174.18	96.15	24.65
Fertilizer Price	The U.S.	109.29	102.33	159.52	70.69	24.08
	The EU 28	113.82	111.71	155.87	83.70	20.20
	New Zealand	102.61	99.09	146.62	70.46	18.84
	Rest of the World	134.21	137.52	171.37	89.35	19.74
Consumer Price Index for Food	The U.S.	107.78	108.37	112.95	99.67	4.04
	The EU 28	106.56	108.40	110.30	99.10	3.48
	New Zealand	105.08	105.64	107.93	98.18	2.39
	Rest of the World	126.95	122.54	164.19	97.29	20.75
Palm Oil Price		96.54	93.86	143.42	59.72	20.54
Crude Oil Price		108.52	125.39	149.02	37.68	31.42

5.5 Empirical Results and Analysis

The weights for constructing foreign variables are of vital importance to the analysis of the dynamics of the model. Most practically, researchers use the trade flows between studied countries as the weights to indicate their mutual trade partnership. Besides, in some popular trade models such as gravity model, geographical distance is also selected as the weights to explain trade relationships among different countries. However, distance cannot properly signal bilateral trade linkages for the studied countries in this GVAR butter export price model which includes merely four exporters. Therefore, the fixed weights calculated by trade flows are employed in this study as outlined in Table 5.4. The dairy export flows by value are constructed as the weights to indicate the mutual trade relations among studied countries. As the weights show, the EU and New Zealand’s export share to the U.S. is higher than the U.S.’s share in the EU and New Zealand markets. However, the rest of the world accounts for most dairy imports from the U.S., the EU and New Zealand.

Table 5.4: Trade weights based on total dairy products export values[75]

Countries	The U.S.	The EU	New Zealand	RoW
The U.S.	0	0.05039	0.039375	0.910235
The EU	0.309259	0	0.016701	0.674040
New Zealand	0.165426	0.071756	0	0.762818
RoW	0.704301	0.289934	0.005766	0

Source: USDA-GATS.

Testing the stationarity is the first and necessary step to analysing time series data. The Augmented Dickey-Fuller (ADF) unit root test results are shown in Table 5.5. As indicated by the ADF tests, all the series included in this model do not reject the null hypothesis of nonstationarity, and are integrated at the first difference level, thus all the time series in the analysis are I (1). Therefore, the variables in each country or region might have cointegrating relationships, and the Maximum Eigenvalue Statistic and Trace Statistic are estimated to determine the cointegrating relationships.

Table 5.5: 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)	-2.16	-2.48	-2.78	-
p_{it}^{e} (no trend)	-2.14	-1.90	-2.47	-
D.p_{it}^{e}	-10.29	-5.11	-5.60	-
e_{it}(with trend)	-	-1.97	-2.09	-2.97
e_{it}(no trend)	-	-0.60	-1.72	0.28

[75] Note: Trade weights are computed using the following equation:

$$W_{ij} = \frac{1}{6}\sum_{t=2011}^{2016}\frac{ExV_t^{ij}}{ExV_t^{iworld}},$$

Where *i* represents the export countries, *j* represents the partner countries, ExV_t^{ij} represents the Export Values of the reporter *i* to partner *j* in the year *t*, ExV_t^{iworld} represents the export values of the reporter *i* exporting to the world in the year *t*.

Therefore, the average of the share of Reporters' dairy export value to Partners in the Reporters' dairy export value to the world from 2011 to 2016. In the above table, the exporters (Reporters) are displayed in the row and each row sums to 1.
Data to compute these are UN Comtrade data extracted from USDA-GATS dataset.

D.e_{it}	-	-4.59	-5.29	-5.80
p_{it}^{f} (with trend)	-2.54	-2.36	-2.42	-2.15
p_{it}^{f} (no trend)	-1.13	-1.63	-1.06	-2.49
D.p_{it}^{f}	-5.20	-4.86	-6.00	-5.83
CPI_{it} (with trend)	-0.04	-1.98	-2.55	-1.69
CPI_{it} (no trend)	-2.49	-1.87	-2.86	0.67
D.CPI_{it}	-4.63	-5.44	-6.79	-4.05
p_{it}^{e*} (with trend)	-2.35	-2.08	-2.51	-2.52
p_{it}^{e*} (no trend)	-1.95	-2.09	-2.49	-2.50
D.p_{it}^{e*}	-4.58	-10.11	-8.85	-8.89
e_{it}^{*} (with trend)	-2.89	-2.95	-2.89	-1.95
e_{it}^{*} (no trend)	-0.10	0.28	-0.10	-0.58
D.e_{it}^{*}	-4.01	-5.78	-4.00	-4.56
p_{it}^{f*} (with trend)	-2.17	-2.26	-2.23	-2.50
p_{it}^{f*} (no trend)	-2.43	-2.03	-2.23	-1.26
D.p_{it}^{f*}	-5.82	-5.69	-5.69	-5.08
CPI_{it}^{*} (with trend)	-1.72	-1.70	-1.75	-0.17
CPI_{it}^{*} (no trend)	0.60	0.30	0.47	-2.82
D.CPI_{it}^{*}	-4.05	-4.12	-4.08	-4.55
p_{it}^{po*} (with trend)				-2.93
p_{it}^{po*} (no trend)				-1.21
D.p_{it}^{po*}				-6.61
p_{it}^{co*} (with trend)	-2.04			
p_{it}^{co*} (no trend)	-0.89			
D.p_{it}^{co*}	-5.88			

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, the orders of p and q are selected using the AIC criteria based on the pre-constraint $4 \geq p_i, q_i \geq 1$. To find appropriate lag orders, it is assumed that the model has both an unrestricted intercept and a co-trending restriction to each country or region model. The results are shown in Table 5.6 and indicate that the p and q selected for VARX models of the US and the EU-28 are constraint to be 4 by the pre-constraint $4 \geq p_i, q_i \geq 1$.

Table 5.6: VARX order and number of cointegrating relationships

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

For the U.S., the EU and New Zealand, the number of cointegrating relationships in their VECMX models are 3, 2 and 3 respectively, while for the rest of the world there is no cointegrating relation among the variables.

The important assumption underlying the GVAR model estimation is the weak exogeneity of the country-specific foreign variables and the global variables with respect to the long-run parameters of the conditional model. The weak exogeneity is tested as described in Harbo, Johansen, Nielsen, and Rahbek (1998).

The results of Table 5.7 reported the F statistics of the weak exogeneity test which indicate that the null hypothesis of weak exogeneity for foreign-specific variables cannot be rejected at the significance level of 5%. It should be noted that the palm oil price might not be weakly exogeneous for the U.S. and the EU VECMX models. Therefore, the results for impulse response functions of the U.S. and the EU after a shock to palm oil price might be misleading. However, as most variables satisfy the weak exogeneity assumption, the GVECM satisfied the condition to do comparative studies on the relationship between country-specific and foreign-specific variables and to conduct the impulse responses analysis.

Table 5.7: F statistics of weak exogeneity test at the 5% significant level

Country	Critical Value	p_{it}^{e*}	e_{it}^{*}	CPI_{it}^{*}	p_{it}^{po}	p_{it}^{co}
USA	2.78	1.47	1.01	0.01	3.38	-
EU 28	3.23	2.44	0.68	0.19	5.80	0.95
New Zealand	2.80	1.30	0.27	1.39	1.48	1.67

The effects of foreign-specific variables on corresponding domestic variables could be analysed with the cointegrating VECMX being performed. The results of the contemporaneous effects of foreign variables on domestic counterparts along with White's heteroscedastic robust t-statistics are reported in Table 5.8. The contemporaneous effects could be interpreted as the impact elasticities to show the short-run impact of the foreign-specific variables on the domestic counterparts (Dees, Mauro, Pesaran, & Smith, 2007; M. Hashem Pesaran et al., 2004). The effects coefficients of butter export price index for all countries or regions are positive, which implies that the "world" butter export price has a positive impact on the butter export price of the US, the EU and New Zealand. However, all the estimates are not statistically significant. In the VARX models for New Zealand and RoW, the exchange rate contemporaneous effects estimations are positive and statistically significant. So, the "world" exchange rate against the US dollar has positive impacts on the bilateral exchange rate between the US dollar and New Zealand and the RoW in the short run. The CPI for food coefficient in the EU model is negative yet not statistically significant. The CPI for food contemporaneous effect estimation in the US VARX model indicates that the "world" CPI for food has a positive impact on the CPI for food in the US in the short run.

Table 5.8: Contemporaneous effects of foreign variables on domestic counterparts

Country	p_{it}^e	e_{it}	CPI_{it}
USA	0.35		0.16
	(1.77)		(2.34)
EU 28	0.06	0.26	-0.12
	(0.56)	(1.96)	(-1.17)
New Zealand	0.13	0.62	0.22
	(1.42)	(12.03)	(2.06)
Rest of World		0.26	0.38
		(2.12)	(1.68)

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

Table 5.9 reports the standard deviations of residuals for each equation in country specific VECMX*. The impulse response functions are based on the shocks to residuals in each variable equation.

Table 5.9: Standard deviations of VECMX* Residuals

	US	EU	New Zealand	Rest of the World
p_{it}^{e}	4.788198	3.234492	5.90504	2.363999
e_{it}		1.726215	1.463513	4.411044
p_{it}^{f}	2.752751	2.785113	3.430495	0.574588
CPI_{it}	0.212703	0.26027	0.507459	-
p_{it}^{co}	4.481961	-	-	-
p_{it}^{po}	-	-	-	5.667314

5.6 The Generalized Impulse Response Analysis

The GVAR model established in this study is dynamically stable with 8 eigenvalues equal to unity and with the remaining moduli less than unity. The eigenvalues in moduli are decreasing to zero gradually, thus it is expected that Generalized Impulse Response Functions (GIRFs) will converge towards a steady-state equilibrium quickly.

Five external shocks were simulated to analyse the dynamic characteristics of the butter export prices and impacts of the shocks on the studied variables in the Global Vector Error Correction Model:

(1) A one-standard-error positive shock to crude oil price
(2) A one-standard-error positive shock to palm oil price
(3) A one-standard-error negative shock to exchange rate
(4) A one-standard-error positive shock to CPI for food
(5) A one-standard-error positive shock to butter export price

In the GIRFs analysis, a one-standard-deviation shock to each variable can be quantified using standard deviations outlined in Table 5.9.

5.6.1 The Impacts of Crude Oil Price Shock

Figure 5.6 depicts the GIRFs of butter export prices to a simulated one-standard-error positive shock to the crude oil price, which means increases in growth of crude oil price index by 4.48. Instead of a positive response to the positive shock to crude oil price as assumed, the simulated shock results in an increase in butter export prices for the first month and then slight decreases in butter export prices after 2 or 3 months, although the negative impacts on butter prices are not significant. The response of the U.S. to the shock is more significant than that of the EU and New Zealand. The reasons could be that: U.S. cows are corn-fed in large and industrialized farms that consume more energy while cows in the EU and New Zealand are mainly grass-fed on a smaller scale. Corn is extensively used in making biofuels, thus highly linked with crude oil price. Therefore, crude oil price as a fuel may influence the butter export price of U.S. more than EU and New Zealand prices.

However, the response of butter export prices to crude oil price shocks is slightly different from previous studies on other agri-food products in which positive relationships between crude oil price and other agricultural commodities were found. The results in this study imply that, unlike other commodities such as wheat, vegetable oils and maize, crude oil price shocks merely influence butter export prices of major exporters in the long term. The butter export prices will respond positively and slightly just after the soaring crude oil price shocks, yet the price increase will not last long. The reason behind this could be due to less dependence on fuel in the production, supply and distribution processes for butter.

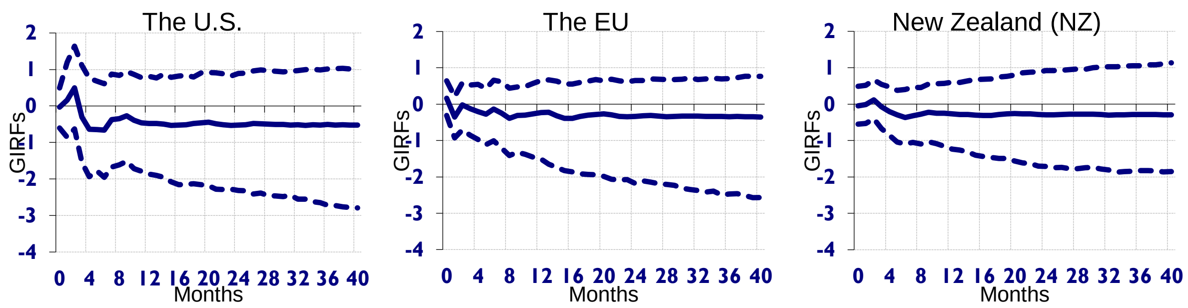

Figure 5.6: Generalized impulse response of butter export price after a positive one-standard-error shock to crude oil price (bootstrap median estimates with 90% bootstrap error bounds)

5.6.2 The Impacts of Palm Oil Price Shock

The GIRFs of butter export prices to a one-standard-error positive shock to palm oil price are illustrated in Figure 5.7 the impacts on the price of the US and New Zealand are statistically significant. A positive one-standard-error shock to growth of palm oil price index (increases by 5.66) instantly raises New Zealand butter export price by 0.38, while, after 8 months the increase is around 2.75 and stabilizes at the level of 2.77. It means 1% increase in palm oil price index will lead to 0.49% increase in New Zealand butter export price in the long run. U.S. butter export price fluctuates for the first 5 months, after which the GRIF remains at a level of 2.25. It means 1% increase in palm oil price index will lead to 0.39% increase in U.S. butter export price in the long run. As for the EU, its butter export price response is a bit weaker and unusual with a slight decrease for the first two months and then increases until stabilizes at the level of 0.8 after 3 months, yet the GIRFs estimates are not statistically significant.

To sum up, palm oil prices have a stronger impact on New Zealand price than on those of the EU and the U.S. The economic logics of the GRIFs patterns for butter export prices among different exporters might be explained by their diverse export destinations and structure. The main butter export destinations for New Zealand are China and other Asian countries, where butter is not the major diet while palm oil is substantially imported. So, when there is a positive shock to the palm oil price, the demand for palm oil shifts to butter, thus causing the butter export price to rise. As for the U.S., the increasing palm oil price could affect the butter price through the crude oil channel. Different from New Zealand and the U.S., the EU is both a major palm oil importer and exporter, and its major extra EU butter export destinations such as the U.S. and Middle East countries merely import palm oil. So, the response of EU butter export prices is not as much as the U.S. and New Zealand's.

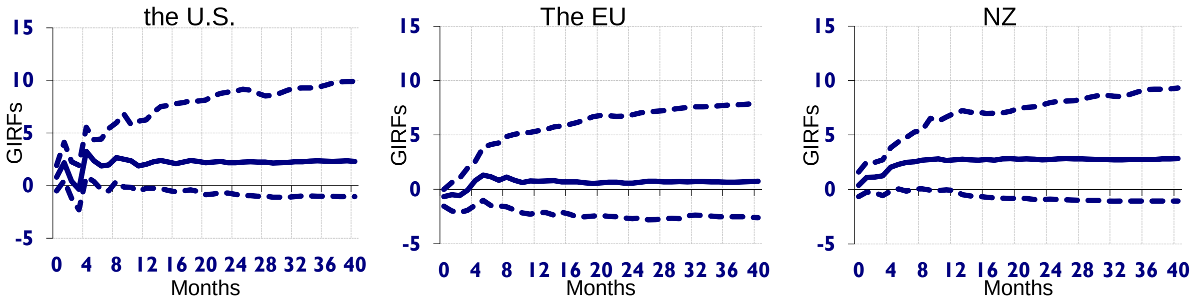

Figure 5.7: Generalized impulse response of butter export price after a positive one-standard-error shock to palm oil price (bootstrap median estimates with 90% bootstrap error bounds)

Figure 5.8 below also reflects the consistency in the movement patterns of the palm oil price index and butter export price indexes of the EU, New Zealand and the US. The co-movement pattern is quite clear.

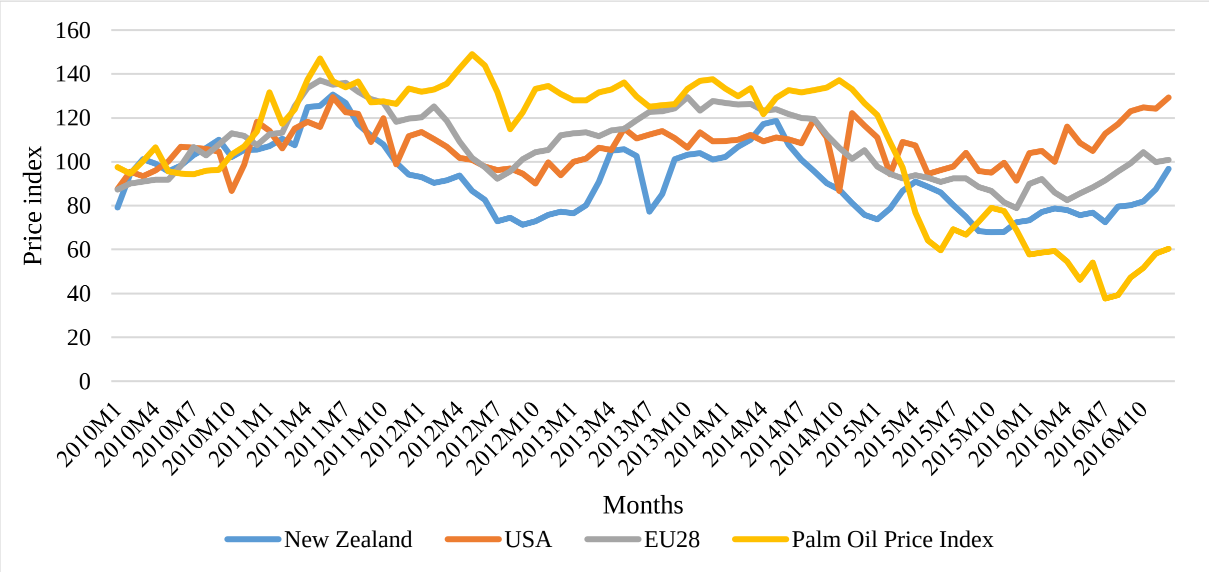

Figure 5.8: Palm oil price index and butter export price indexes of New Zealand, the U.S. and the EU

5.6.3 The Impacts of Exchange Rate Shock

Exchange rate of local currency per US dollar represent the relative price relationship of the local currency and the US dollar. A negative shock to the exchange rate indicates the depreciation of US dollar or the appreciation of the local currency against the US dollar.

Figure 5.9 to Figure 5.11 outline the responses of butter export prices to a one-standard-error negative shock to the exchange rate of local currency per US dollar, which simulates a relative depreciation of the US dollar and appreciation of local currency. In general, US dollar depreciation causes an increase in butter export prices of the U.S., the EU and New Zealand with different impacts: a) the negative shock to exchange rate of the EU (decrease in the growth of Euro-US Dollar exchange rate index by 1.73) and the RoW (decrease in the growth of RoW-US Dollar exchange rate index by 4.41) resulted in an increase of butter export prices in the U.S., the EU and New Zealand as shown in Figure 5.9& Figure 5.11. New Zealand's butter price responds more significantly than the U.S. and the EU's when facing a shock in the RoW's exchange rate; specifically, a one-standard-error shock to RoW's exchange rate (decrease in growth of RoW exchange rate index by 4.41) leads to 4.45 increase in butter export price of New Zealand. It means 1% decrease in RoW exchange rate growth will lead to 1.01% increase in New Zealand butter export price; b) the impact of negative shock to the exchange rate of the New Zealand dollar per US dollar on the studied countries' butter export prices is not statistically significant as illustrated in Figure 5.10.

To sum up, the exchange rate has significant impacts on butter export prices and different currencies appreciation against the US dollar results in different levels of price rises among different exporters. New Zealand's butter export price could be significantly affected by the negative shock to RoW currency appreciation against the US dollar. This might be due to the fact that most countries aggregated as the Rest of World (RoW), such as China, are net importers of dairy products and the main export destinations for New Zealand butter. The negative shock to the exchange rate increases purchasing power and price incentives of these importers as it lowers import prices for these RoW importers. However, the appreciation of the New Zealand dollar against the US dollar barely affects butter export prices in the U.S. and the EU, while it will have positive impacts on butter export prices for New Zealand for the first three months and then the impacts stay at a negative level. This result indicates that the exchange rate of New Zealand has little spill over effect on butter exports prices of other countries.

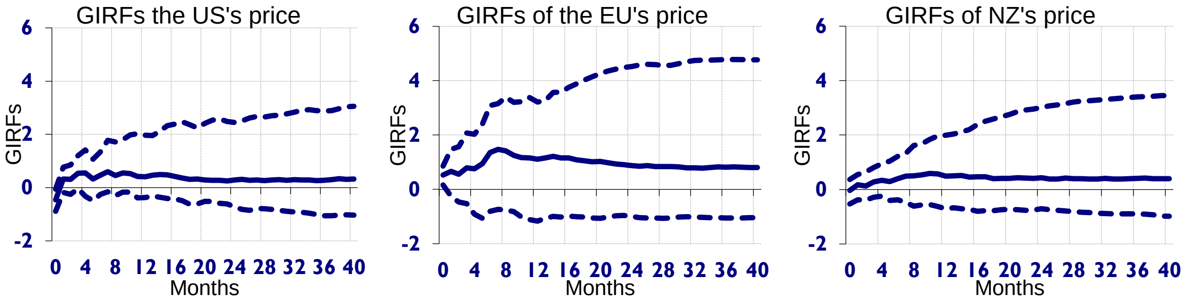

Figure 5.9: Generalized impulse response of butter export prices after a negative one-standard-error shock to exchange rate of the Euro per US dollar (bootstrap median estimates with 90% bootstrap error bounds)

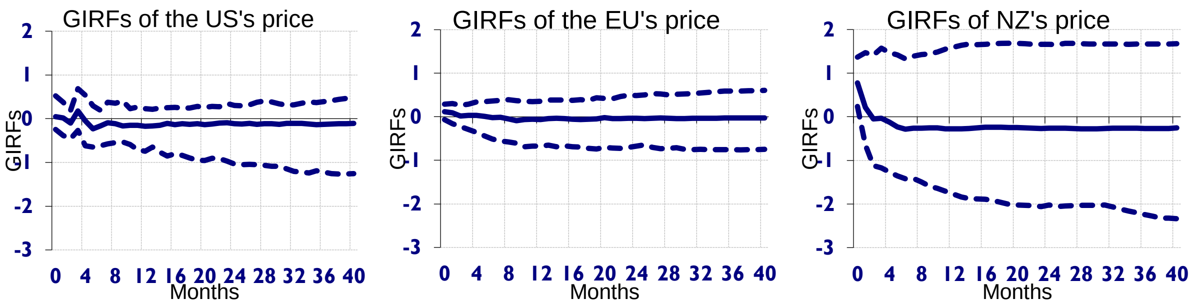

Figure 5.10: Generalized impulse response of butter export prices after a negative one-standard-error shock to exchange rate of New Zealand dollar per US dollar (bootstrap median estimates with 90% bootstrap error bounds)

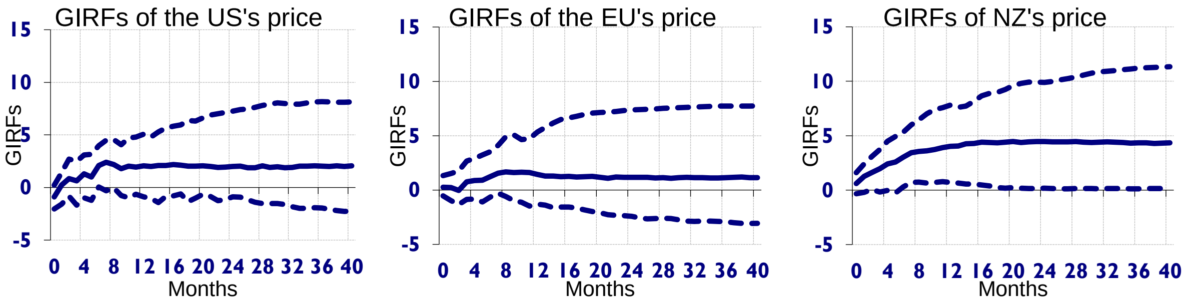

Figure 5.11: Generalized impulse response of butter export prices after a negative one-standard-error shock to exchange rate of the aggregated RoW's currency per US dollar (bootstrap median estimates with 90% bootstrap error bounds)

5.6.4 The Impacts of CPI for Food Shocks

Figure 5.12 illustrates the time profiles of butter export prices' GIRFs after a one-standard-error positive shock to CPI for food index. The simulated positive shock to different countries' food CPI has different impacts on butter export prices of different countries, and these impacts are generally not statistically significant: a) A positive shock to food CPI of the EU (increase in growth of food CPI of the EU by 0.26) causes significant butter export price increases for the EU and New Zealand. Increases in the US butter price is swift and stabilizes at the level of 0.34, yet it is not statistically significant; the increase in the EU butter price is statistically significant and swift, rises to a level of over 2 and then stabilizes at the level of 1.40; New Zealand's price also swiftly and statistically significantly increases and stabilizes at the level of 1. Therefore, 1% EU CPI inflation will lead to 5.38% and 3.84% increases in butter export prices of the EU and New Zealand, respectively, in the long run; b) A positive shock to New Zealand's food CPI hardly impacts on butter export prices; c) A positive shock to U.S. food CPI (growth of U.S. food CPI increase by 0.21) decreases butter export prices of the U.S. statistically significantly, while it causes decreases in the prices of the EU and New Zealand yet not significantly; d) a positive shock to RoW's food CPI deceases butter export prices of the U.S. and the EU, and increases that of New Zealand at a high level of 2.8. However, its impacts are not statistically significant.

Responses of butter export prices among different exporters to positive shocks in the food CPI in different countries and regions vary. Theoretically, rising CPI indicates that domestic prices will rise in general, however, the domestic dairy price which is only a small part of the food CPI basket might not contribute to a rise in CPI for food. Moreover, there would be different impacts of CPI for food[76] on export prices for export-oriented countries and high domestic consumption countries: a) for export-oriented, open and small countries such as New Zealand, their export price will be influenced by both the domestic CPI and the CPI in the main export destinations. Inflations in its destinations (such as the EU and the RoW) will stimulate the exports of New Zealand, thereafter its export prices will rise. However, as a small economy, inflation of New Zealand hardly impacts on other countries' export prices; b) for high domestic butter consumption countries such as the U.S. (99%) and the EU (90%), domestic food price

[76] CPI for food basket may compose different food products and their contribution to CPI varies too.

inflation will have more impact on the butter export prices than food price inflation from other countries.

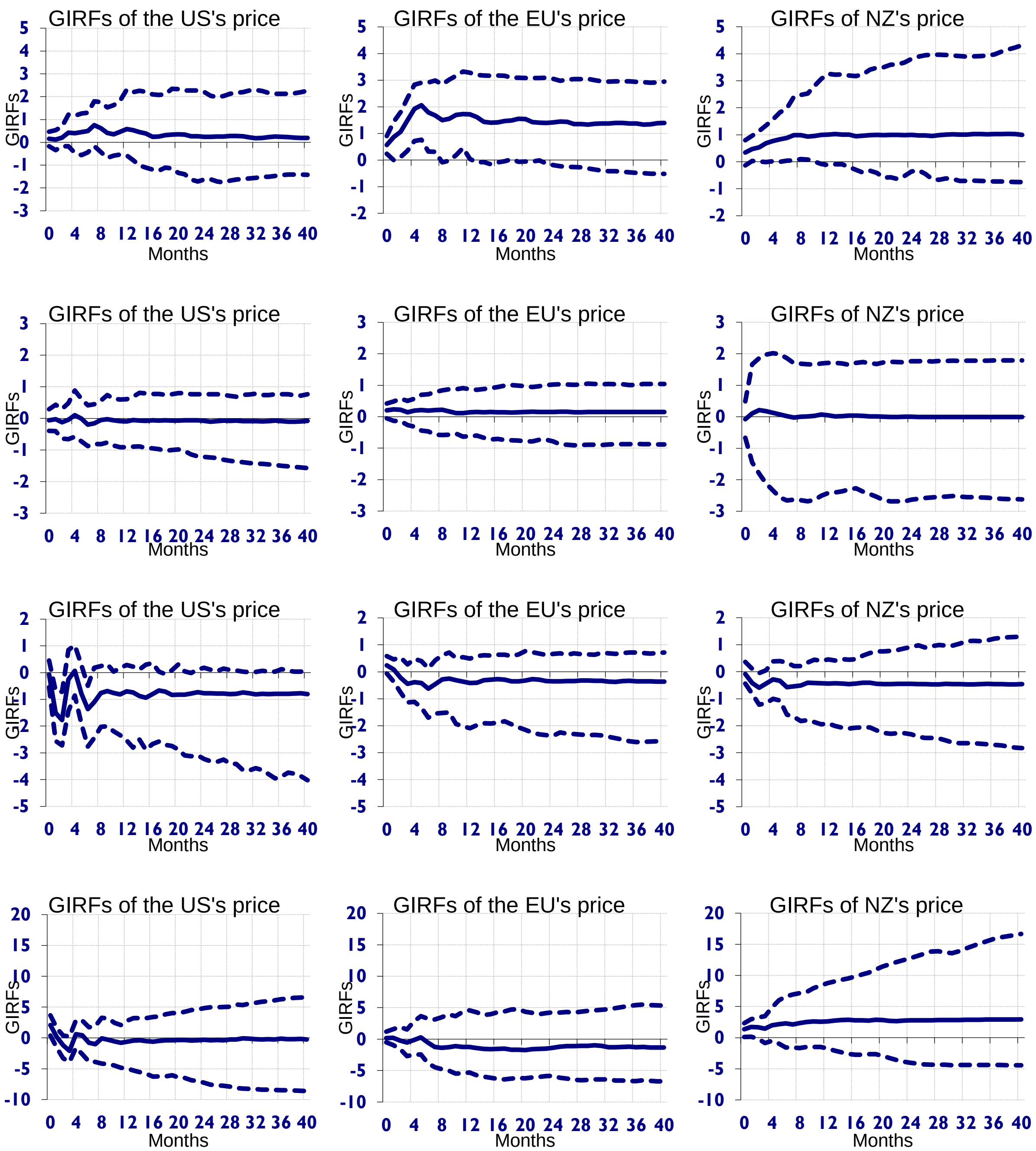

Figure 5.12: Generalized impulse response of butter export prices after a positive one-standard-error shock to CPI for food of the EU (top), New Zealand (row 2), the U.S. (row 3) and the RoW (bottom) (bootstrap median estimates with 90% bootstrap error bounds)

5.6.5 Spatial Price Transmission and Market Integration in the Global Butter Export Market

Figure 5.13 depicts the GIRFs of a positive shock to the butter export prices of each country. Butter export prices in the U.S., the EU and New Zealand increase swiftly with a positive shock to the butter export price of one exporter. The results illustrate that: a) butter export prices increase swiftly and at a higher level with a positive shock to itself, although the responses are at different levels for different countries. The EU butter export price rises at the level of 2.5 and stabilizes at a level of 2.2 after a shock to itself (growth of EU butter export price index increases by 3.23). Thus, 1% increases in EU butter price will lead to 0.68% increases in itself in the long run. New Zealand's butter export price increase immediately at the level of almost 6 and then stabilizes at the level of 4.8 when facing a shock to itself (increase by 5.91). Thus, 1% increases in EU butter export price will lead to 0.81% increase in itself in the long run. The U.S.'s butter export price increase at the level of 4.7 swiftly when facing a positive shock to itself (increase by 4.79), and then stabilize at the level of 0.9; Thus, 1% increase in US butter export price will lead to 0.19% increase in itself in the long run. b) the GIRFs of U.S. butter export prices display similar patterns but slightly different scales when facing positive shocks to the butter export prices of the EU and New Zealand. A positive shock to the EU butter price has a relatively weaker instantaneous effect on the U.S. butter price with an increased level of 0.56 for the first month, reaching a stable level of 0.7 after 8 months; while a shock to New Zealand's butter price increases the U.S. butter price by 1.28 for the first month, reaching a stable level of 0.4 after 8 months; c) The butter export price of New Zealand only slightly responds to a positive US butter price shock, while its increase stabilizes at a level of 1.38 when facing a positive shock to EU butter price; d) the EU butter export price increases for 12 months when there is a positive shock to New Zealand's butter price, after which the increase almost stabilizes at the level of 0. When there is a positive shock to the U.S. butter price, the EU price increases slightly for the first 8 months and then stabilizes at the level of 0.47.

To sum up, there is market integration among geographically separated butter exporters, yet the spatial price shock spill-overs are weak and butter export markets are not well-integrated. Price transmission from one exporter to the others is not as significant and swift as on itself, but the price of New Zealand could be subjected to the prices of the EU in the long run. The shock to the U.S.'s butter price doesn't have a significant impact on the others. This might be because the U.S. is less competitive and influencing in international butter export markets. Comparing it to the EU and New Zealand, the U.S. butter export share of the global market is much smaller, and the U.S. is also a large consumer and importer of butter.

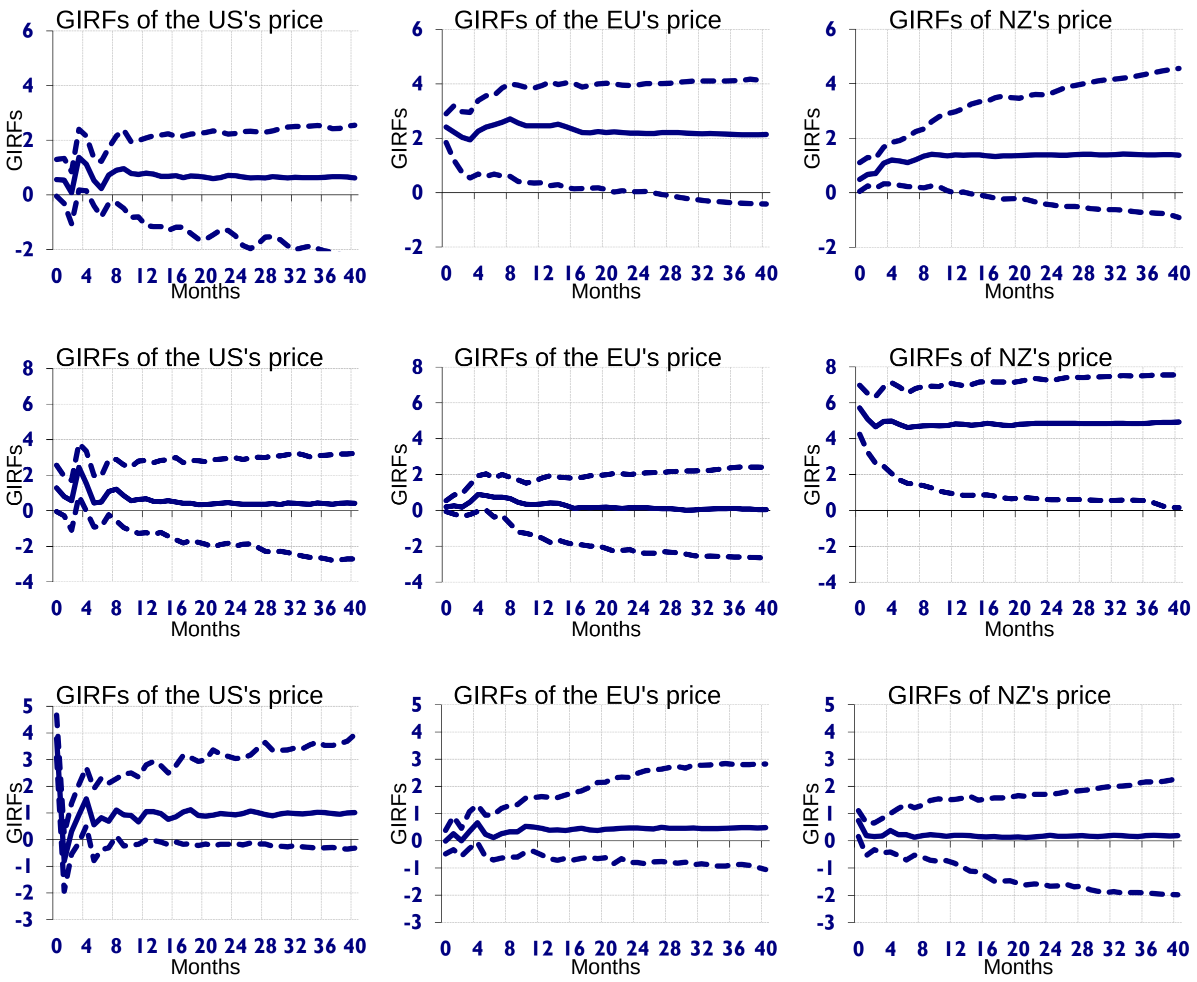

Figure 5.13: Generalized impulse response of butter export prices after a positive one-standard-error shock to butter export prices of the EU (top), New Zealand (middle) and the U.S. (bottom) (bootstrap median estimates with 90% bootstrap error bounds)

5.7 Conclusion and Discussion

5.7.1 Conclusion

This chapter has analysed the spatial price transmission and the impacts of other influencing factors on butter export prices in the global butter export market using a

Global Vector Error-Correction Model (GVECM). The empirical research into the long-run price dynamics and market integration, as well as interaction of butter export prices with five drivers (CPI for food, exchange rate, fertilizer price, palm oil price and crude oil price) among major geographically separated exporters (the U.S., the EU and New Zealand) reveals several significant findings:

(1) Positive shock to crude oil price seems to have no statistically significant impact on butter export prices, or even surprisingly deceases the butter export prices slightly.
(2) Shocks to international palm oil price could be transmitted to the EU, New Zealand and the U.S.'s the butter export prices. Price transmission intensity is the highest from palm oil price to New Zealand's butter export price, and next on U.S. butter export prices.
(3) Simulated U.S. dollar depreciations against the Euro and the aggregated RoW currency will cause a butter export price upsurge in the U.S. and New Zealand, respectively. However, a U.S. dollar depreciation against the New Zealand dollar has no impact on butter export prices.
(4) Shocks to different countries or regions' CPI for food results in different responses on butter export prices in terms of response directions. Generally, CPI for food spill-over effects and causality relations with butter export prices are not clear. Increases in EU CPI for food will lead to increases in butter export price of the EU and New Zealand, while increases in US CPI for food will decreases butter export price of the US and have no impacts on others.
(5) Shocks to the butter export price of the EU do have spill-over effects to the U.S. and New Zealand butter export prices. Shocks to the U.S. and New Zealand' butter export prices, however, seemed to be retained within the country. The spatial price shock spillovers are weak and butter export markets are not well-integrated, but New Zealand's butter export price would be more significantly influenced by the shock to the EU's butter price.
(6) EU butter export price is more resilient to external shocks such as US dollar depreciation, palm oil price and other countries price shocks than New Zealand and the US.

5.7.2 Discussion

The empirical results of this study have several important policy implications for the international butter export markets and several policy advices are drawn from the above conclusions: (1) Palm oil price might be set as a price signal for butter export prices. Policy makers should pay attention to international palm oil prices and trade performance to monitor the butter export market. (2) Exchange rate fluctuations greatly influence butter export prices and the US dollar depreciation will lead to price upsurges for major butter export countries that has large exports to production ratio. Stabilizing the exchange rate and avoiding sudden policy changes and uncertainties is a necessary step in stabilizing butter export prices. (3) The pattern of price transmission implies that policy intervention measures by the EU, such as controlling domestic food prices and imposing export refunds may affect New Zealand's butter export price stability, so EU butter exporters should be watched more closely by New Zealand's agriculture policies and domestic food market situation. (4) The EU butter export price has been proved to be resilient to external shocks, which might due to its strong internal trade market and weak dependence on extra-EU exports.

There are several potential directions for future research. Firstly, grain commodity prices used as feeds (e.g. corn price) and climate indicators (e.g. rainfall precipitation, temperature and extreme weather events see (Chatzopoulos, Domínguez, Zampieri, & Toreti, 2019; Gornall et al., 2010) for analysis of climate changes impacts on crop commodities) may be incorporated into the analysis to discuss impacts across sectors and climate change effects. Secondly, the price transmission among various dairy commodities such as milk powders, cheese and whey, and their interlinkage with macroeconomic factors. Thirdly, innovative models such as the regime-switching GVAR, copula-GARCH model may be used to compare price transmission and dynamics under different regimes.

Chapter 6 Market Integration, Price Dynamics and Market Shocks in European Union Internal and External Cheese Export Markets

6.1 Introduction

European Union (EU) dairy policy is subject to the Common Agricultural Policy (CAP) and one of the most important objectives of the CAP is to facilitate spatial agricultural market integration within individual member states as well as at EU level by reinforcing price discovery mechanisms. The EU is heterogeneous with 28 member states of different economies, industry structures and trade patterns. Article 2 of the Lisbon Treaty (European Union, 2007[77]) states the common ideal of the EU member states to progress by cooperation specifically:

> *"The Union shall establish an internal market. It shall work for the sustainable development of Europe based on balanced economic growth and price stability, a highly competitive social market economy, aiming at full employment and social progress, and a high level of protection and improvement of the quality of the environment. …*
>
> *…*
>
> *It shall promote economic, social and territorial cohesion, and solidarity among Member States"*

As seen in Article 2, the EU promotes internal market, economic and social cohesion and designs various policies to achieve this goal. The Common Customs Tariff[78] and the European Single Market[79] play a central role for the EU agricultural sector to be competitive in the international market, while somewhat protected with a barrier-free internal market. The single market functions to stimulate trade and competitiveness of

[77] Treaty of Lisbon (2007). European Union Official Website: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=OJ:C:2007:306:TOC.

[78] See the European Commission Website for details of Common Customs Tariff: https://ec.europa.eu/taxation_customs/business/calculation-customs-duties/what-is-common-customs-tariff_en.

[79] See the European Commission website for details of the European Single Market: https://ec.europa.eu/growth/single-market_en.

the EU. These two major strategies of the EU imply a liberalization and more intense competition of intra-EU trade among EU countries through market integration and enhanced competitiveness and protection for EU countries in international trade with third countries. In terms of the dairy sector, CAP has undergone several rounds of reforms to implement a more market-oriented policy for enhancing competitiveness of the EU dairy sector in the international market. These policy and market changes have resulted in market-oriented competition and interactions among member states of the EU and structural changes for the EU dairy sector in international trade (Zimmermann & Heckelei, 2012). However, changes to EU dairy policies such as the abolition of milk production quota and removal of price floors has also led to price fluctuation and market unpredictability (R. A. Jongeneel & van Berkum, 2015). The most fundamental policy change was the abolition of the milk quota in March 2015 which really released constraint on milk production in the north-western EU member states. EU CAP reform and the outcome of WTO trade negotiations to lower border protection from imports and reduce subsidized exports make it clear that the EU dairy sector will be more market oriented in future. Besides CAP reforms, the EU dairy sector is experiencing market shocks, such as uncertainties brought on by Brexit, rising trade protectionism, and a slowdown in economic growth, which could impact on the equilibrium of EU dairy markets and trade patterns. Therefore, it is necessary to have a comprehensive understanding of EU dairy price transmission and market dynamics for the intra-EU and extra-EU trade market.

Many studies have conducted research on market integration in the EU at the regional level (Benedek, Bakucs, Fałkowski, & Fertő, 2017; Viju, Nolan, & Kerr, 2006; Zimmermann & Heckelei, 2012) or studied the effects of changes on the dairy sector at the national level for a single-country case (Salou et al., 2017). However, there are few studies that focus on the effect of influencing factors on the dairy sector across the EU or comprehensive studies on the degree of market integration in terms of dairy trade for the EU. Besides, the production, processing and industry characteristics of dairy sectors in different EU member states also vary. Therefore, a comprehensive analysis to reveal the interactions and heterogeneity across EU member states can provide insightful information to facilitate industry development, enhance competitiveness and ensure price stability in the EU dairy sector.

The dairy sector is a multi-product, high energy-consumption, and dynamic industry with its products varying in terms of storability, market characteristics and price stability. Thus, it is necessary to conduct analysis at disaggregated product level to better understand the market dynamics and price mechanisms for each specific product. In this study, cheese is selected as a representative dairy product to analyze spatial price transmission and market dynamics in the EU for the following reasons: (1) the EU is the world's biggest cheese exporter and is a producer with enormous cheese varieties[80] exported all over the world; (2) cheese, as one of the major dairy products mainly produced and exported in developed countries, has more potential for future market expansion to other emerging markets.[81] Understanding price transmission and price dynamics mechanisms for cheese could shed light on the adjustment of trade strategy and policy to boost the dairy industry as a whole; (3) in the case of the EU dairy product exports, cheese in the EU has the unique characteristic that its export market is dominated by a few major European exporters. (4) Cheeses are one of the major dairy products with great nutritional and biological value, produced through the coagulation of milk protein (casein) separated from the milk's whey,[82] and many different varieties are traded and marketed around the world. It is an important dairy product that its price transmission could reflects the effects of marketing, branding and geographical protections. This indicates useful implications on policy prescription to ensure market and price stability for dairy products. Among 28 EU member states, Germany, the Netherlands, France, Italy, Ireland and the United Kingdom (UK) are selected as the countries to study for the following reasons: (1) Germany, the Netherlands, France and Italy are the top four European cheese exporters accounting for almost half of EU total cheese exports; (2) Brexit could incur potential policy shocks for the EU, especially for Ireland and this is the main area of interest for policy investigation interest in this chapter. Ireland and the UK have very close trade relations in terms of cheese. Incorporating these two countries into the analysis could provide insights on the possible consequences of Brexit on trade relations between the UK and EU member states.

[80] BRIEFINGEPRS | European Parliamentary Research Service Author: Marie-Laure Augère-Granier Members' Research Service PE 630.345 – December 2018. The EU dairy sector-Main features, challenges and prospects

[81] Cargill, 2018. The shifting global dairy market: Ushering in a new era of dairy products. Accessed at https://www.cargill.com/doc/1432126152938/dairy-white-paper-2018.pdf on 30/12/2019.

[82] Gateway to dairy production and products, FAO. Website: http://www.fao.org/dairy-production-products/products/types-and-characteristics/en/, accessed on 14/08/2019.

This chapter concentrates on the EU dairy market with a special focus on cheese exports and investigates whether an internal export market with strong market integration for cheese exists in the EU and whether price transmission is smooth in non-EU (external) export markets. It also examines the impact of market shocks on the dairy export price of each individual country.

In particular, the following questions are investigated and analyzed:

(1) To what degree is there market integration among major EU cheese exporting member states in terms of intra-EU and extra-EU (non-EU) exports, respectively?
(2) How do export prices for different countries interact with one another? Are there any differences for intra-EU export price transmission and extra-EU export price transmission?
(3) How do various market shocks affect cheese export prices for different countries? Are there any differences in the impacts on intra-EU export prices and extra-EU export prices?

To better understand these questions, the Global Vector Autoregressive Model (GVAR) proposed by M. Hashem Pesaran et al. (2004) is employed. Compared with econometric models, such as dynamic equilibrium models and basic Vector Autoregressive model, the GVAR approach has special advantages: (1) the data requirements are relatively low, while at the same time this high-dimensional model can arrive at rich conclusions via model estimates; (2) it can illustrate the dynamic relationships among studied variables across both country and time spans; (3) it connects country-specific models via several channels of international linkages, deciphering the size and speed of price transmission and shocks from other countries and its domestic markets; (4) it well fits the objectives of this study: it allows for a high-dimension dataset that allows this study simultaneously incorporate higher country-dimension, time-dimension and variable-dimension dataset to conduct dynamic analysis the price transmission and interactions between different countries following market shocks (Chudik & Pesaran, 2016).

The structure of the rest of this chapter is as follows: Section 6.2 presents an overview of EU's trade patterns for cheese in the internal and international markets. Section 6.3 describes the methodology and conceptual framework for this study. Section 6.4

presents the results of the empirical analysis. Finally, section 6.5 reaches the conclusion and discusses implications and future research.

6.2 Overview of EU Cheese Sector and Trading Context

6.2.1 Cheese in the EU

The EU is the largest cheese producer and exporter in the world and accounts for 79% of global cheese export with 24.8 billion US dollar in export value in 2018.[83] The EU is projected to account for 37% of world cheese exports by 2027 and 48% by 2028. This export growth will be sustained by increased exports to Canada via the EU-Canada Comprehensive Economic and Trade Agreement (CETA agreement), the assumed future ending of the ban imposed by the Russian Federation, and increased exports to Japan following ratification of the bilateral trade agreement in 2019 (OECD-FAO, 2018, 2019). Many cheeses from the EU member states has been protected under the Rules and Regulations 2081/92 and No. 1804/99[84]: namely, Protected Designation of Origin (PDO), Protected Geographical Indication (PGI) and Traditional Speciality Guaranteed (TSG).[85] These quality labels protect product names against imitation of cheese originating from specific areas, promoting the product diversity and creating uniqueness for EU cheese products (Bouamra-Mechemache & Chaaban, 2010; Velčovská, 2015).

Figure 6.1 indicates that production levels of EU cheese remains stable over the years and consumption to production ratio exhibit a slight downward trend. In 2018, total production and consumption of cheese amount to over 9.9 million and 8.8 million tonnes, respectively, with a production to consumption ratio of 88.74%. In general, a large share of cheese produced in the EU is domestically consumed either by trade between EU members or domestic consumption within individual EU member states.

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[83] Calculated using the data downloaded from the WITS-UN Comtrade database, including both intra-EU and extra-EU exports of the EU 28 member states. If the intra-EU export is excluded from the calculation, the share of EU export in the world total cheese export is 41.55% in 2018, the calculation is using the equation: $Share = \frac{value_{world}^{EU} - value_{EU}^{EU}}{value_{world}^{World} - value_{EU}^{EU}}$

[84] European Commission, March 1996. Commission adopts draft decision protecting the designations of various agricultural and food products: https://ec.europa.eu/commission/presscorner/detail/en/IP_96_153.

[85] For details of EU Geographical indications, see European Commission website at: https://ec.europa.eu/info/food-farming-fisheries/food-safety-and-quality/certification/quality-labels/quality-schemes-explained_en.

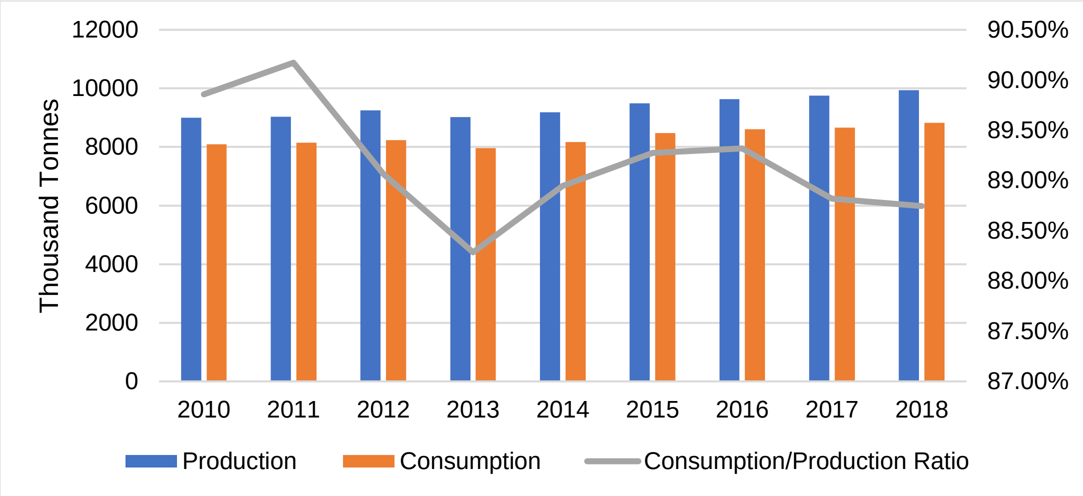


Figure 6.1: EU cheese production and consumption context from 2010 to 2018

Source: OECD-FAO Agricultural Outlook Database (2018-2029)

Intra-EU trade of cheese is much more pronounced than extra-EU trade in terms of both exports and imports. Table 6.1 outlines the studied EU countries' major export destinations for cheese, cheese export values and share of total cheese exports, and the top 5 cheese exporters in the world. Germany is the largest cheese exporter with an average export value of 4.3 billion US dollars, which represents 15% of total world export. The most significant export destinations are Italy (21%), the Netherlands (13%), Austria (6.9%), France (6.5%) and Spain (6.1%). The second place belongs to the Netherlands with an average export value of 3.80 billion US dollars which represents 13% of total world exports. Its top 5 export destinations are Germany (32%), Belgium-Luxembourg (13%), France (9.4%), Spain (5.7%) and the United Kingdom (4.3%). They represent almost three-quarters (64.4%) of the Netherlands' cheese export. France ranks the third for cheese exports in trade value with the average export value hitting 3.50 billion US dollars representing 12% of world exports, followed by Italy and Denmark with share of 9.8% and 5.7%, respectively. In total, the top 5 cheese export countries have absolute dominance as they account for 55.5% of global cheeses export by value. Compared with Germany, the Netherlands, France and Italy, the United Kingdom and Ireland have much smaller cheese exports by value and over 50% of Ireland's cheese export is destined for the United Kingdom.

Table 6.1: Top 5 cheese export destinations of studied EU countries and Top 5 exporters in the world, 2017

	Ranking of Top 5 export destinations of studied EU countries[86]				
Exporters	**1**	**2**	**3**	**4**	**5**
UK	Ireland	France	Netherlands	Germany	USA
Share	21%	14%	11%	7.30%	6.60%
Value	162.79	105.65	82.45	55.88	50.75
Ireland	UK	Germany	Netherlands	France	Algeria
Share	51%	8.80%	5.40%	4.90%	4.20%
Value	494.61	85.78	52.68	48.07	40.88
Netherland	Germany	Belgium-Luxembourg	France	Spain	UK
Share	32%	13%	9.40%	5.70%	4.30%
Value	1230.15	500.99	357.72	216.93	164.91
Italy	France	Germany	USA	UK	Belgium-Luxembourg
Share	19%	16%	11%	8.90%	5.20%
Value	543.29	476.00	317.47	259.14	150.93
Germany	Italy	Netherlands	Austria	France	Spain
Share	21%	13%	6.90%	6.50%	6.10%
Value	906.52	553.55	295.04	277.70	261.96
France	Germany	Belgium-Luxembourg	UK	Spain	Italy
Share	24%	19%	8.50%	8.20%	5.90%
Value	841.39	675.03	298.19	288.44	207.83
	Ranking of Top 5 exporters in the world				
	1	**2**	**3**	**4**	**5**
Exporters	Germany	Netherlands	France	Italy	Denmark
Value in billion USD	4.30	3.80	3.50	2.90	1.69
Share	15%	13%	12%	9.80%	5.70%

Source: Compiled by author, downloaded from the Observatory of Economic Complexity: OEC (HS92 Classification, HS Sub-Chapter 0406: Cheese and Curd), accessed on 12/08/2019.

[86] Value in million US Dollars

Intra-industry trade (IIT), which is defined as the concurrent importation and exportation of similar goods (Greenaway & Milner, 1984), has been a common phenomenon in international trade (Hartman, Henderson, & Sheldon, 1993). There exists strong IIT in the EU cheese trade. Table 6.2 outlines the studied EU countries' Top 5 import origins of cheese, cheese import values and share of total cheese exports and the Top 5 cheese importers in the world. In 2017, Germany was world's leading importer of cheese with an average import value of 4.26 billion US dollars which represents 14% of global imports, with 60% of its cheese imports originating from the Netherlands (29.0%), France (20.0%) and Italy (11.0%). The United Kingdom is the second largest cheese importer with a share of 6.9% of the world's total cheese imports and its cheese import value amounts to 2.03 billion US dollars, with around 63% of its cheese import from Ireland (24.0%), France (15.0%), the Netherlands (13.0%) and Germany (11.0%). For Germany, it is the high cheese consumption and the deeper assortment of high-quality varieties of cheese that lead to the high imports of cheese. It is the expanding and deepening of assortment of quality cheese in domestic market of the UK that results in the high level of cheese imports of the UK (Vlahović, Popović-Vranješ, & Mugoša, 2014). Italy ranks third in cheese imports with almost half of its cheese imported from Germany (46%) accounting for 6.6% of the world's total cheese imports. France is in fourth place for cheese imports with 5.8% share of the world's total cheese imports. Italy (31.0%), the Netherlands (21.0%) and Germany (16.0%) accounts for almost 70% of France's total cheese import. The top 5 importers account for 38.9% of global cheese imports by value in 2018 and all belong to the developed countries category. In the recent OECD-FAO agricultural outlook, it is projected that the Russian Federation, Japan, China, the United States, and Mexico will be the top five cheese importers by 2027 and cheese imports in developing countries will increase at a faster growth rate than developed countries (OECD-FAO, 2018).

Table 6.2: Top 5 cheese import origins of studied EU countries and Top 5 importers in the world, 2017

	Ranking of Top 5 import origins of studied EU countries[87]				
Importers	**1**	**2**	**3**	**4**	**5**
UK	Ireland	France	Netherlands	Germany	USA
Share	24.0%	15.0%	13.0%	11.0%	8.8%
Value	0.49	0.30	0.26	0.23	0.18
Ireland	UK	Germany	France	Italy	Netherlands
Share	63.0%	13.0%	6.6%	6.1%	3.1%
Value	0.16	0.03	0.02	0.02	0.01
Netherland	Germany	Belgium-Luxembourg	France	Denmark	Italy
Share	39.0%	21.0%	7.1%	6.3%	6.3%
Value	0.55	0.29	0.10	0.09	0.09
Italy	Germany	France	Netherlands	Lithuania	Belgium-Luxembourg
Share	46.0%	11.0%	7.4%	5.9%	5.0%
Value	0.91	0.21	0.15	0.12	0.10
Germany	Netherlands	France	Italy	Denmark	Austria
Share	29.0%	20.0%	11.0%	9.2%	8.4%
Value	1.23	0.84	0.48	0.39	0.36
France	Italy	Netherlands	Germany	Belgium-Luxembourg	UK
Share	31.0%	21.0%	16.0%	8.0%	6.1%
Value	5.43	3.58	2.78	1.39	1.06
	Ranking of Top 5 importers in the world				
	1	**2**	**3**	**4**	**5**
Importers	Germany	UK	Italy	France	Belgium-Luxembourg
Value	4.26	2.03	1.96	1.73	1.66
Share	14%	6.90%	6.60%	5.80%	5.60%

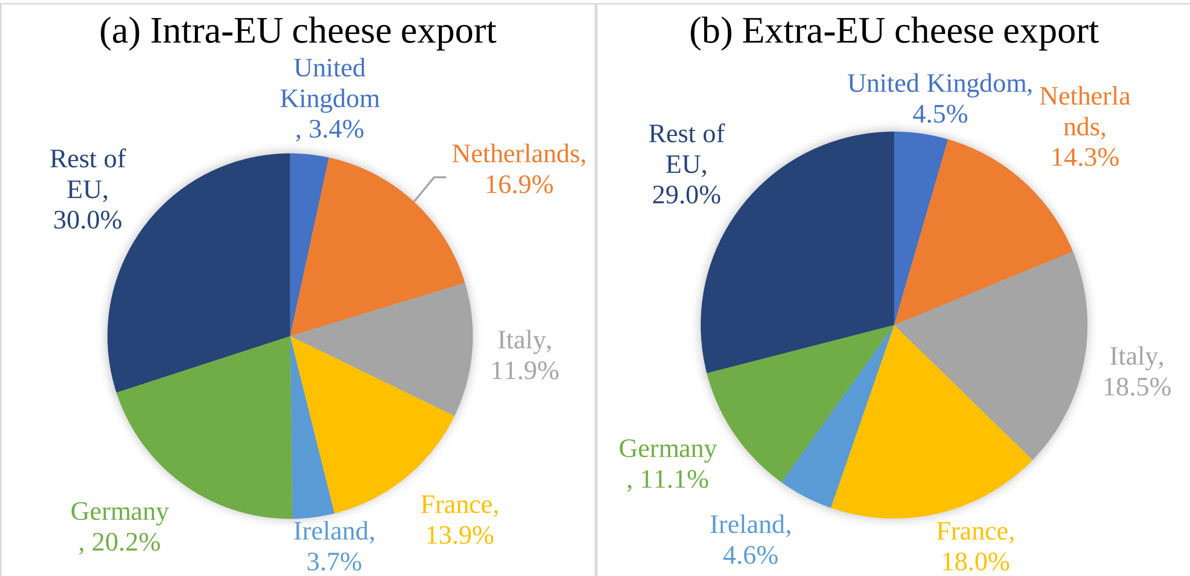
Source: Compiled by author, downloaded from the Observatory of Economic Complexity: OEC (HS92 Classification, HS Sub-Chapter 0406: Cheese and Curd), accessed on 12/08/2019 and 08/12/2019.

[87] Value in billion US Dollars

Therefore, there is high intra-industry trade of the EU due to taste similarity, product differentiation and scale economies. Specifically, economic integration, proximity to community and other European markets might lead to deeper intra-industry trade of the EU (McCorriston & Sheldon, 1991). Many European countries trade cheese to offer wider varieties of cheeses in its domestic markets for its residents to select and consume whichever types of cheeses they prefer. The intra-industry trade of cheese in the EU satisfies the consumers who prefers variety, choice and the advantages accruing from competitive pressures. (Bano & Lane, 1995).

Figures 6.2 (a) and 6.2 (b) depict the Intra-EU and Extra-EU cheese export shares of the six studied countries. Germany contributed the largest share (20.2%) of Intra-EU cheese exports, followed by the Netherlands (16.9%), France (13.9%) and Italy (11.9%). In terms of Extra-EU cheese export, Italy takes first place in cheese export share, accounting for 18.5% of the EU's extra-EU cheese exports, followed by France (18.0%), the Netherlands (14.3%) and Germany (11.1%). So, the United Kingdom and Ireland are not major cheese exporters among EU member states, while Germany, the Netherlands, France and Italy are the major EU cheese exporters that dominate EU cheese exports.

Figure 6.2: Cheese export shares in international markets in 2018 (Billon USD)



Source: Eurostat dataset, accessed on 11/08/2019

Table 6.3 presents each country's share of the various cheese products in each country's total intra-EU and extra-EU cheese exports. In 2018, most countries exported large share of the product HS 040690 "Cheese, Others, Including Cheddar, Colby, etc.", especially Ireland and the Netherlands (NL). In 2018, around 98.74% and 86.61% of Ireland's extra-EU and intra-EU cheese exports belong to the product category HS 040690, respectively. In the case of the Netherlands, 88.02% and 75.90% of its extra-EU and intra-EU cheese exports, respectively, belong to the product category HS 040690. While for Germany, France, Italy and the UK, a considerable share of their intra-EU cheese exports belong to the product category HS 040610 "Fresh cheese" as well, which is consistent with export proportions for different cheese categories in the aggregated EU28 cheese exports.

Table 6.3: Share of different cheese categories in their total intra-EU and extra-EU cheese exports at HS 6-digit product level, (%, 2018)

HS codes[88]	040610		040620		040630		040640		040690	
Countries	Extra-EU	Intra-EU	Extra-EU	Intra-EU	Extra-EU	Intra-EU	Extra-EU	Intra-EU	Extra-EU	Intra-EU
EU28	18.52	32.82	3.63	6.20	12.43	6.1	2.02	1.47	63.41	53.20
Germany	28.97	43.63	0.59	1.91	9.88	8.29	1.99	1.08	58.57	45.09
Ireland	0.29	2.85	0.01	4.01	0.87	6.47	0.09	0.06	98.74	86.61
France	14.05	36.70	7.23	2.98	22.27	7.13	1.60	2.08	54.84	51.11
Italy	29.20	47.42	4.79	12.66	0.63	0.60	3.16	6.67	62.22	32.64
NL	5.55	5.20	1.37	17.73	4.74	1.05	0.33	0.12	88.02	75.90
UK	16.24	39.71	11.71	3.01	8.22	5.28	2.25	0.90	61.57	51.09

In summary, the EU is the largest exporter of cheeses globally and its intra-EU cheese exports outweigh its extra-EU cheese exports. Most of the top cheese exporting countries of the EU are also top cheese importers, because different EU member states produce different cheese varieties and customers have preferences for different varieties of cheeses. Various types of cheeses from the EU are traded between EU member states and all over the world. The UK and Ireland are relatively small cheese exporters in the EU yet the cheese trade between the two countries is vibrant and in

[88] 040610: Fresh cheese, i.e. unripened or uncured cheese, incl. whey cheese, and curd;
040620: Grated or powdered cheese;
040630: Processed cheese, not grated or powdered;
040640: Blue-veined cheese;
040690: Cheese (excl. fresh cheese, incl. whey cheese, not fermented, curd, processed cheese, blue-veined cheese, and grated or powdered cheese, Including Cheddar and Colby).

large quantities. These two countries could be affected most by Brexit and potential trade policy changes.

6.2.2 EU Cheese Export Price Trends

Figures 6.3 (a) and 6.3 (b) below depicts the studied European countries' monthly export prices for cheese to extra-EU and intra-EU markets between 2010 and 2017. The free movement and trade among EU member states and the tariff and non-tariff barriers faced by EU member states for non-EU exports results in clear differences between intra-EU and extra-EU export prices for EU cheeses. As indicated in Figures 6.3 (a) and 6.3 (b), extra-EU export prices are higher than intra-EU export prices, and Italy has the highest export prices while Germany, as the largest cheese exporter and importer, has the lowest prices over the years. The cheese prices of all the studied countries displayed common movement patterns but were different of price levels. For extra-EU export prices, price levels and fluctuations of different countries vary greatly: (a) Prices of Italy, France and the UK are the top 3 highest, while prices of the Netherlands, Ireland and Germany are relatively lower and their price series display similar fluctuation patterns over the years; (b) The price series of Italy and France have displayed similar patterns since 2012, while the UK's price fluctuates violently over the years and has inflated to a high level during 2012 to 2015. For intra-EU export prices, the price series of all countries display similar fluctuation patterns, while the price level for Italy is the highest and its price fluctuation before 2012 is larger than other countries. The main reason for the price level differences among the studied countries is that their major exported cheese types are different: In 2018, the Netherlands owns the largest net export quantity, with Gouda, Edam and Emmentaler as the main exported cheeses. France is in second place as net exporter of cheeses, with Brie, Camembert and Other processed cheese, not grated or powdered (CN 04063039) as the main exported cheese types. Italy is in third place as a net exporter of cheeses, with Grana Padano, Parmigiano Reggiano, Other fresh cheese (CN 04061080) and Cheese of sheep's milk or buffalo milk as the main exported cheese types. Ireland ranks fourth place as a net exporter, with Cheddar, Other processed cheese, not grated or powdered and Jarlsberg as the top 3 net exported products. Compared with other countries, Germany is both the largest cheese exporter and importer in the EU. It is in fifth place as a net exporter in the studied 6 EU member states. Among various exported and imported cheese types, Gouda, Edam, Other processed cheese, not grated or powdered and Emmentaler are the top 4 exported cheeses, while Gouda, Cheddar and Edam are the top 3 imported cheeses in Germany. Different from other countries, the UK is a net importer of cheese and imports Cheddar most. Other fresh cheese (CN 04061080) and Kefalograviera, Kasseri are the only two categories of cheeses that have positive net exports for the UK (for details, please see Section III.2 Appendix III for descriptive analysis).

Russia had imported huge amounts of cheese from the EU. In 2014, Russia banned EU dairy products import (Boulanger, Dudu, Ferrari, & Philippidis, 2016), which greatly harmed EU cheese exports and cheese then ended up on world markets, resulting crash in prices. In March 2015, the EU abolished its quotas on milk production which boosted the milk production further, thus causing further price declines. At the same period, New Zealand, Australia and the United States increases their dairy production. All of these factors created a challenging environment for the EU dairy sector in 2015 (OECD-FAO, 2017). The charts that export prices of both extra-EU and intra-EU cheese exports have declined from early 2014 to mid of 2016. The gradually rise of price since mid of 2016 is due to development of both supply and demand sides of EU dairy sector: (1) the EU removed 351,029 tonnes of skim milk powder from market by public purchases (EU intervention policy); (2) increases in domestic and international cheese consumption and production reduction in some key producers created stronger demand for EU cheeses. (OECD-FAO, 2017)

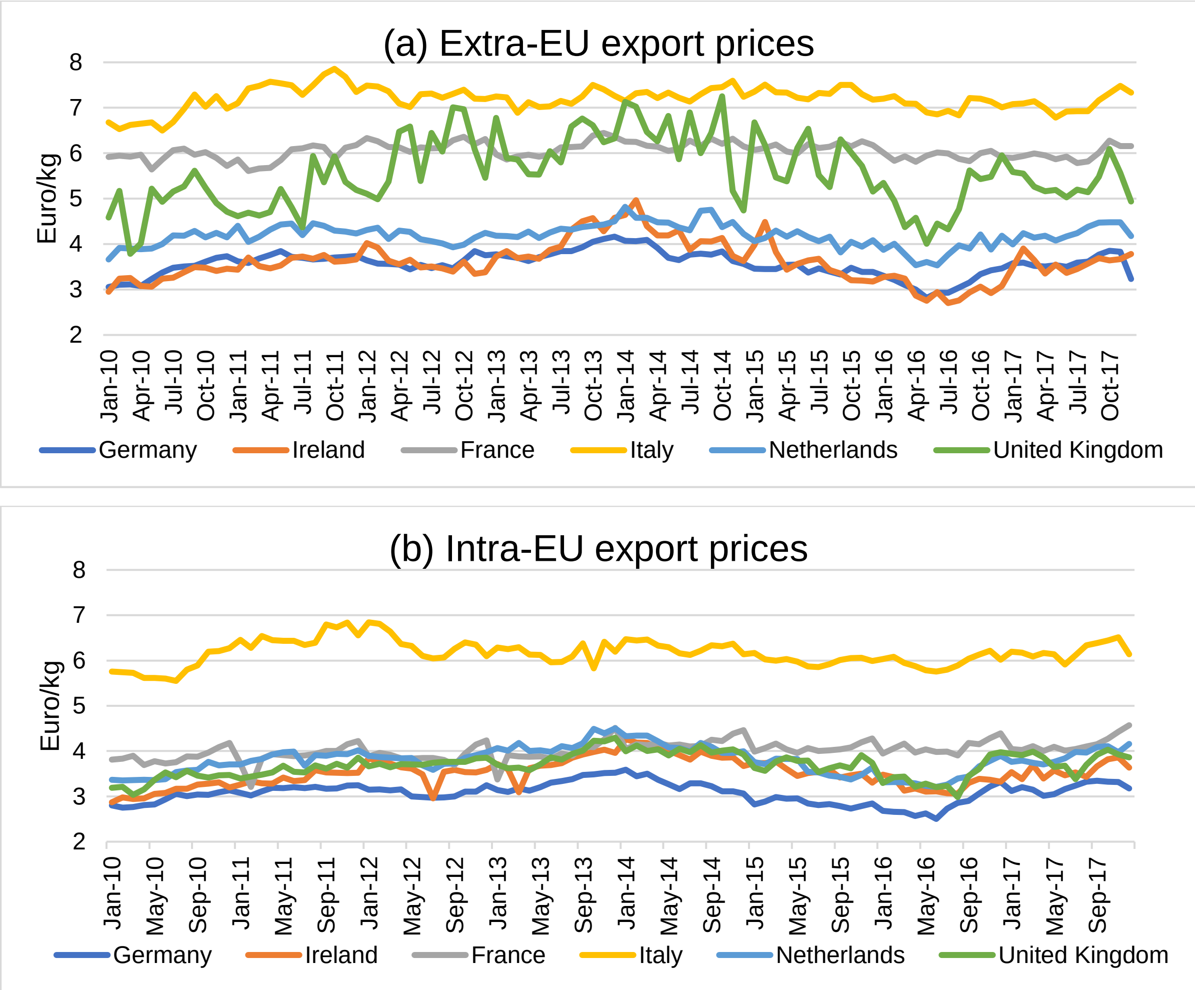


Figure 6.3: Intra-EU and Extra-EU cheese export prices of major EU exporters, Jan 2010-Dec 2017

Source: Price calculated by author, downloaded from Eurostat Database (HS Classification EU trade since 1988 by HS2,4,6 and CN8 [DS-645593], HS heading 0406-cheeses and curds), accessed in Aug 2019.

6.2.3 Challenges Faced by the EU Cheese Sector

The export market for cheese has encountered challenges from both internal and external market shocks. The rise in trade protectionism as well as the possible changes and uncertainties brought by Brexit could have negative impacts on EU cheese exports and influence the price transmission and dynamics of EU cheese export prices: (a) Milk quota removal and other CAP reforms directly influenced production levels; (b) Brexit and trade protectionism could hinder the trade of EU cheeses and cause price fluctuations; (c) Series of CAP reforms to liberalize the dairy market and domestic policy in individual member states will affect competition and price interactions among EU member states; (d) potential recession and current economic slowing down in the globe with corresponding unstable CPI and crude oil prices might also affects spatial price transmissions and dynamics in the EU cheese trade.

6.2.3.1 Brexit and the New EU-UK Dairy Framework

Many stakeholders in the EU dairy sector have concerns over the inevitable Brexit and the corresponding disruption of the EU free trade and single market system. The UK has very close trade relationships with other EU member states in the case of dairy trade and Brexit might have a negative influence on EU market structure, and on the intra-EU and extra-EU dairy trade, especially for Irish dairy exports. It is important to maintain the current free trade foundation for both UK and EU dairy products. The figures below underline the high level of market integration for dairy products.

Figure 6.4 (a) shows the export quantity of skim milk powder (SMP), butter, cheese and whey from 27 member states of the EU to the British market. Cheese is the most exported dairy product from the other EU countries to the UK with increasing export quantities over the years. Although the export quantity of whey is low, it has been increasing over the years. Figure 6.4 (b) depicts the UK's export quantity of SMP, butter, cheese and whey to the other EU member states. Cheese is the most exported dairy product, followed by whey, butter and SMP. In summary, the net export of cheese from the EU-27 to the UK market is significant and cheese is of vital importance for both EU-27 member states and the UK.

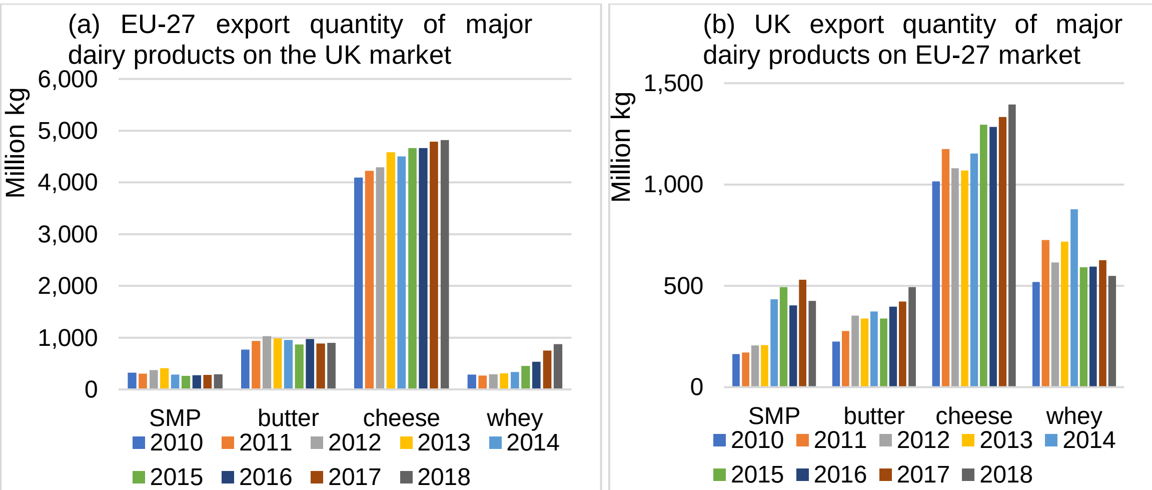


Figure 6.4: The bilateral export in quantity of major dairy products between EU-27 and the UK

Source: Eurostat database, accessed on 06/09/2019

In August 2019, the UK released the Most-Favored-Nation (MFN) of customs duty on imports if the UK leaves the EU with no deal as outlined in Table 6.4. Cheddar (CN sub-heading 04069021) is the most imported cheese type of the UK and is mainly imported from Ireland and other EU member states. In 2018, the UK imported over 30.4 million kg Cheddar from the EU and its average import price from 2010 to 2018 is 314.79 EUR/100kg (See Section III.2 Appendix III for data analysis). If the MFN is applied to the imported EU cheddar, it means 22.1 EUR/kg will be charged if the EU member states export cheddar to the UK. So, if the UK exits from the EU without a deal or the free trade commitments with the other EU member states are disrupted, the EU cheese sector could be severely and negatively affected due to the tariffs imposed by the UK and consumers in the UK might have to face higher retail prices for imported cheeses.

Table 6.4: MFN rate applied if the UK leaves the EU with no deal

CN8 tariff code[89]	Product description	If an MFN rate is applied
04062000	Grated or powdered cheese, of all kinds	24.9 EUR/100kg
04063010	Processed cheese, not grated or powdered, in the manufacture of which no cheeses other than emmentaler, gruyère and appenzell have been used and which may contain, as an addition, glarus herb cheese "known as schabziger"; put up for retail sale, of a fat content by weight in the dry matter of <= 56%	19.1 EUR/100kg
04063031	Processed cheese, not grated or powdered, of a fat content, by weight, of <= 36% and of a fat content, by weight, in the dry matter of <= 48% (excl. Processed cheese mixtures made from Emmentaler, Gruyère and Appenzell, with or without the addition of glarus herb cheese known as schabziger, put up for retail sale)	18.4 EUR/100kg
04063039	Processed cheese, not grated or powdered, of a fat content, by weight, of <= 36% and of a fat content, by weight, in the dry matter of > 48% (excl. Processed cheese mixtures made from Emmentaler, Gruyère and Appenzell, with or without the addition of glarus herb cheese known as schabziger, put up for retail sale, of a fat content by weight in the dry matter of <= 56%)	19.1 EUR/100kg

[89] 8-digit Combined Nomenclature (CN) codes. For definition and details of CN, please check at: https://ec.europa.eu/taxation_customs/business/calculation-customs-duties/what-is-common-customs-tariff/combined-nomenclature_en

04063090	Processed cheese, not grated or powdered, of a fat content, by weight, of > 36% (excl. Processed cheese mixtures made from Emmentaler, Gruyère and Appenzell, with or without the addition of glarus herb cheese known as schabziger, put up for retail sale, of a fat content by weight in the dry matter of <= 56%)	28.4 EUR/100kg
04064090	Blue-veined cheese and other cheese containing veins produced by "penicillium roqueforti" (excl. Roquefort and gorgonzola)	18.6 EUR/100kg
04069001	Cheese for processing (excl. Fresh cheese, incl. Whey cheese, curd, processed cheese, blue-veined cheese and other cheese containing veins produced by "penicillium roqueforti", and grated or powdered cheese):	22.1 EUR/100kg
04069021	Cheddar (excl. Grated or powdered and for processing)	22.1 EUR/100kg

Source: UK Gov. Preferential, MFN and tariff quota rates of customs duty on imports if the UK leaves the EU with no deal, website: https://www.gov.uk/government/publications/temporary-rates-of-customs-duty-on-imports-after-eu-exit, access on 12/08/2019

6.2.3.2 Non-Tariff Measures (NTMs)

Trade protectionism is on the rise in recent years, hindering globalization and disrupting the global value and supply chains to a large extent. As a multilateral trade-facilitating international organization, WTO allows countries to regulate their imports and exports to correct market failures such as information asymmetries, externalities and monopoly power and set standards, labelling rules and certification to protect consumers, the environment and national industries or infant industries.[90] These regulations can be implemented by Non-tariff measures (NTMs). NTMs in WTO has various forms, including Sanitary and Phyto-sanitary (SPS) measures, Technical Barriers to Trade (TBT), Anti-Dumping, Import Licensing, Safeguard measures etc. Non-tariff measures can potentially have an economic effect on international trade in goods, changing the quantities traded, or prices, or both.[91] These NTMs are sometimes improperly used as trade barriers and incur negative impacts on trade due to the conflicting food standards and differences on both SPS and TBT issues (Jurenas, 2015). Nowadays, the NTMs have been implemented to distort and restrict bilateral and multilateral trade, leading to unfair competition in international trade as non-tariff

[90] UN ESCAP: https://www.unescap.org/sites/default/files/1-1.NTM%20introduction.pdf
[91] UNCTAD/GNTB-MAST. https://unctad.org/en/Pages/DITC/Trade-Analysis/Non-Tariff-Measures/What-are-NTMs.aspx

barriers. The Russian ban on the EU agricultural products (including dairy) providing a typical example of exploiting NTMs to distort free trade. Therefore, harmonisation, equivalence and mutual recognition of NTMs and regulatory coherence still require further efforts to achieve.

To understand the nature of NTMs that affect the trade of dairy products, especially cheese, the SPS and TBT measures that are notified by other countries to WTO and affect the studied six European countries are mainly analyzed. These measures are in the form of standards or labelling requirements etc., which must be complied with for imports. The data was taken from the WTO-ITiP database with the period ranges from 1995 to 30 June 2019. A summary of SPS and TBT measures and other NTMs that initiated and in force is given in Table 6.5 below.

Table 6.5: Non-Tariff Measures affecting the studied European countries (From 1995 till 31 Aug 2019)

Products[92]		SPS in force	SPS initiation	TBT in force	TBT initiation	Other NTMs[93] in force	Other NTMs initiation
Cheese and curds		96[94]	689	72	913	504	0
Dairy Products	France	378	1757	108	1288	1088	0
	Ireland	3657	15587	2871	24093	6770	364
	Italy	374	1731	106	1279	1088	0
	Germany	387	1732	106	1279	1088	0
	Netherlands	384	1743	106	1279	1088	0
	United Kingdom	374	1731	106	1279	1088	0

Source: WTO NTM database, available at:
https://i-tip.wto.org/goods/Forms/GraphView.aspx

In general, the number of SPS measures is higher than TBT measures, and the number of SPS and TBT measures in force are more than the number initiated. On HS

[92] Harmonized System Codes (HS Code) of Chapter 04 was used to represent dairy products and HS Code of Heading 0406 represents the cheese and curds.
[93] Other NTMs including special safeguards, Quantitative Restrictions, Tariff-rate quotas and Export Subsidies.
[94] Netherlands, Germany and France have 97 SPS in force: Russian Federation imposed the SPS on the Netherlands and Germany; Madagascar imposed the SPS on France.

code of Heading 0406 items, the SPS and TBT measures in force that affect France, Germany, Ireland, Italy, the Netherlands and the United Kingdom are 96 and 72 respectively, while the SPS and TBT initiation numbers are 689 and 913 respectively. Remarkably, the number of other NTMs in force such as cheese and curds are 504, which is much higher than the numbers of SPS and TBT in force. Special Safeguards is the most usual NTM initiated or entered into force by the imported countries, and the US has 190 special safeguard measures on cheese and curds imports, followed by Poland with 112 special safeguards measures imposed. It should be noted that these measures on HS 0406 are not country specific but are applied globally for every country that exports cheese and curds to imposing countries (not only affecting the studied European countries).

On the HS code of Chapter 04, the numbers of NTMs affecting the different European countries vary and Ireland is affected by much more NTMs than its European competitors of dairy exports. It may also be observed that the number of other NTMs in force on dairy products are much higher than the SPS and TBT in total, amounting to 1088 till end of Aug 2019. Similar to the cheese and curds, Special Safeguards are the main measures countries impose on dairy products as a whole with the US, Poland and Japan imposing 315, 182 and 110 of Special Safeguards respectively. It should be noticed that the number of NTMs imposed on dairy products that affect Ireland is much higher: the numbers of SPS and TBT measures in force that affect Ireland amount to 3657 and 2871, respectively, and initiated SPS and TBT amount to 15,587 and 24,093 respectively. Table 6.6 below illustrates the numbers of various NTMs specially imposed to affect Ireland’s dairy products exports. Anti-dumping and SPS are two main measures that affect Ireland’s dairy products export with 1860 anti-dumping and 833 SPS measures in force and 277 anti-dumping and 1153 SPS measures initiated.

Table 6.6: Non-Tariff Measures affecting Ireland (From 1995 till 31 Aug 2019)

	In force				Initiation		
Product	SPS	Anti-dumping	Countervailing	Quantitative Restrictions	SPS	Anti-dumping	Countervailing
Dairy products	833	1860	178	53	1153	277	54

Source: WTO NTM database available at: https://i-tip.wto.org/

Therefore, the numbers of NTMs affecting the studied countries' cheese exports are equal, the non-tariff barriers in terms of SPS and TBT are increasingly exploited in cheese international trade and could have a direct negative impact on dairy trade volume and prices.

6.3 Methodology and Conceptual Framework

6.3.1 Conceptual Framework

The conceptual framework used to conduct this analysis is illustrated in Figure 6.5. It is assumed that cheese export prices in the EU are driven by shocks to (a) macroeconomic factors (price index of food); (b) production-side factors (production levels and crude oil price); (c) input prices (farm-gate raw milk price and crude oil price); and (d) competition and price transmission (the cheese export prices of other major exporters). The flow chart presents four drivers including CPI for food, production level, farm-gate raw milk price and crude oil price that could influence cheese export prices. To understand market integration and spatial price transmission of cheese export prices among the EU member states, cheese prices of 7 studied countries and country group are incorporated into the analysis. The spatial price transmission analysis is to test the assumption that the internal EU cheese market is well-integrated, while the extra-EU cheese trade market is less integrated than the internal one. Market shocks will be simulated to test and address the assumption that increases in crude oil price, raw milk price, and CPI for food cause increases in cheese export prices and increases in production will decrease cheese export prices.

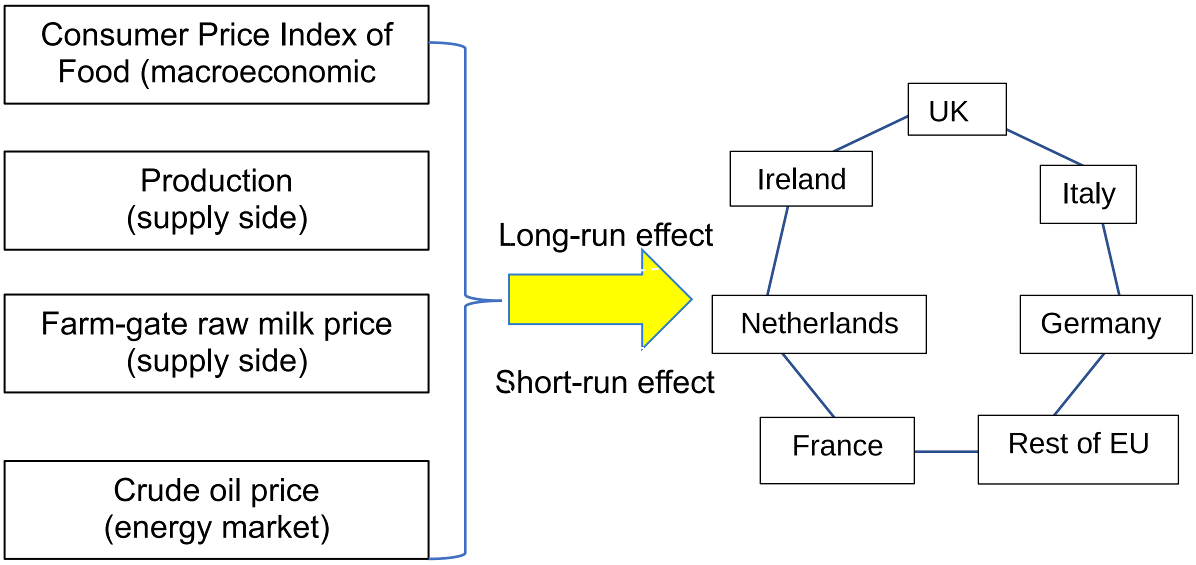


Figure 6.5: Flow Chart of factors influencing cheese export prices

One of the prevalent definitions for market integration is the degree to which shocks from demand and supply sides are transmitted from one location (country/region, etc) to another, with prices showing common movements in different locations in the long run (Goodwin & Piggott, 2001; Georege Rapsomanikis et al., 2006). The analysis of price transmission and market integration for intra-EU and extra-EU cheese export markets demonstrates price sensitivity to shocks from domestic and from foreign markets. It is essential to conduct analysis on the price transmission and market integration of cheese in intra-EU and extra-EU export markets, respectively, to evaluate the effectiveness of EU policies for cheese.

It should be noted that major cheese products in different European countries are of different quality and cheeses are characterised as having great product differentiation. The major exported cheese for Italy is Grana Padano, Parmigiano Reggiano, which is known as the King of cheeses and has higher quality, prices and consumer loyalty. The most exported cheese in France is Brie that is known as Queen of cheeses. While for Germany and the Netherlands, their most exported cheese is the same type called Gouda which is a homogenous cheese type that is not protected by GPO/GPI. For the selected EU countries, their major cheeses are differentiated from each other, while in the HS 4-digit heading 0406, they are all aggregated and categorised as cheeses. However, product differentiation reduces the speed of price adjustment to exogenous shocks and leads to more sluggish price adjustment (J. P. Loy & Weiss, 2019). Also, in a world of uncertainty, increases in product differentiation will lead to decreases in the correlation of demand shocks (Shaked & Sutton, 1982). Therefore, the spatial price transmission of cheese export prices of these countries and the impacts of market shocks will show different responses due to production differentiation.

6.3.2 Methodology and Data

Two Global Vector Autoregressive (GVAR) models, as described in Chapter 5, are separately constructed to analyze the price dynamics and impacts of shocks on intra-EU and on extra-EU export prices. For both the intra-EU GVAR model and extra-EU GVAR model, six VECX models are constructed, respectively, one for each of the main exporters among EU member states: Ireland, the Netherlands, Italy, Germany, France and the UK. Also, a Rest of the EU (REU) regional VECX model is specified to represent the effects from all the other EU member states.

The country-specific variables include: 1) Index of extra-EU28 export prices in Euro as $p_{it}^{e\_ex}$, which is only included in the extra-EU export price GVAR model; 2) Index of intra-EU28 export prices in Euro as $p_{it}^{e\_in}$, which is only included in the intra-EU export price GAVR model; 3) Harmonised Index of Consumer Price (HICP) of food, $HICPF_{it}$, which reflects food inflation in each country; 4) Cheese production, Pro_{it}, which reflects the supply of cheese in each country; 5) Index of farm-gate prices of raw milk in Euro as p_{it}^{f}, which represents the upstream price along the supply chain.

The foreign-specific variables are established as a geometric average of the country-specific variables. The weights are computed as averages of shares of total EU exports from 2010 to 2017. Therefore, the foreign-specific variables include: 1) The average of competitors' export prices for extra-EU28 trade, $p_{it}^{e\_ex*} = \sum_{i \neq j} w_j p_{jt}^{e\_ex}$ (extra-EU export price GVAR model only); 2) The average of competitors' export prices for intra-EU28 trade, $p_{it}^{e\_in*} = \sum_{i \neq j} w_j p_{jt}^{e\_in}$ (intra-EU export price GVAR model only); 3) the average of the HICP food, $HICP_{it}^{*} = \sum_{j \neq i} w_j HICP_{jt}$; 4) The average of the cheese production index, $Pro_{it}^{*} = \sum_{j \neq i} w_j Pro_{jt}$; 5) The average of competitors' raw milk prices, $p_{it}^{f*} = \sum_{i \neq j} w_j p_{jt}^{f}$.

Global variables can impact the systems of each region and are of vital importance to all countries. The dairy industry is dependent on energy in that oil and energy are necessary for the production and transportation of milk and dairy products. Also, oil price inflation will indirectly increase feed prices through biofuel and corn price transmission. Therefore, the dairy market can be affected by changes in energy prices such as world crude oil price, p_t^o. In the constructed GVAR model or Global Vector Error-Correction model (GVECM), crude oil price is set to be endogenous in the UK VECX model for both intra-EU and extra-EU models. It is because that the UK is the major crude oil producer among the 28 member states of the EU (Vrontisi, Kitous, Saveyn, & Vandyck, 2015). The variable vectors are as follows:

The domestic variables vectors for the intra-EU VECX models:

$x_{it} = (p_{it}^{e_{in}}, HICPF_{it}, Pro_{it}, p_{it}^{f})'$ (1a),

The domestic variables vectors for the extra-EU VECX models:

$x_{it} = (p_{it}^{e_{ex}},\ HICPF_{it}, Pro_{it}, p_{it}^{f})'$ (1b),

The foreign variables vector for the intra-EU VECX models:

$x_{it}^{*} = \left(p_{it}^{e\_in*}, HICP_{it}^{*}, Pro_{it}^{*}, p_{it}^{f*}\right)'$ (2a),

The foreign variables vector for the extra-EU VECX models:

$x_{it}^{*} = \left(p_{it}^{e\_ex*}, HICP_{it}^{*}, Pro_{it}^{*}, p_{it}^{f*}\right)'$ (2b),

The global variable vector for intra-EU and extra-EU VECX models:

$d_t = (p_{it}^{o})$ (3),

Where $i = 1, \dots, 7$;

Put the above-mentioned vectors into the model specification as follows:

$$x_{it} = a_{i0} + a_{i1}t + \sum_{l=1}^{p_i} \Phi_{il} x_{i,t-l} + \Lambda_{i0} x_{it}^{*} + \sum_{l=1}^{q_i} \Lambda_{il} x_{i,t-l}^{*} + \Psi_{i0} d_t + \sum_{l=1}^{s_i} \Psi_{il} d_{t-l} + \varepsilon_{it} \quad (4)$$

for i = 1, 2, ..., 7, which represents the 7 studied EU countries, that is, Ireland, the Netherlands, Italy, Germany, France, the UK and REU, respectively; where Φ_{il} is $k_i \times k_i$ [95]matrix of unknown parameters for domestic variables, for *l* = 1, 2, ..., p_i , and p_i is the selected lag order for the domestic variables. Λ_{il} is $k_i \times k^*$ [96]matrices of unknown parameters for foreign variables, for *l* = 0, 1, 2, ...q_i, and q_i is the selected lag order for the foreign variables. Ψ_{il} is $k_i \times k_i$ matrix of unknown parameters for global variable, and ε_{it} are $k_i \times 1$ error vectors.

The monthly data series from January 2010 to December 2016 are used for the analysis[97] and all the variables are transformed to their indexes using the average value of data from Jan/2010 to Dec/2010 as the base year data and then converting the index into natural logarithm forms. The export prices are calculated using the equation: $p_{it}^h = \frac{V_{it}^h}{Q_{it}^h}$, where V_{it}^h is the total export value (FOB) in Euro and Q_{it}^h is the total export weight in kilogram (net mass). Export quantity, export value, HICP of food index and cheese production data series are downloaded from Eurostat. Raw milk prices and crude oil prices are downloaded from the European Commission Milk Market Observatory and the World Bank database, respectively. The Table 6.7 below lists the data sources with exact name of database and organisation, URL link and names of variable series as well as date of retrieval. In this study, the software MATLAB 2019(a) is used for statistical analysis and Microsoft Excel is used for the depiction of figures. Specifically, the GVAR Toolbox 2.0 developed by L. Smith and A. Galesi (2014) was applied for the GVAR model estimation and analysis.

[95] k_i depends on the number of domestic variables and lag orders.
[96] k^* depends on the number of foreign variables and lag orders.
[97] The data analysis part of this chapter was conducted mainly in 2017 and 2019 for intra-EU and extra-EU market, respectively. So, all the data series used in this chapter were ended in Dec 2016 for consistency and comparison between intra-EU and extra-EU market. However, analysis covering period from Dec 2017 onward could be conducted for comparison of price transmission of cheese before and after “Brexit” Referendum. Besides, the reason for data series in this thesis not covering period before 2010 is that the period of 2008-2010 is the economy crisis around the world and the price movements are quite unusual and fluctuates. The period 2008-2010 should better be analysed separately as an independent period if included. It will weaken the policy and economic implication, and research objectives and results of my thesis will not be general enough if the unusual period is included. A further study should take period 2008-2010 into analysis to see whether there is difference in price dynamics.

Table 6.7: Data sources for variables

Variables	Database	URL links	Data of Retrieval
Intra EU Export Price	Eurostat-Database by theme-International Trade-International Trade in goods-detailed data: EU trade since 1988 by HS2,4,6 and CN8 (DS-645593), HS-0406: Cheese and curds	https://ec.europa.eu/eurostat/data/database	08 Jan 2018
Extra EU Export Price			
Cheese Production	Eurostat-Database by theme-Agriculture, Forestry and Fisheries-Agriculture-Agricultural Production-Animal Production-Milk and Milk products: Cows' milk collection and products obtained - monthly data (apro_mk_colm)		
Harmonised Index of Consumer Price	Eurostat-Database by theme-Economy and Finance-Prices-Harmonised Index of Consumer Price (HICP) (prc_hicp): HICP (2015 = 100) - monthly data (index) (prc_hicp_midx)		
Raw Milk Price	European Commission-Milk market observatory-EU historical series Historical EU price series of cow's raw milk in euro/100 kg	https://ec.europa.eu/info/food-farming-fisheries/farming/facts-and-figures/markets/overviews/market-observatories/milk_en#euhistoricalseries	12 Sep 2018
Crude Oil Price	World Bank Commodity Price Data Crude oil price. Average spot price of Brent, Dubai and West Texas Intermediate, equally weighed Nominal US dollar per barrel.	http://pubdocs.worldbank.org/en/596831580311438199/CMO-Pink-Sheet-February-2020.pdf	2017

Table 6.8 below reports the descriptive statistics of domestic and global variables in the analysis. All the data series are in the natural logarithm forms of their index with average of Jan 2010-Dec 2010 as the base. The mean value and standard deviation for crude oil price is 4.633 and 0.356, respectively. The standard deviations for Ireland and the UK are higher than other countries in terms of intra-EU and extra-EU export prices and cheese production.

Table 6.8: Descriptive statistics of variables

Variables	Countries	Mean	Median	Maximum	Minimum	Std. dev.
Intra EU Export Price	UK	4.692	4.699	4.852	4.488	0.077
	Ireland	4.725	4.731	4.922	4.526	0.092
	Netherlands	4.681	4.695	4.856	4.518	0.083
	Italy	4.659	4.656	4.765	4.556	0.047
	Germany	4.644	4.659	4.806	4.445	0.079
	France	4.636	4.634	4.758	4.417	0.053
	Rest of EU	4.624	4.631	4.731	4.520	0.052
Extra EU Export Price	UK	4.733	4.723	5.000	4.351	0.149
	Ireland	4.695	4.696	5.021	4.413	0.129
	Netherlands	4.638	4.641	4.782	4.471	0.062
	Italy	4.660	4.665	4.746	4.556	0.037
	Germany	4.655	4.664	4.815	4.424	0.083
	France	4.629	4.634	4.690	4.551	0.030
	Rest of EU	4.665	4.654	4.761	4.552	0.044
Cheese Production	UK	4.679	4.685	4.942	4.432	0.115
	Ireland	4.446	4.861	5.254	2.585	0.835
	Netherlands	4.657	4.646	4.807	4.540	0.071
	Italy	4.601	4.599	4.683	4.481	0.045
	Germany	4.642	4.649	4.742	4.538	0.049
	France	4.601	4.599	4.690	4.483	0.046
	Rest of EU	4.694	4.682	4.873	4.492	0.084
Harmonised Index of Consumer Price	UK	4.590	4.592	4.651	4.494	0.040
	Ireland	4.625	4.630	4.659	4.577	0.020
	Netherlands	4.585	4.596	4.621	4.528	0.026
	Italy	4.577	4.590	4.616	4.519	0.030
	Germany	4.566	4.586	4.633	4.478	0.046
	France	4.591	4.601	4.622	4.540	0.023

	Rest of EU	4.582	4.600	4.617	4.510	0.033
Raw Milk Price	UK	4.744	4.764	4.966	4.456	0.131
	Ireland	4.664	4.681	4.981	4.334	0.145
	Netherlands	4.680	4.697	4.941	4.375	0.148
	Italy	4.673	4.680	4.816	4.501	0.084
	Germany	4.654	4.677	4.921	4.315	0.137
	France	4.656	4.647	4.838	4.504	0.083
	Rest of EU	4.673	4.687	4.880	4.431	0.107
Crude Oil Price		4.633	4.831	5.004	3.629	0.356

The average share of each country's total dairy export values compared to the EU's total dairy export values from 2010 to 2017 was used for the fixed weights as shown in Table 6.9.

Table 6.9: Trade weights based on total dairy products export values[98]

Countries	The UK	Ireland	Netherlands (NL)	Italy	Germany	France	Rest of EU
The UK	0	0.711359	0.044705	0.009894	0.016276	0.047488	0.047138
Ireland	0.255302	0	0.046463	0.004949	0.028415	0.035054	0.02155
NL	0.089263	0.059234	0	0.062786	0.339163	0.211221	0.236062
Italy	0.07023	0.016594	0.03607	0	0.070562	0.14972	0.071726
Germany	0.129338	0.080058	0.435481	0.405671	0	0.188045	0.381733
France	0.202296	0.063443	0.09476	0.17051	0.143953	0	0.241792
Rest of EU	0.253571	0.069311	0.342521	0.346191	0.401631	0.368472	0

[98] Note: Trade weights are computed using the following equation:

$$W_{ij} = \frac{1}{8}\sum_{t=2010}^{2017}\frac{ExV_t^{ij}}{ExV_t^{iEU}},$$

Where *i* represents the export countries, *j* represents the partner countries, ExV_t^{ij} represents the Export Values of the reporter *i* to partner *j* in the year *t*, ExV_t^{iEU} represents the export values of the reporter *i* exporting to other EU member countries in the year *t*.

Therefore, the average of the share of Reporters' dairy export value to Partners in the Reporters' dairy export value to the rest of EU member countries from 2010 to 2017 is calculated as the weight. In the above table, the exporters (Reporters) are displayed in the column and each column sums to 1.

The dairy export flows by value are constructed as the weights to indicate the mutual trade partnership among studied countries. As the weights show, the main dairy export destinations of the UK are Ireland, Germany, France and the Rest of EU, while Irish dairy is primarily exported to the UK. The Netherlands and Italy share similar export destinations. Germany and France share similar export destinations.

6.4 Empirical Results and Analysis

In this section, the empirical results are presented and analysed.

6.4.1 Cointegration, Weak Exogeneity Tests and Contemporaneous Effects Analysis

Firstly, the unit root test is conducted to test the stationarity of all the variable series. The results of Augmented Dickey-Fuller (ADF) Unit Root Tests for each variable series in Intra-EU GVECM and Extra-EU GVECM are shown in Table 6.10. As indicated by the ADF tests, the intra-EU export price series of France, and cheese production index series for all countries except the Netherlands are stationary, while all other series included in this model do not reject the null hypothesis of nonstationarity and are stationary at the first difference level, thus they are I (1). Therefore, the variables in each country or region could have cointegrating relationships that require cointegration tests.

Table 6.10: Augmented Dickey-Fuller (ADF) unit root tests statistics for domestic and foreign variables

Variables	The United Kingdom	Ireland	Netherlands	Italy	Germany	France	Rest of EU
p_{it}^{in} (with trend)	-2.88	-1.82	-1.97	-3.17	-1.97	-5.36	-2.55
p_{it}^{in} (no trend)	-2.96	-2.17	-1.87	-2.69	-1.85	-4.03	-1.97
D.p_{it}^{in}[99]	-6.51	-8.96	-5.91	-5.81	-5.48	-8.10	-6.70
p_{it}^{ex} (with trend)	-2.53	-1.49	-2.58	-3.29	-2.55	-3.14	-2.37
p_{it}^{ex} (no trend)	-2.66	-1.44	-2.35	-3.46	-2.18	-3.16	-2.45
D.p_{it}^{ex}	-10.76	-4.29	-7.41	-7.88	-4.98	-5.60	-7.20
Pro_{it} (with trend)	-6.74	-5.87	-2.43	-4.04	-6.71	-4.15	-5.61

[99] D. denotes the first difference; the following labels are the same.

Pro_{it} (no trend)	-4.23	-5.94	-1.04	-4.03	-4.49	-2.84	-1.30
D.Pro_{it}	-5.78	-6.92	-11.06	-9.90	-4.91	-12.13	-5.31
$HICPF_{it}$ (with trend)	-1.08	-0.56	-2.38	-2.08	-2.69	-2.22	-1.42
$HICPF_{it}$ (no trend)	-2.40	1.14	-1.34	-1.54	-0.80	-1.75	-1.91
D.$HICPF_{it}$	-5.45	-5.92	-6.21	-7.12	-5.18	-6.86	-5.75
p_{it}^{f}(with trend)	-2.13	-2.85	-2.51	-2.26	-3.12	-2.26	-3.34
p_{it}^{f} (no trend)	-2.25	-2.71	-2.41	-1.93	-2.90	-2.15	-3.26
D. p_{it}^{f}	-4.41	-4.76	-4.19	-4.68	-4.59	-7.09	-4.16
p_{it}^{in*} (with trend)	-2.15	-2.72	-2.20	-2.19	-2.22	-2.26	-2.18
p_{it}^{in*} (no trend)	-2.18	-2.78	-2.06	-2.09	-2.11	-2.03	-2.17
D. p_{it}^{in*}	-5.61	-6.30	-5.61	-6.50	-6.29	-5.02	-6.27
p_{it}^{ex*} (with trend)	-1.89	-2.49	-3.26	-2.87	-2.44	-2.78	-2.97
p_{it}^{ex*} (no trend)	-2.32	-2.64	-3.19	-2.83	-2.55	-2.82	-2.81
D. p_{it}^{ex*}	-6.59	-10.33	-3.92	-4.70	-5.77	-5.10	-4.36
Pro_{it}^{*} (with trend)	-5.98	-6.53	-7.12	-6.26	-5.86	-7.19	-6.41
Pro_{it}^{*} (no trend)	-5.82	-4.37	-3.66	-2.91	-2.01	-2.79	-4.81
D. Pro_{it}^{*}	-5.44	-5.92	-6.12	-5.39	-6.09	-5.73	-5.95
$HICPF_{it}^{*}$ (with trend)	-1.65	-1.09	-2.21	-2.31	-1.67	-1.90	-2.07
$HICPF_{it}^{*}$ (no trend)	-1.94	-2.55	-1.44	-1.47	-1.69	-1.60	-1.37
D. $HICPF_{it}^{*}$	-5.27	-5.21	-5.35	-4.97	-4.98	-4.86	-4.94
p_{it}^{f*}(with trend)	-3.11	-2.61	-3.22	-3.25	-2.44	-3.24	-3.37
p_{it}^{f*}(no trend)	-2.96	-2.64	-3.07	-3.10	-2.33	-3.34	-2.40
D. p_{it}^{f*}	-4.31	-3.78	-4.64	-4.50	-3.48	-3.59	-4.04
p_{it}^{co*} (with trend)	-1.98	-	-	-	-	-	-
p_{it}^{co*} (no trend)	-0.79	-	-	-	-	-	-
D.p_{it}^{co*}	-5.72	-	-	-	-	-	-

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

For each country or region's VARX model, the orders of p and q were selected using the AIC criteria based on the pre-constraint 4 ≥ q(i) ≥1. To find appropriate lag orders, it is assumed that the model has both an unrestricted intercept and a co-trending restriction to each country or region model. The cointegration test is conducted using the Maximum Eigenvalue Statistic and the Trace Statistic. The results are shown in

Table 6.11. There are cointegrating relations among the variables for every studied country. Therefore, the vector-error correction models will be implemented in the following analysis. In the Intra- EU GVARM, the selected p and q lags for most of the relations fall into the constraint of no larger than 4. However, in the Extra-EU GVARM, the selected lags of Germany, France, Rest of EU country-level models are constrained to 4 lags in terms of both p and q. As shown in Table 6.11, the rank for country cases were changed to 1 in all cases due to the fact that using the tested cointegrating relations will cause model instability, following many previous GVAR studied such as Assenmacher (2013) and Bettendorf (2017). This ensures model stability and ensures the analysis better serves the objectives of this study.

Table 6.11: VARX order and number of cointegrating relationships for intra-EU GVARM (GVECM) and extra-EU GVARM (GVECM)

	Intra-EU				Extra-EU			
	p	q	Tested Cointegrating relations	Adjusted Cointegrating relations	p	q	Tested Cointegrating relations	Adjusted Cointegrating relations
The United Kingdom	1	4	1	1	3	2	3	1
Ireland	4	4	2	1	2	3	3	1
Netherlands	2	3	4	1	3	1	2	1
Italy	1	4	3	1	1	1	2	1
Germany	2	2	4	1	4	4	2	1
France	4	4	3	1	4	4	2	1
Rest of EU	2	1	1	1	4	4	2	1

Given the results that there are cointegrating relations among the variables, the VARX equation (1) can be rewritten in its Vector Error-Correction (VECMX) form,

$$\Delta x_{it} = a_{i0} + a_{i1}\mathrm{t} + \Lambda_{i0}\Delta x_{it}^{*} - \Pi_{i0}\mathrm{Z}_{i,t-1} + \sum_{l=1}^{p} H_{il}\Delta \mathrm{Z}_{i,t-l} + \varepsilon_{it} \quad (5)$$

Where $\Pi_{i0} = -(\mathrm{A}_{i0} - \sum_{l=1}^{p} \mathrm{A}_{il})$, $H_{il} = -\sum_{l=1}^{p-1} \mathrm{A}_{i,l+1}$, $\Delta = 1 - \mathrm{L}$ is the first order difference; $Z_{it} = (x_{it}', x_{it}^{*'})'$ be $k_i + k^{*}$ dimensional vector. x_{it} and x_{it}^{*} is the variables vector as defined previously in equation (1a), (1b) and (2a), (2b).

The important assumption of the GVAR model estimation is the weak exogeneity of foreign variables. The weak exogeneity hypothesis has a profound implication for the analyses of the international market for EU cheese. It indicates that all the countries in the model jointly determine each other and there is no leader, which is consistent with the assumption of this study that cheese export prices of the EU member states are jointly determined. It also allows the short-run impact of one or more main exporting countries on export prices dynamics for the EU as a whole.

The weak exogeneity hypothesis can be tested following the procedure proposed by Johansen (1992) and Harbo et al. (1998) to perform the regression below for each GVECX country model and each foreign variable in the vector of x_{it}^* :

$$x_{it,l}^* = \mu_{il} + \sum_{j=i}^{r_i} \gamma_{it,l} \widehat{ECT}_{i,t-1}^{j} + \sum_{p=1}^{p_i} \Phi_{ip,t} \Delta x_{i,t-p} + \sum_{m=1}^{q_i} \theta_{im,t} \Delta y_{t,t-m}^* + \varepsilon_{it,l} \quad (6)$$

In this equation (6), $\Delta x_{i,t-p}$ is the vector of domestic variables in first differences, where,$\mathrm{p} = 1, 2, \dots, p_i$ and p_i is the selected lag order of the domestic vector of variables for each country model i=0, 1, 2, 3 in this study. $\Delta y_{t,t-m}^*$ is the vector of foreign and global variables in first differences, where $\mathrm{m} = 1,2, \dots, q_i$ and q_i is the lag order of the foreign and global vectors of variables for each i^{th} country model. $\widehat{ECT}_{i,t-1}^{j}$ is the estimated Error Correction Term, where $\mathrm{j} = 1, 2, \dots, r_i$ and r_i is the number of cointegrating relations for the VECM of country i. The weak exogeneity test is to test the null hypothesis that $y_{i,j-1}$=0 for each $\mathrm{j} = 1, 2, \dots, r_i$ using the F test. The weak exogeneity assumption in the GVECM implies no long-run feedback from domestic variables to foreign variables, without necessarily ruling out lagged short-run feedback between these two sets of variables. The weak exogeneity of foreign can then be tested in the country-specific models.

Table 6.12 reports the results of the weak exogeneity tests which indicate that the null hypothesis of weak exogeneity for foreign-specific variables cannot be rejected at the 95% significance level if the value is smaller than the critical value. As the results show, most of the foreign-specific variables are weakly exogenous. However, it may be a concern that, for intra-EU GVAR model: (1) all the foreign variables in the model for France are not weakly exogenous. Besides, (2) export price variable in the intra-EU models for the Netherlands and Germany, the production variable in the intra-EU models for Ireland and Germany, the HICPF variable for Netherlands and the raw milk price variable for Germany all reject the weak exogeneity hypothesis. For extra-EU GVAR model, the foreign cheese production index is excluded from models as it is estimated to fail the weak exogeneity hypothesis. In addition, HICP for food in the Netherlands and the rest of the EU models are estimated to reject the weak exogeneity hypothesis. Failing to meet the weak exogeneity might lead to long run feedback between foreign and domestic variables, thus enhancing the impacts of that variables in the long run. Therefore, the following contemporaneous effects analysis and impulse response analysis should consider this issue. However, this does not seem to be too serious a violation and could be due to insufficient dynamics (Dees et al., 2007; di Mauro & Smith, 2013). However, for the following analysis, the France intra-EU model and shocks to these that cannot satisfy the weak exogeneity hypothesis in the intra-EU and extra-EU model should be taken into consideration.[100] The GVAR model partially satisfied the condition to do comparative studies on the relationship between country-specific and foreign-specific variables.

Table 6.12: F statistics of weak exogenous test at the 5% significant level of intra-EU and extra-EU GVECMs

	Intra-EU					Extra-EU				
Country	p_{it}^{in*}	Pro_{it}^{*}	$HICPF_{it}^{*}$	p_{it}^{f*}	p_{it}^{co}	p_{it}^{ex*}	Pro_{it}^{*}	$HICPF_{it}^{*}$	p_{it}^{f*}	p_{it}^{co}
The UK	0.49	0.01	2.87	0.90	-	2.98	-	0.87	1.57	-
Ireland	1.36	4.52	0.18	0.74	0.34	0.00	-	0.22	0.58	0.20
Netherlands	4.63	0.20	6.76	0.00	0.42	0.03	-	4.07	0.33	0.00
Italy	0.02	0.01	2.25	0.59	1.07	0.24	-	2.89	1.82	0.45
Germany	4.96	8.56	0.18	4.05	0.03	0.24	-	0.19	0.66	0.37
France	7.96	10.12	4.20	4.94	4.11	3.38	-	2.84	2.17	3.91
REU	0.00	0.00	0.19	1.15	0.32	3.13	-	10.03	0.11	0.48

Note: critical values for intra-EU UK is 4.04 and critical values for others are all 3.98.

The effects foreign-specific variables have on the corresponding domestic variables can be analysed when performing the cointegrating VECMX as reported in Table 6.13. The contemporaneous effects could be interpreted as the impact elasticities to show the short-run relationship between domestic and foreign variables. The Table 6.13 below shows the following results: (1) The effect coefficients of intra-EU cheese export

[100] The possible significant impacts might be due to the violation of weak exogeneity.

price of the UK, the Netherlands, Germany and the Rest of EU are estimated to be positive and statistically significant, while the coefficients for other countries' cheese export prices are estimated to be negative and not statistically significant. However, only the coefficients for contemporaneous effects of extra-EU cheese export prices of Ireland and Germany are statistically significant; (2) In both models, the effects coefficients estimated for CPI for food in all the countries, with the exception of Ireland, are positive and statistically significant, implying that in the short run domestic food prices in one EU member states are easily affected by changes in other EU member states' food prices regardless of intra-EU or extra-EU export prices; (3) In intra-EU model, the effect coefficients estimated for cheese production for all the countries, except Ireland, are positive and statistically significant, suggesting there are relatively strong co-movements among EU member states' cheese production in the short term. However, weak exogeneity is not found in the production series of Ireland, Germany and France, so the strong co-movement pattern could be due to the endogenous relationship between domestic and foreign production; (4) In the extra-EU GVAR model, it is statistically significant for the short-run co-movement of foreign and domestic farm-gate raw milk price indices of the UK, the Netherlands, Italy, Germany and the Rest of EU, and of all the countries have a positive short-run contemporaneous effect coefficient. In the intra-EU models, it is statistically significant for the short-run co-movement of foreign and domestic farm-gate raw milk price indices of the UK, Ireland, the Netherlands, Germany and the rest of EU, and all the estimated coefficients are positive. This indicates that possible linkages exist across the EU member states for farm-gate milk prices.

Table 6.13: Contemporaneous effects of foreign variables on domestic counterparts of intra-EU and extra-EU GVECMs

		Intra-EU				Extra-EU			
Country		p_{it}^{in}	Pro_{it}	$HICPF_{it}$	p_{it}^{f}	p_{it}^{ex}	Pro_{it}	$HICPF_{it}$	p_{it}^{f}
The UK	Coefficient	0.62	0.19	0.70	0.75	0.96		0.45	0.42
	t-ratio	2.36	2.64	2.80	4.40	1.18		1.84	2.39
Ireland	Coefficient	-0.36	-0.55.	0.10	0.81	0.20		0.04	0.52
	t-ratio	-1.51	-0.71	1.11	3.01	2.73		0.48	1.91
Netherlands	Coefficient	0.83.	0.31	0.61.	0.52	0.25		0.76.	0.38
	t-ratio	4.30	3.42	3.70	3.07	0.91		5.44	2.15
Italy	Coefficient	-0.13	0.32	0.63	0.25	-0.02		0.79	0.30
	t-ratio	-0.71	2.49	6.14	1.65	-0.08		7.65	2.83

Germany	Coefficient	0.75.	0.89.	1.14	1.05.	0.50	1.09	1.22
	t-ratio	5.05	14.08	7.16	7.64	2.24	7.68	6.15
France	Coefficient	0.61.	0.70.	0.86.	0.37.	-0.17	0.63	0.41
	t-ratio	1.45	8.11	6.86	1.54	-0.83	4.70	1.56
Rest of EU	Coefficient	0.44	0.78	0.83	0.72	0.20	0.7.	0.80
	t-ratio	6.13	13.98	16.02	23.64	1.24	9.55	22.82

Note: "." after the coefficient estimates denotes the variables that fail the weak exogeneity tests.

Table 6.14 reports the standard deviations of each variable equation residuals for country specific VECMX* in the intra-EU GVECM and the extra-EU GVECM, respectively. It will help quantify the shocks to explore its impacts on cheese export prices using generalized impulse response function analysis.

Table 6.14: Standard deviations of VECMX* Residuals

	Intra-EU					Extra-EU				
Country	p_{it}^{in*}	Pro_{it}^{*}	$HICPF_{it}^{*}$	p_{it}^{f*}	p_{it}^{co}	p_{it}^{ex*}	Pro_{it}^{*}	$HICPF_{it}^{*}$	p_{it}^{f*}	p_{it}^{co}
The UK	0.027	0.050	0.005	0.022	0.077	0.090	0.052	0.005	0.022	0.074
Ireland	0.030	0.185	0.002	0.031		0.036	0.254	0.003	0.038	-
Netherlands	0.019	0.027	0.004	0.021		0.031	0.028	0.004	0.026	-
Italy	0.021	0.028	0.002	0.018		0.022	0.037	0.003	0.020	-
Germany	0.017	0.017	0.004	0.016		0.017	0.025	0.003	0.014	-
France	0.028	0.013	0.002	0.018		0.018	0.019	0.002	0.020	-
REU	0.011	0.018	0.001	0.004		0.013	0.027	0.001	0.003	-

6.4.2 Dynamic Analysis: General Impulse Response Function Analysis

In this section, the dynamic analysis will be conducted using the general impulse response function (GIRF) analysis proposed by Koop, Pesaran, and Potter (1996) and developed by M Hashem Pesaran and Shin (1996) to understand the dynamic interactions of cheese export prices with other influencing factors and global variables. A GIRF approach can be sufficient and effective to identify the short-run dynamics of the established GVEC models without a priori information and strong structural assumptions, as it is invariant to the ordering of the variables and the ordering of the studied countries. In this chapter, all the variables are in their logarithm form of their index, so the GIRFs derived from the two GVEC models shows the growth rate of each variable. To better investigate the research objective of this chapter and display the dynamic interlinkages more effectively, only the GIRFs of cheese export prices for the studied countries are presented here with a focus on the 40-month time profile after each simulated shock. The following analyses are based on GIRFs figures for cheese export prices in the different EU member states, and the bootstrap median estimates of GIRFs are visualized.

Five shocks were simulated to analyse the dynamic characteristics of cheese export prices and the impacts of the shocks on intra-EU and extra-EU export prices in intra-EU and extra-EU GVECMs, respectively:

(1) A one-standard-error positive shock to cheese export prices in the intra-EU and extra-EU models, respectively;
(2) A one-standard-error positive shock to crude oil price;
(3) A one-standard-error positive shock to raw milk price;
(4) A one-standard-error positive shock to CPI for food;
(5) A one-standard-error negative shock to cheese production.

6.4.2.1 Spatial price transmission and market integration for Cheese exports

One of the essential ideas behind the creation of the EU is for common policies to form an internal market and foster the integration of spatially separated commodity markets, to facilitate the products free movement among EU members and for trade with non-EU countries as a common economy in international markets. In terms of the dairy market, the CAP, with principles supporting free trade within the EU and common external tariffs and policies externally, was developed to facilitate the market integration of EU agricultural and food markets. Prices can act as appropriate signals for the redeployment of resources to profit from trade in a well-integrated market. The lack of market integration in the EU could make trade-liberalizing initiatives and EU economic development do not function as predicted (Moodley, Kerr, & Gordon, 2000). Hence, examinations of market integration are important for the EU.

6.4.2.1.1 Intra-EU cheese export price transmission and market integration

Figure 6.6 illustrates the GIRFs of intra-EU export price after a positive shock to intra-EU export price, which demonstrates how a country’s export price responds to its own and other EU countries' price shocks. In general, the intra-EU cheese export market is not well-integrated, and the positive shock to one country's cheese export price leads to an immediate increase in the export price itself at a level of around 1.8% (for the Netherlands, it increase itself by around 3%), and also increases export prices of other EU member states with similar price dynamic patterns but at lower levels.

Notably, there are several insightful findings from the GIRFs of intra-EU export price transmission: (1) Strong trade relationships exhibit higher price response: The more one country imports from exporters, the more the price of this country is affected by its exporters' price shocks. For instance, a one-standard-deviation shock to the growth rate of Germany's intra-EU export price (increase by 1.72%) will trigger higher increases in the growth rate of intra-EU export prices of France, the Netherlands, and rest of the EU at the level of 0.77%, 0.51% and 0.27% over time, respectively. (2) Large exporters are significantly affected by other intra-EU countries' cheese prices: as the Top 3 largest EU cheese exporters for the intra-EU export market, the prices of Germany, the Netherlands and France, together with the aggregated prices of the rest of EU countries, are estimated to have a positive and significant response to positive shocks to other countries' prices. The reasons could be that major exported cheeses of Germany and the Netherlands are classic and homogenous products without name protections and have similar price settings as shown in Section III.2 Appendix III (Figure III.10). So, cheeses prices of Germany and the Netherlands are likely to subject to import demand of other countries and their substitute's price. (3) Ireland and Italy is not well integrated into the EU market: Positive shocks to prices of France, Germany, Italy, and the UK do not statistically significantly affect prices of Ireland and Italy, while the positive shocks to their own prices, and prices of the Netherlands and rest of the EU have significant and positive impacts on the prices of Ireland and Italy. This might be because Ireland and Italy don't compete directly with other countries due to speciality types of cheese with product differentiation. (4) A positive shock to the price of the rest of EU (cheese export price increases by 1.1%) will cause increase in the prices of all the studied countries, with the prices of Italy and France displaying long-lasting and significant increases compared to prices for the other countries.

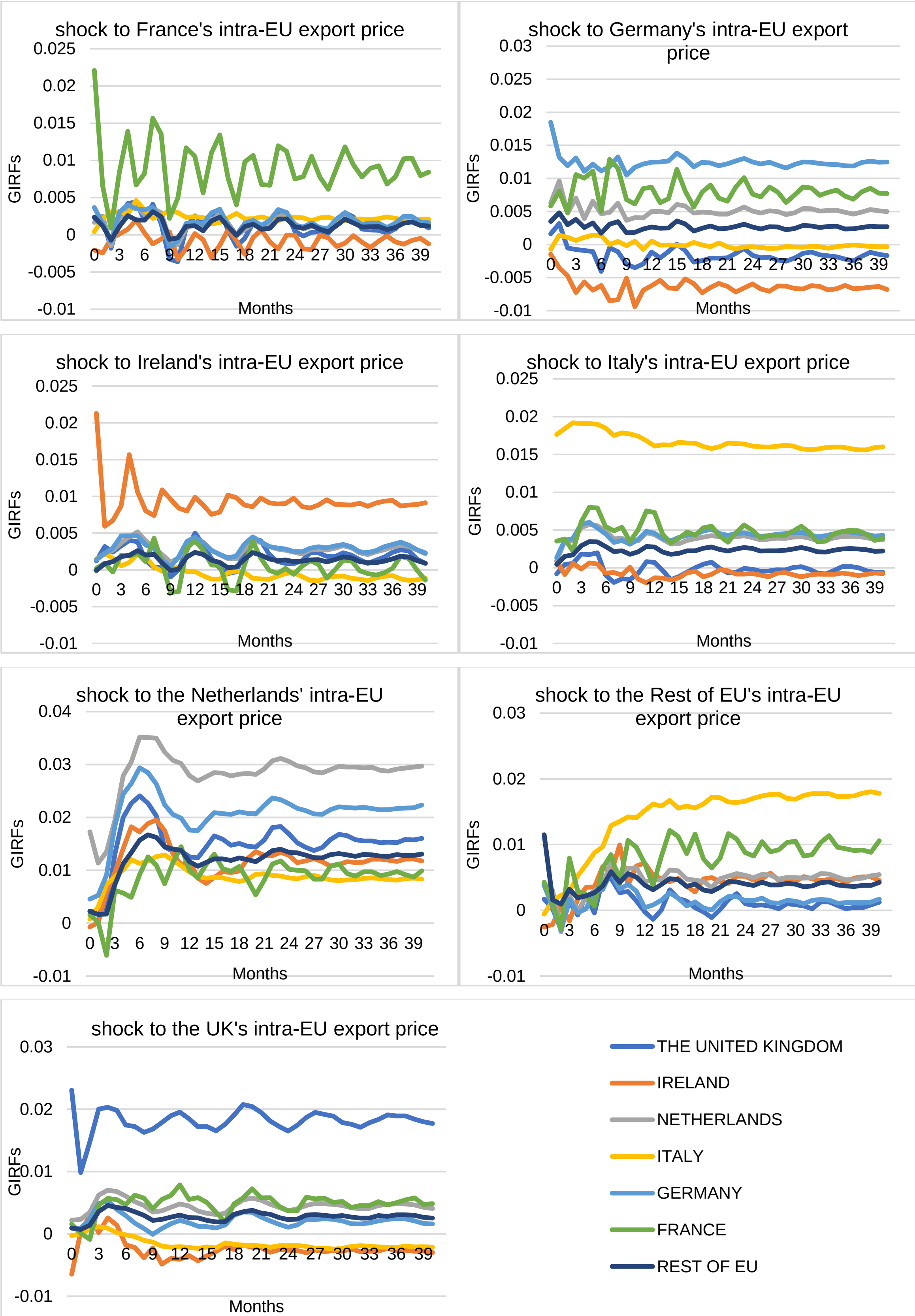


Figure 6.6: Generalized impulse response of a positive one-standard-error shock to intra-EU cheese export price on intra-EU cheese export price

6.4.2.1.2 Extra-EU cheese export price transmission and market integration

Price transmission in intra-EU and in extra-EU export markets follows different dynamics. A positive one-standard-deviation shock to each price is equal to 9%, 3.6%, 3.1%, 2.2%, 1.7%, 1.8% and 1.3% increase in extra-EU cheese export price of the UK, Ireland, the Netherlands, Italy, Germany, France and Rest of the EU, respectively. The time profiles GIRFs in Figure 6.7 illustrate the extra-EU cheese export price transmission and indicate that this export market is not well integrated as well. However, there are clear price interactions between Ireland and the UK. A positive shock to one country's export price instantly increases the price itself and the increases stablise at the level of around 1% (for Ireland, the UK and Italy, the responses are +3%, +5% and +2.2%, respectively), while it causes increases in other country's export price at smaller levels. Several findings can be identified from the GIRFs results depicted in Figure 6.7: (1) A positive shock to Germany's price will cause increases in prices of Germany, the UK, Netherlands and Italy, although at a relatively lower level than the increase in itself. However, the positive shocks to the prices of France and Italy don't have statistically significant impact on other country's extra-EU export prices. (2) A positive shock to the price of the Netherlands will lead to an increase in the prices of itself, Germany, Ireland and the UK at a similar level, which means a shock to extra-EU export price of the Netherlands has strong spill-over effects on the prices of Germany, Ireland and the UK. (3) A positive shock to Ireland's price leads to significant price inflation in the UK at a level of 1%, while a positive shock to the UK's price leads to significant and long-lasting price inflation of itself (6%) and Ireland (2%). (4) The extra-EU export price of France is not affected by price shocks to other countries and shows no interlinkages with other prices.

In summary, market integration exists in the extra-EU cheese export market for several countries, however, France and Italy, the second and third largest extra-EU exporter, are not integrated in the extra-EU market because they do not directly compete with other countries due to product differentiation. The price shocks of the UK and Ireland have less spillover effects on other EU countries. But there is strong market integration between these two counties: The prices of Ireland and the UK are vulneralable to direct shocks to their own prices , and the price shock will transmit to each other at a larger scale than other countries and the impact will last longer. The shocks to Netherlands' prices will cause swifter and long-lasting responses from their competitors at the similar level and has strong contageous effects.

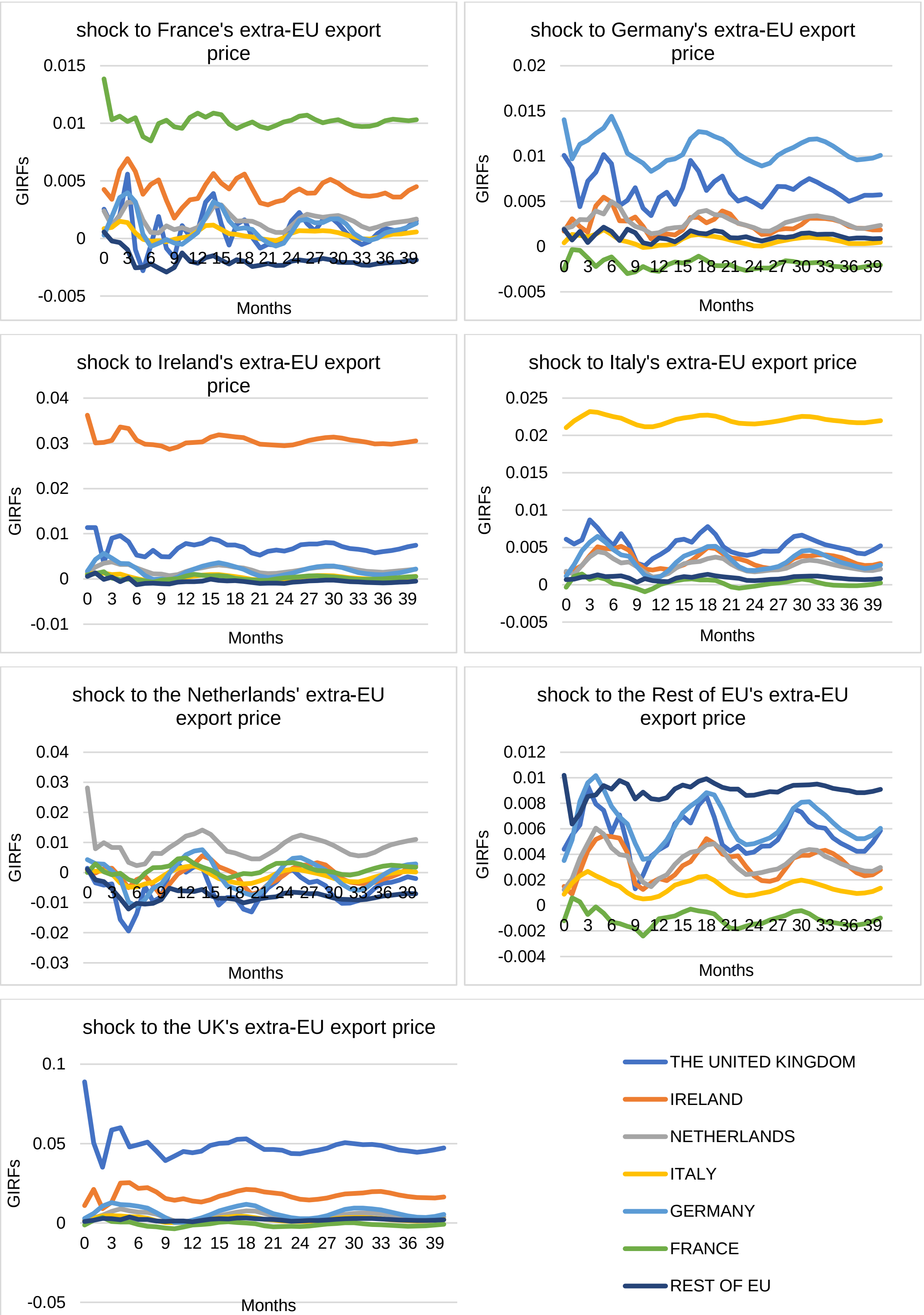


Figure 6.7: Generalized impulse response of a positive one-standard-error shock to extra-EU cheese export price on other countries' extra-EU cheese export price

6.4.2.2 Impact of crude oil price shocks

Crude oil price is assumed to affect agricultural commodity price via two major channels: (1) directly as input costs: production, transportation and distribution consumes energy that is directly linked to the crude oil price; (2) indirectly from the price transmission of biofuel production: the productions of biofuel consumes large quantities of corns which are the feeds for the cows in the dairy sector. Although the theoretical and some empirical evidences points out the impacts of crude oil price on the agricultural commodities prices, there is still no consensus in the empirical literature on the crude oil price transmission to individual agricultural markets (Nazlioglu & Soytas, 2012).

6.4.2.2.1 Impact on intra-EU cheese export prices

Figure 6.8 depicts the generalized impulse response functions (GIRFs) of intra-EU export price after a positive shock to the price of crude oil. Overall, a positive shock will only cause slight increases in the intra-EU export price for the first 4 months, while the positive impact dies down over time. Crude oil price inflation is estimated to cause higher intra-EU export price changes in the UK and the Netherlands than in other EU countries. Specifically, Ireland and the Netherlands display similar response patterns after the shock, while the impact on the UK's export price is the greatest. In summary, crude oil price has negligible impact on intra-EU cheese export prices. The reasons might be that the EU dairy sector is characterized by grass-fed and less industrialized production processes which are less reliant on crude oil and energy.

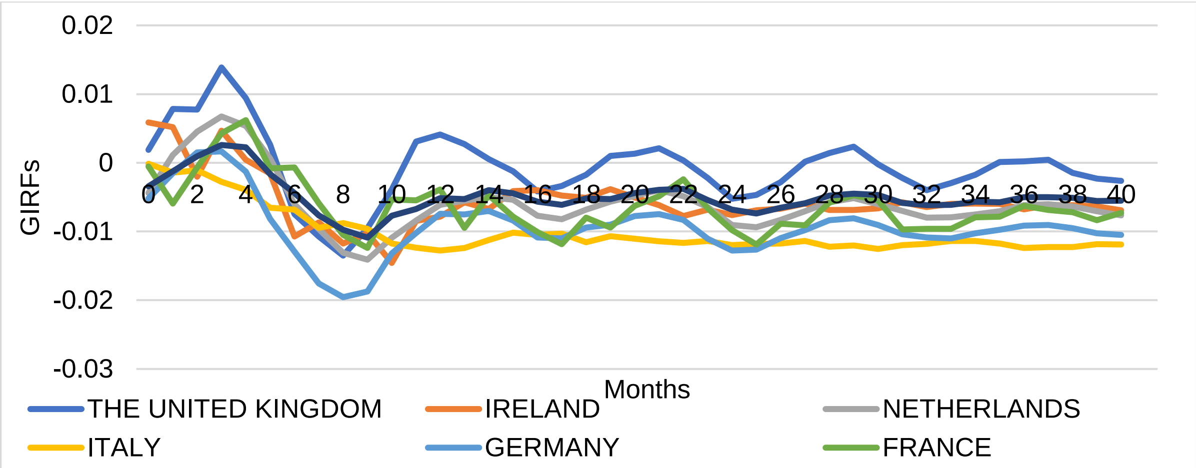


Figure 6.8: Generalized impulse response of a positive one-standard-error shock to crude oil price on intra-EU cheese export price

6.4.2.2.2 Impact on the extra-EU cheese export price

Figure 6.9 illustrates the time profile of generalized impulse response functions (GIRFs) of extra-EU export prices after a positive shock to the crude oil price. Different from the responses of intra-EU export prices, the crude oil price inflation is estimated to cause more significant extra-EU export price rises in all the countries. Moreover, the GIRFs patterns show obvious differentiations among the studied countries. The impact on the UK's cheese export prices is the highest for first few months after shocks, while the impacts on France and Italy are negligible over time. The responses in the extra-EU export prices of Ireland, the Netherlands and Germany display similar patterns over the time and the shows higher increases at a level of 0.5%. So, extra-EU export prices are more vulnerable to crude oil price shocks than intra-EU export prices. This might be due to the fact that the economies of major importers such as the US, Japan, and Saudi Arabia, etc., are highly dependent on crude oil and transportation costs connect cheese export prices to energy prices.

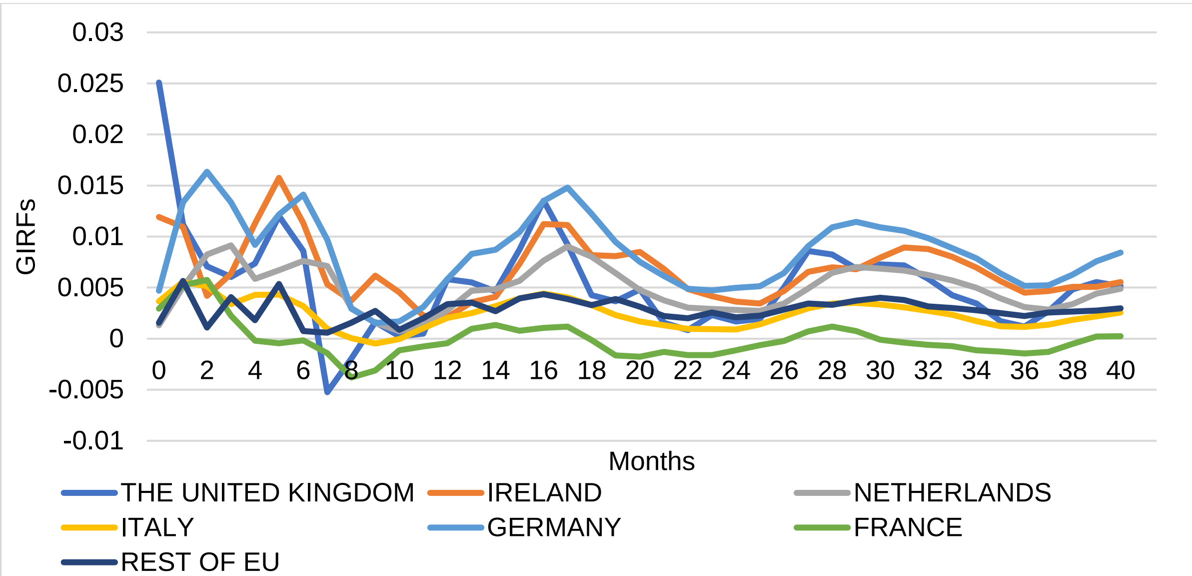


Figure 6.9: Generalized impulse response of a positive one-standard-error shock to crude oil price on extra-EU cheese export price

6.4.2.3 The impacts of Raw milk price

Price transmission across countries and from upstream along the supply chain to export price reflects price relationships between domestic and international markets. Understanding both vertical and spatial price transmission could shed light on welfare allocation for different stakeholders in the export-oriented dairy industry. If the domestic markets or local suppliers are isolated from the international market, the price in the latter will not respond quickly to changes in prices in domestic national markets (Getnet et al., 2005; Siqueira, Kilmer, & Campos, 2010). Besides, farm-gate raw milk is the main raw materials to produce cheeses, so the rise in raw milk prices will increase the final product prices.

6.4.2.3.1 Impact on the Intra-EU cheese export price

Figure 6.10 illustrates the GIRFs of intra-EU export price after a positive shock to raw milk price. A one-standard-deviation positive shock to each raw milk price is equal to increase in raw milk price of the UK, Ireland, the Netherlands, Italy, Germany, France and Rest of the EU by 2.2%, 3.1%, 2.1%, 1.8% 1.6%, 1.8% and 0.4%, respectively. In general, the positive shock to raw milk price in one country is estimated to lead to increases in the intra-EU export prices of all EU countries, though at different levels, which implies strong integration between the domestic and the EU internal markets. There are several insightful results to indicate the pattern and degree of price transmission and market integration in the intra-EU cheese export market: (1) The responses of export prices of Germany and the Netherlands show similar patterns and at similar levels after the shocks to raw milk prices of each studied EU country. (2) The impact on the prices of Italy are the lowest after simulated shocks to raw milk prices of France, Ireland, Italy, the UK and aggregated rest of the EU, while the impact on the prices of Italy is highest after a shock to raw milk price of Germany. (3) A shock to raw milk price of the Netherlands has the most significant impacts on export prices of all the EU countries, while Germany has the least impact on export prices of all the countries over time.

In summary, the intra-EU export price and raw milk price transmission found relatively strong integration of EU internal markets with domestic raw milk markets, dominated by local supply shocks and quick contagion effects and price adjustments. Italian cheese export prices are not significantly affected by raw milk price shocks.

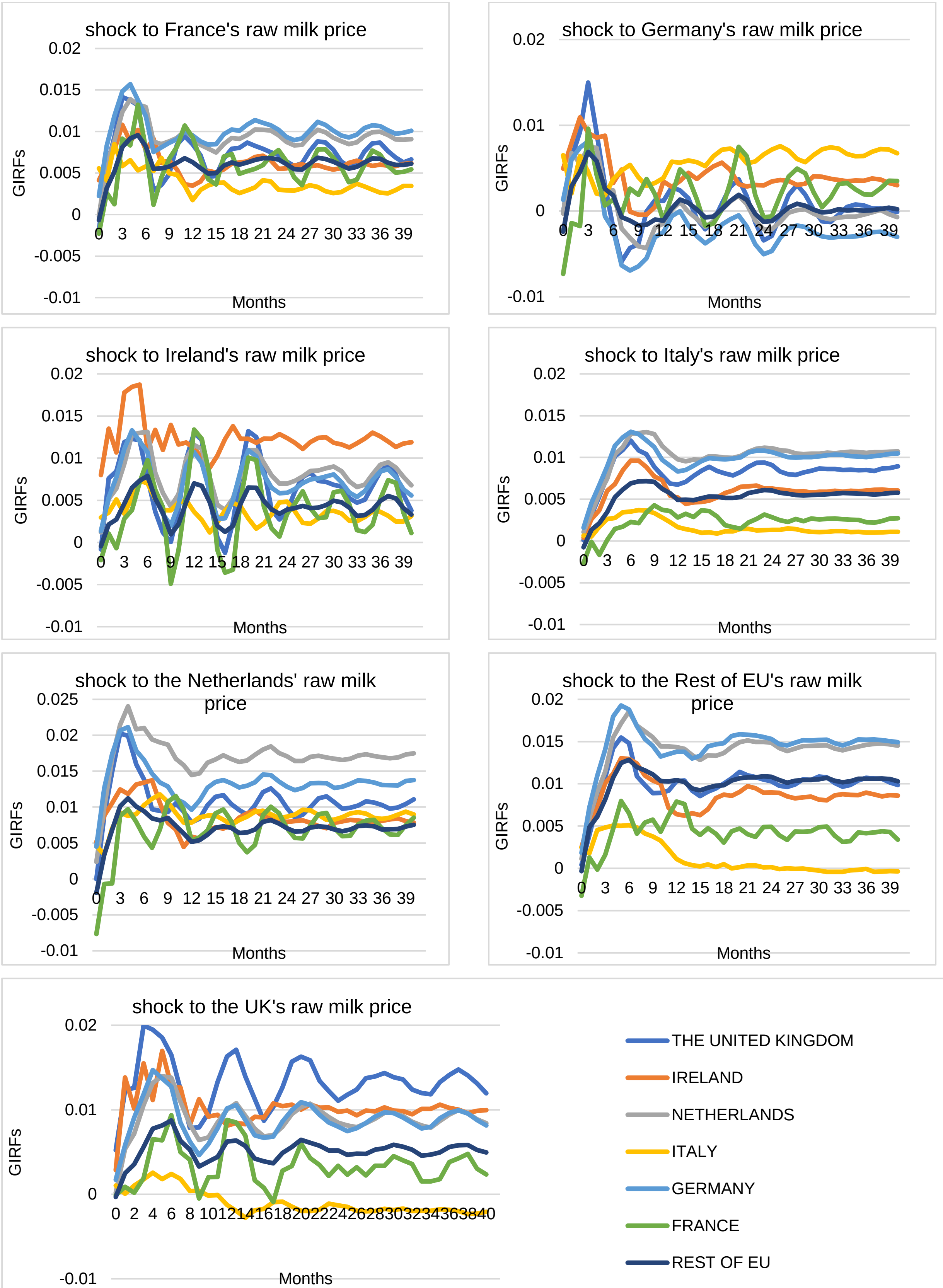


Figure 6.10: Generalized impulse response of a positive one-standard-error shock to raw milk price on intra-EU cheese export price

6.4.2.3.2 Raw milk price shock's impact on the Extra-EU cheese export price

Figure 6.11 illustrates the GIRFs of extra-EU export price after a positive shock to raw milk price. A one-standard-deviation positive shock to each raw milk price is equal to increase in raw milk price of the UK, Ireland, the Netherlands, Italy, Germany, France and Rest of the EU by 2.2%, 3.8%, 2.6%, 2.0%, 1.4%, 2.0% and 0.3%, respectively. In general, the shocks to raw milk price leads to less significant changes in extra-EU export prices of the studied countries. In the international market outside of the EU, integration between raw milk price and cheese export price is weak. Specifically, (1) In the extra-EU market, the export prices of the Netherlands and Germany display similar patterns and similar response level after the positive shocks to raw milk prices of every studied country. (2) Raw milk price shocks from all the studied countries will lead to statistically significant increase in the export price of the rest of EU. (3) Export prices of Ireland, France and Italy are barely affected by the shocks to raw milk prices of every studied country except their own domestic raw milk prices. The reason could be that most exported cheeses of Ireland, France and Italy are high-end and differentiated cheeses, thus are less susceptible to raw milk price changes. Brie (CN04069084) is the most exported and net exported cheese type for France and is known as "The Queen of Cheeses" under the EU geographical protection. Grana Padano, Parmigiano Reggiano (CN 04069061) are the most exported and net exported cheese category for Italy. Grana Padano, granted DOP on 12 June 1996, is one of the few cheeses that can possibly compete with the King of Cheeses; Parmigiano-Reggiano. Cheddar is the most exported cheese of Ireland and is known around the world.[101] These cheeses are highly associated with its exporting countries and have stable market shares, higher margin and loyal consumers, so they are more resilient facing shocks from upstream supply chain.

In summary, there is weaker raw milk price and extra-EU export price transmission for EU member states than intra-EU export price transmission. The export markets of Ireland, France and Italy are isolated from raw milk markets of other countries.

[101] Information on cheeses is from https://cheese.com. See Section III.2 in Appendix III for trade details.

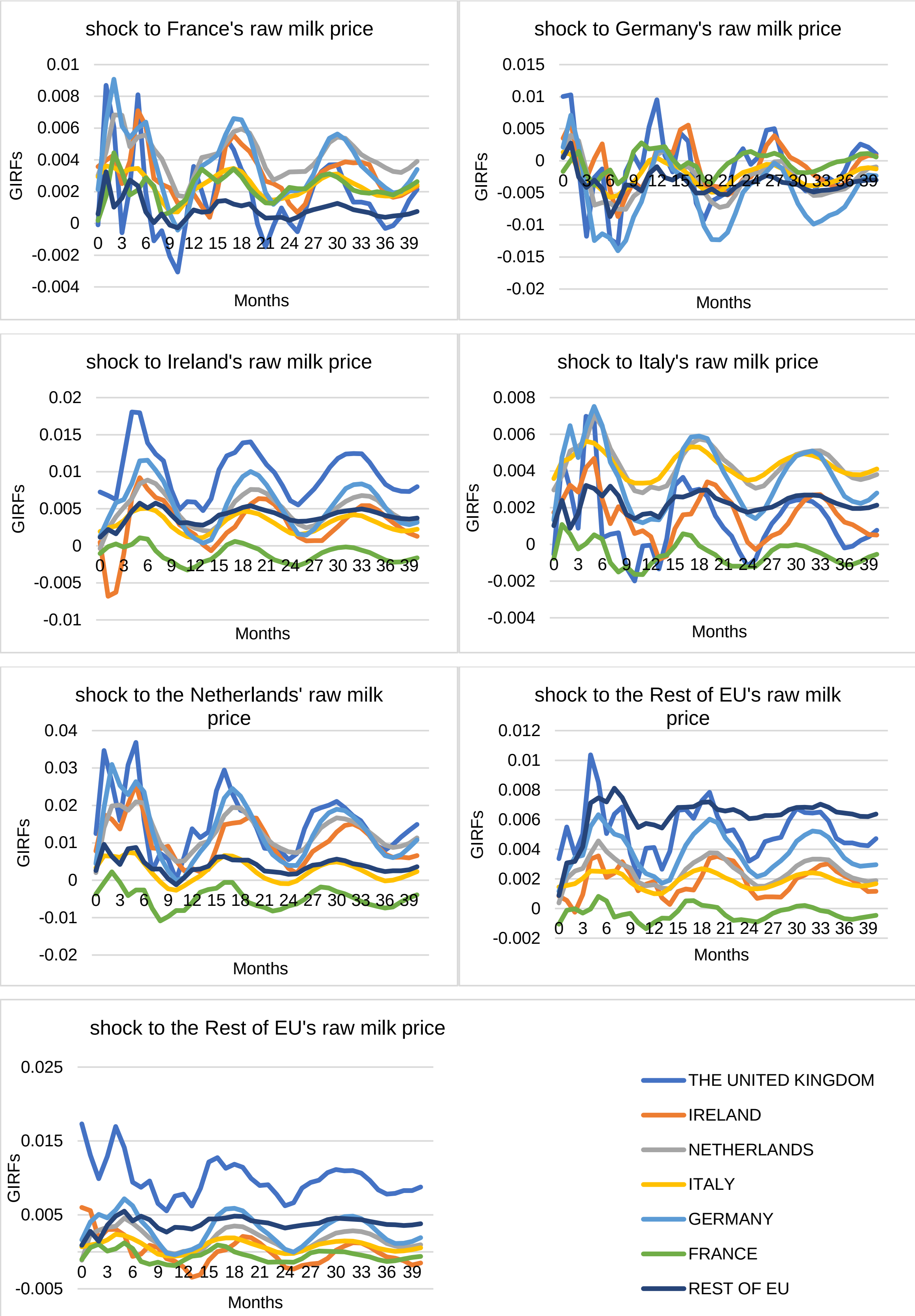


Figure 6.11: Generalized impulse response of a positive one-standard-error shock to raw milk price on extra-EU cheese export price

6.4.2.4 The impacts of CPI for food

The consumer price index of food in the EU has been collected and calculated using the Harmonized Index of Consumer Price (HICP) of food[102] to ensure the statistical consistency and harmonization of CPI in different EU member states, which allows international comparisons of consumer price inflation for EU member states. The stability of HICP of food serves the purpose of EU monetary policy effectiveness.

6.4.2.4.1 Impact on the intra-EU cheese export price

Figure 6.12 illustrates the GIRFs of intra-EU export price after a positive shock to HICP for food. A one-standard-deviation positive shock is equal to increase in CPI for food of the UK, Ireland, the Netherlands, Italy, Germany, France and Rest of the EU by 0.5%, 0.2%, 0.4%, 0.2%, 0.4%, 0.2% and 0.1%, respectively. The direction for the responses of export prices after a positive shock to the HICP for food are not consistent across countries: (1) The export prices of most countries increase after a positive shock to Italy's HICP for food, with prices of Italy, Germany and the Netherlands having common movements. However, the export prices of most countries decrease after positive shocks to HICP for food in Ireland and the Netherlands. (2) The export prices of France, Ireland and Italy decrease after a positive shock to HICP for food in almost all the countries. (3) The export price of Germany responds positively and more significantly than others after simulated shocks to HICP for food of France, Germany, Italy, the UK and the rest of EU.

To sum up, positive shocks to the food CPI lead to significantly negative responses in Italian cheese prices and slight negative responses in French and Irish cheese prices. The reasons behind the results are that the most exported Italian cheese represent a type of high-end products. According to economic theory of consumption, as price level rises, interest rates rise, domestic investment in foreign countries decreases, the real exchange rate appreciates, net exports decrease, which suggest inflation means less exports and more imports of that countries. Consumers are price sensitive to food and high-end cheese price elasticity of demand is high. So, demands for Italian high-end

[102] HICP – food: Harmonised Indices of Consumer Prices (HICP) are designed for international comparisons of consumer price inflation. See the Eurostat website for details: https://ec.europa.eu/eurostat/web/products-datasets/-/teicp010.

cheese decline as consumers give up it to purchase other cheaper and substitute cheeses when inflation occurs in the import countries, then the price of exported Italian cheese will decrease accordingly.

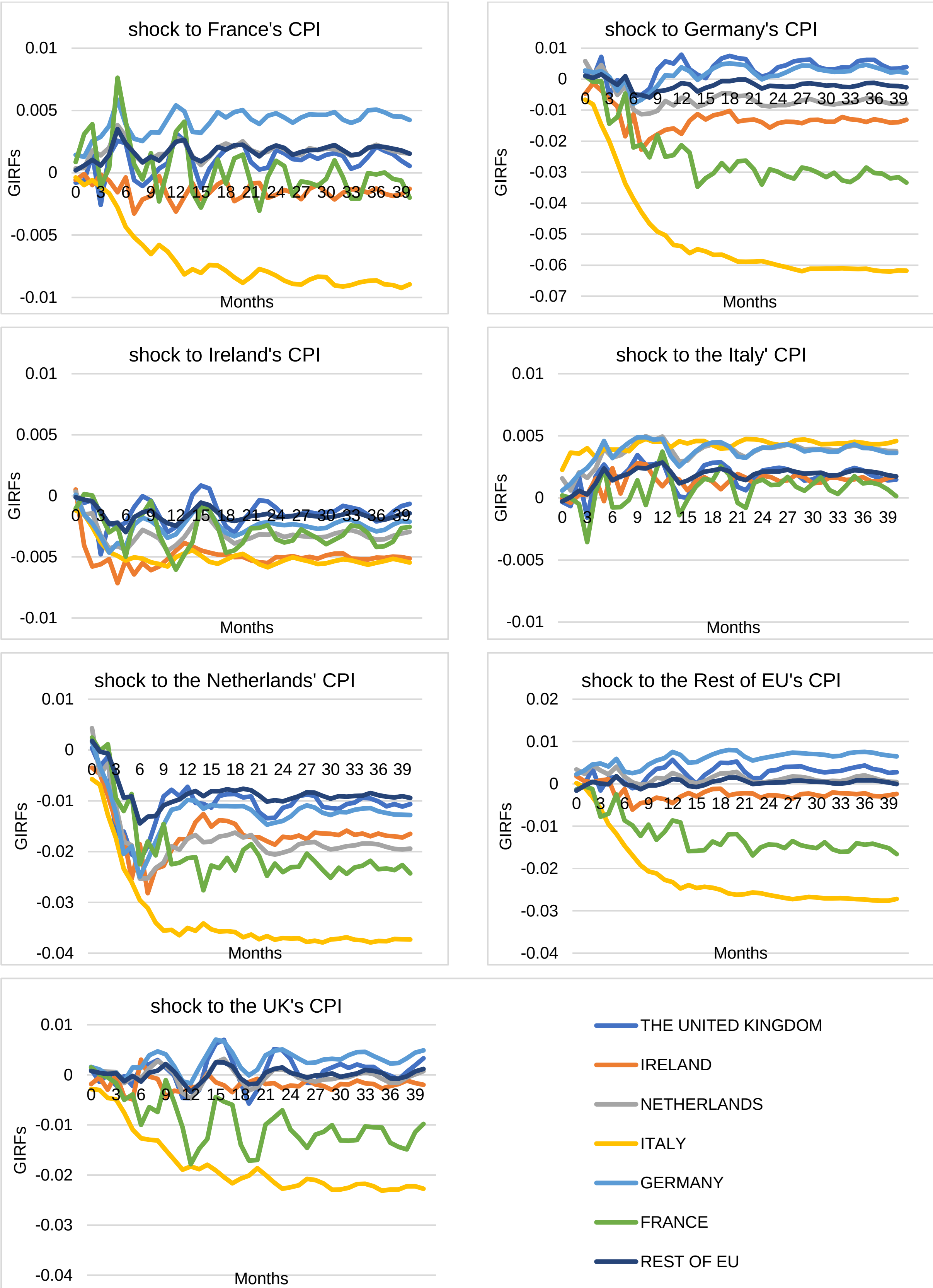


Figure 6.12: Generalized impulse response of a positive one-standard-error shock to the HICP for food on intra-EU cheese export price

6.4.2.4.2 Impact on the extra-EU cheese export price

Figure 6.13 illustrates the GIRFs of extra-EU export price after a positive shock to HICP for food. A one-standard-deviation positive shock is equal to increase in CPI for food of the UK, Ireland, the Netherlands, Italy, Germany, France and Rest of the EU by 0.5%, 0.3%, 0.4%, 0.3%, 0.3%, 0.2% and 0.1%, respectively. In general, extra-EU export price dynamics are different from intra-EU export price dynamics after a positive shock to HICP for food. The extra-EU cheese export prices are hardly affected by HICP for food with only a few countries showing statistically significant responses to shocks from HICP for food: (1) The shocks to HICP for food of Ireland, Germany, Italy and are estimated to hardly affect extra-EU export prices of almost all the countries. (2) There are statistically significant and positive response of cheese export prices of Ireland and France after shocks to France HICP for food. If France HICP for food increase by 0.2%, the cheese export prices of Ireland and France will increase by 0.3% and 0.23%, respectively. (3) There are negative responses of cheese export price of rest of the EU after shocks to HICP for food of France, Germany, Ireland, Italy. (4) There are statistically significant and positive responses of cheese export prices of the Netherlands after shocks to its own HICP of food. So, if HICP for food of the Netherlands increases by 0.4%, the extra-EU cheese export price of the Netherlands will increase by 1%.

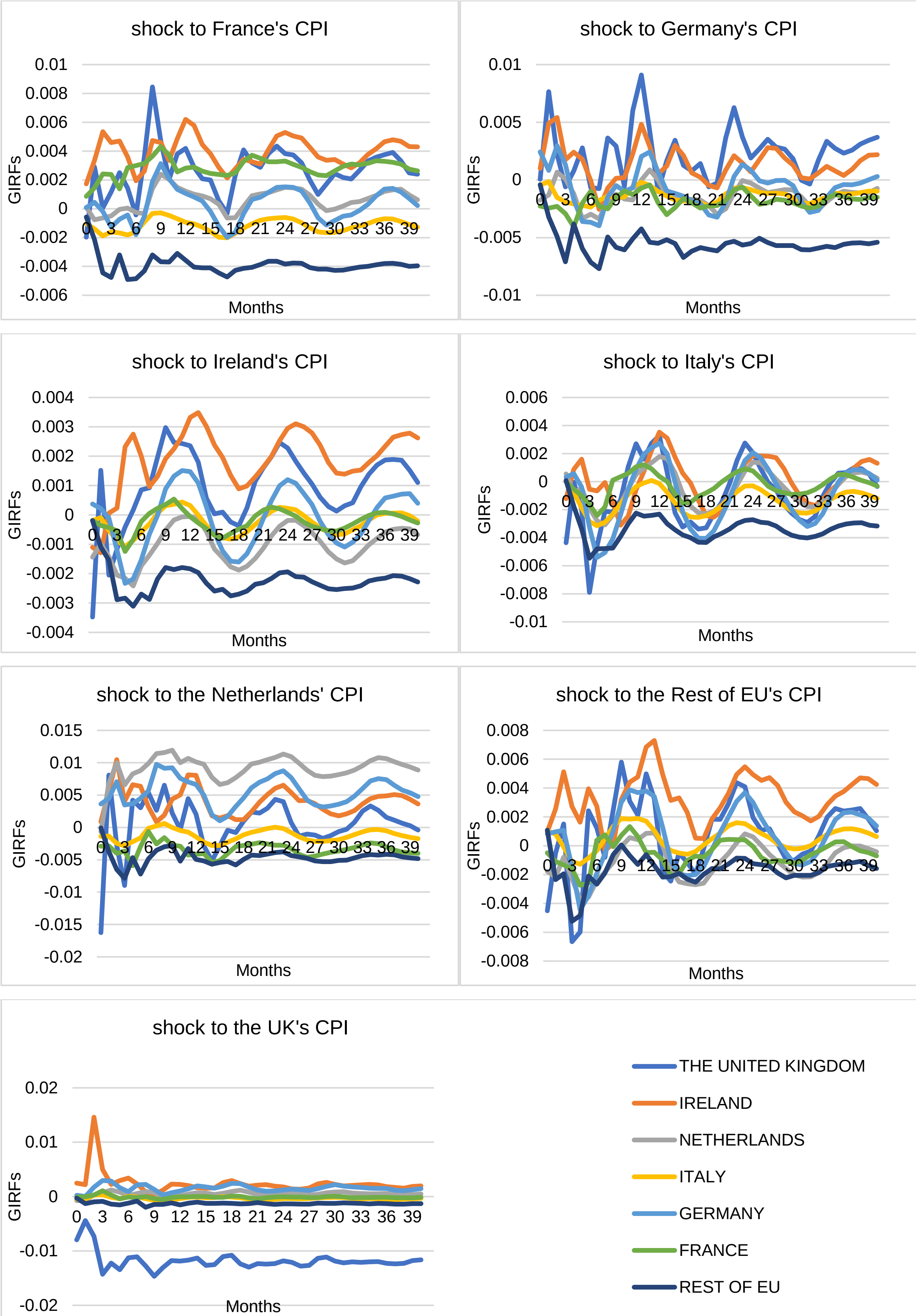


Figure 6.13: Generalized impulse response of a positive one-standard-error shock to the HICP for food on extra-EU cheese export price

6.4.2.5 The impact of shocks in the cheese production index

Slow growth or decline in production has always been regarded as a critical supply-side factor that can cause sharp increases in the global agricultural commodity prices (Mitchel, 2008; Trostle, 2008). Extreme weather and climate conditions, distorted policies and wrong market signals might cause cheese production decline in the EU market.

6.4.2.5.1 Impact on the intra-EU cheese export price

Figure 6.14 illustrates the GIRFs of intra-EU export price after a negative shock to the cheese production index. A negative one-standard-deviation positive shock is equal to decreases in cheese production of the UK, Ireland, the Netherlands, Italy, Germany, France and Rest of the EU by 5%, 1.85%, 2.7%, 2.8%, 1.7%, 1.3% and 1.8%, respectively. In general, the impact direction of negative shocks to cheese production indexes on intra-EU cheese export prices are uncertain: (1) A negative shock to cheese production of the Rest of the EU has a positive impact on export prices of almost all the studied countries. (2) The export price of France remains unaffected after a shock to production indexes of France, Germany, Ireland and the rest of EU, while it decreases over time after shocks to production indexes of Italy, the Netherlands and the UK. (3) The impacts of shocks to cheese production of France, Ireland, Italy and the Netherlands on the export price of Ireland are negligible, while the export price of Ireland will increase after simulated shocks to production of the UK and the rest of EU and decrease after a shock to cheese production of Germany. (4) The export prices of many countries decrease after negative shocks to cheese production of Germany, Italy, the Netherlands and the UK.

However, due to endogeneity found in the foreign cheese production indices for VECMX of Ireland, Germany and France, the impacts of shocks to these countries' cheese production might not reflect the reality. As the long-run feedback exists between foreign and domestic cheese production indices of these country, so the spill-over effects of shocks to these indices may be offset or enhanced, thereafter, leading to decreases in cheese export prices.

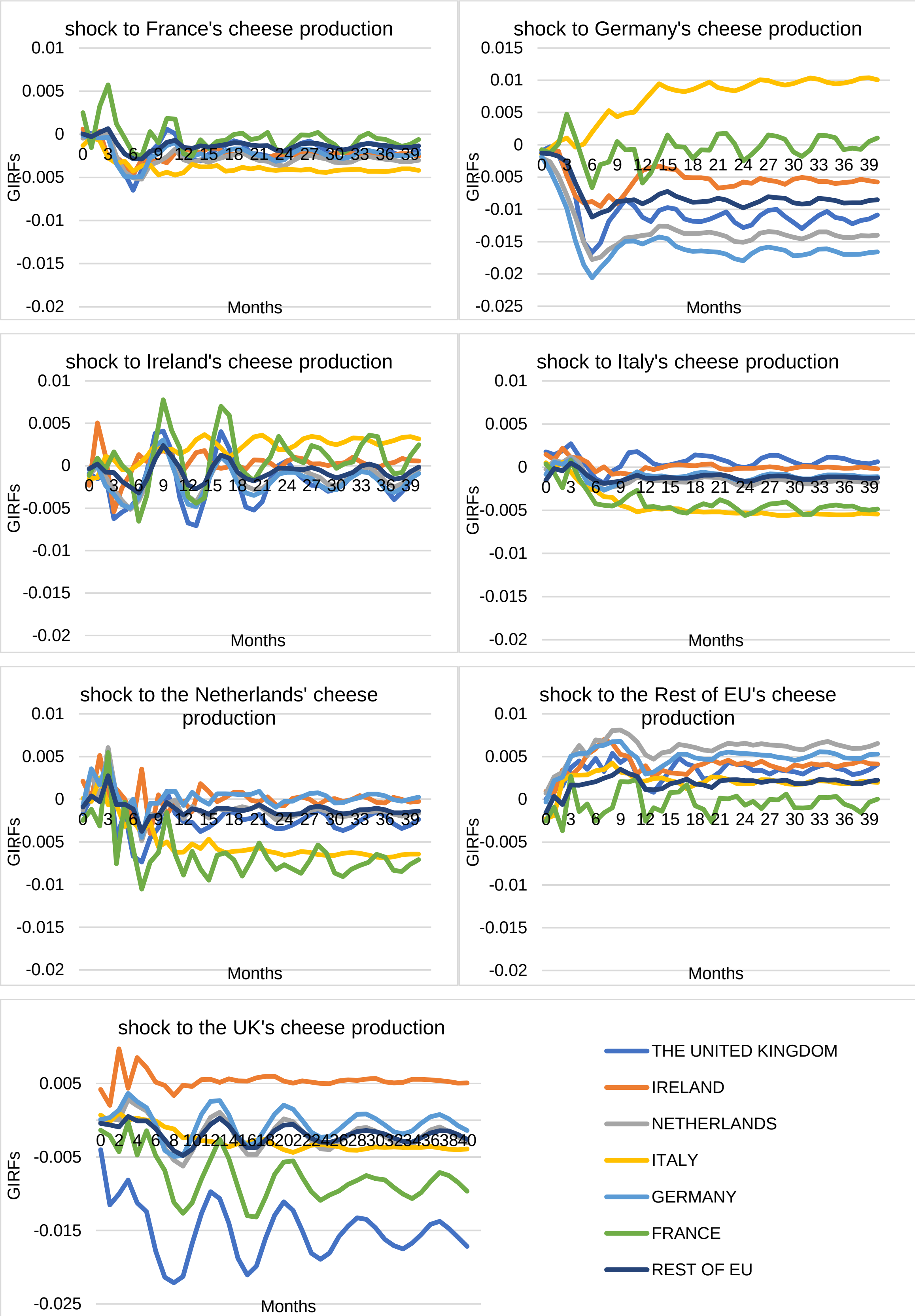


Figure 6.14: Generalized impulse response of a negative one-standard-error shock to cheese production on intra-EU cheese export price.

6.4.2.5.2 Impact on the extra-EU cheese export price

Figure 6.15 illustrates the GIRFs of extra-EU export prices after a negative shock to the cheese production index. A negative one-standard-deviation positive shock is equal to decrease in cheese production of the UK, Ireland, the Netherlands, Italy, Germany, France and Rest of the EU by 5.2%, 2.54%, 2.8%, 3.7%, 2.5%, 1.9% and 2.7%, respectively. The extra-EU export price dynamics are different from intra-EU export price dynamics after one-standard-error shock to the cheese production and the direction of response is uncertain as well. In general, production shocks only affect extra-EU export prices of a few countries: (1) The negative shocks to cheese production of France, Ireland and Rest of the EU barely have an impact on extra-EU export prices of all studied countries. (2) A negative shock to cheese production of Germany will lead to decreases in cheese export prices of Italy and the Rest of the EU. (3) A negative shock to Italy leads to increases in export prices of the Netherlands, Germany and the Rest of EU, while negative shocks to the Netherlands will lead to decreases in export prices of the Netherlands, Germany and the Rest of EU. (4) A negative shock to cheese production of the UK will lead to decreases in prices of the UK and Rest of the EU.

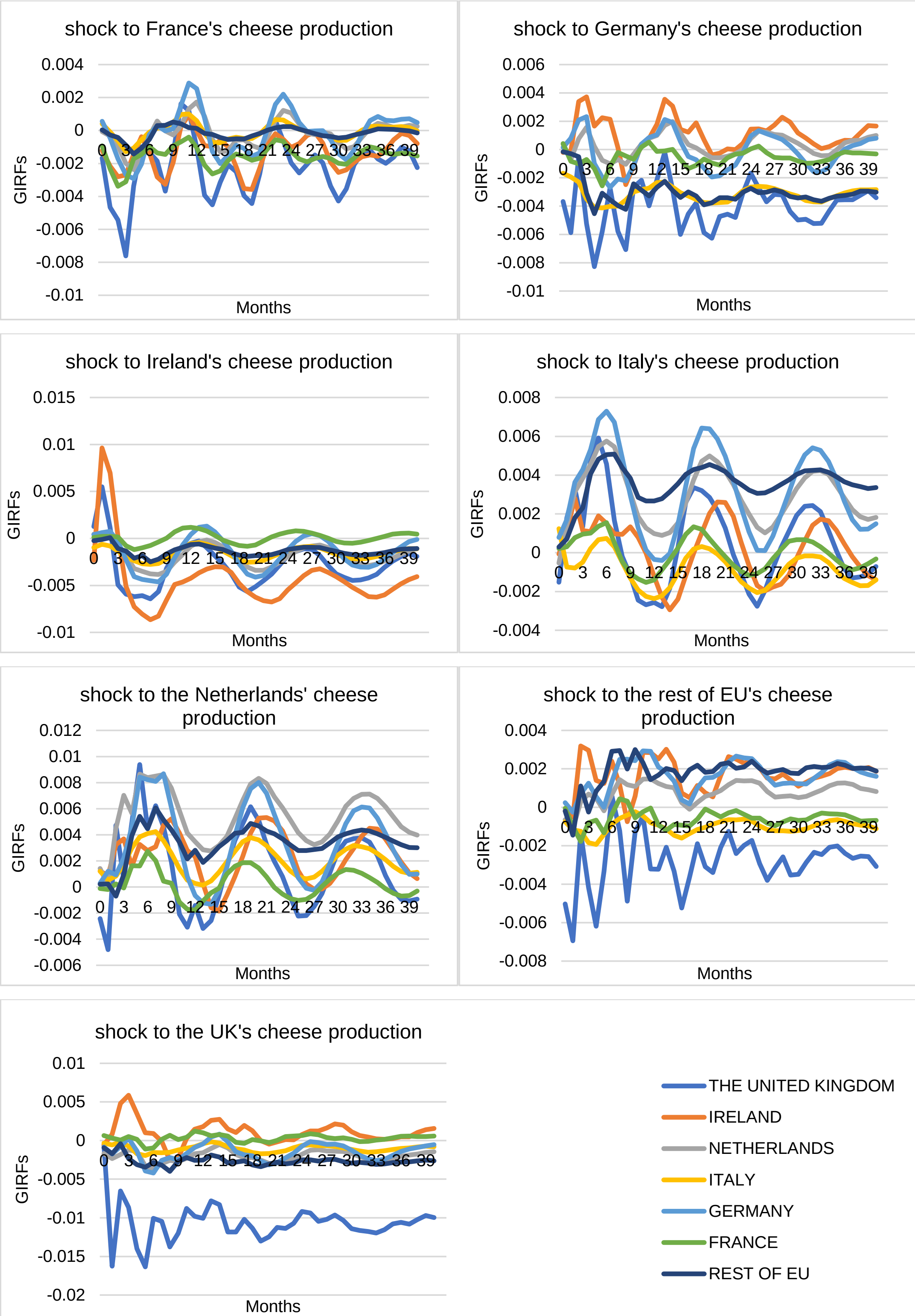


Figure 6.15: Generalized impulse response of a negative one-standard-error shock to cheese production on extra-EU cheese export price

6.5 Conclusion and Discussion

6.5.1 Conclusion

This chapter has sought to identify and compare the drivers of export price dynamics and market integration in the intra-EU and extra-EU cheese export markets by estimating two Global VAR models separately for EU member states. This study has considered shocks to crude oil price, raw milk price, CPI for food and cheese production index as possible influencing factors for export price dynamics and market integration in EU cheese export markets. The results indicate that the shocks have different impacts on intra-EU and extra-EU cheese export prices and the impacts on intra-EU export prices are more consistent and milder than extra-EU export prices.

Several findings are taken from the empirical evidence that provide economic and policy insights:

(1) The transmission mechanism of intra-EU cheese export prices implies weak contagion effects in the EU internal market, yet the degree of contagion effects is determined by the trade relationships between member states, which means the internal market of EU cheese is not well-integrated. In the internal market, the importing market's price dynamics are subject to its major exporters' price dynamics to certain degree. The intra-EU export prices of the UK and Ireland are weakly linked, despite a close trade relationship and export dependence of Irish cheese on the UK. However, a stronger market integration exits in the external market for several countries, except France, the second largest extra-EU exporter that shows insensitivity to all countries' price shocks. The extra-EU export prices of Ireland and the UK are vulnerable to direct shocks to their prices, and their extra-EU export prices are highly linked with each other.

(2) The intra-EU cheese export prices are not sensitive to global crude oil price shocks, while oil price shocks will have slight effects on extra-EU cheese export prices. This implied that EU internal single market creates a strong protection from external shocks for EU member states.

(3) The transmission mechanism between raw milk prices shocks and intra-EU export prices indicates the upstream producer prices in the supply chains have spill-over effects in the internal trade market of the EU. However, weaker price

transmission from raw milk prices to extra-EU export prices implies that upstream producer prices have weaker spill-over effect to the EU external trade market. This implies that raw milk prices could be an effective signal for internal trade among EU member states and could primarily affect the intra-EU cheese trade, thus influencing welfare of producers and exporters.

(4) Food inflation effects on the intra-EU and extra-EU cheese export prices of most countries are statistically insignificant, and intra-EU and extra-EU export prices of different EU member states respond in different directions after food inflation shocks.

6.5.2 Discussion

The findings are useful for policymakers and dairy sector stakeholders in the EU. Successive CAP reforms (e.g. decrease in intervention prices and milk quota removal, etc) have created more market-oriented openness to global markets[103], which brings both challenges and opportunities for the EU dairy sector. Cheese as a heterogenous dairy product exhibits comparative price stability to market shocks. However, free trade and movement of products enhances the price linkages along the supply chain, incorporating intra-EU export prices into the cheese supply chain in the EU internal market, which enhances the interaction of raw material prices and end products, and amplifies the contagious effects of upstream raw milk price volatility and fluctuation transmission. In the EU's international external market, cheese prices are more susceptible to external shocks such as crude oil price, than shocks from internal market. As the EU opens its market further via the bilateral free trade agreement to reduce the duty or even grant duty free market access, this might increase competition for EU producers.

The findings also provide an interesting debate for the possible impacts of Brexit on the EU dairy industry, especially for Ireland, its neighbour and biggest dairy exporter. Ireland and France are the main exporters of cheeses to the British market, especially fresh cheese and some processed cheeses. The UK's exit from the EU and the corresponding uncertainties on the Brexit have been hotly discussed by political

[103] Marie-Laure Augère-Granier (2018). The EU dairy sector Main features, challenges and prospects, European Parliamentary Research Service: https://www.europarl.europa.eu/RegData/etudes/BRIE/2018/630345/EPRS_BRI(2018)630345_EN.pdf

leaders, scholars and stakeholders of various industries. However, this study implies that the negative impacts on Irish cheese export to the UK might be overestimated and exaggerated because the cheese export market of the UK and Ireland is weakly linked in terms of market shocks and price dynamics.

The cheese market of the EU has been mature, competitive and increasingly volatile over the years. To tackle future uncertainty and change to EU cheese markets and exports, the following strategic options and suggested new business models for further growth and price stability in both intra-EU and extra-EU export are recommended:

(1) Consolidating market integration to create a strong, resilient and competitive internal market still requires further effort.
(2) Creating product differentiation and value by developing unique selling points (organic products, special and unique varieties, etc.) and building brands.
(3) Developing ingredient markets and service portfolios of cheeses for usages in pizzas, sandwiches and restaurants and served together with wine to retain trade and price stability in global markets.
(4) Exploring new markets and non-traditional cheese consumption markets such as emerging economies in Asia to counteract possible demand fluctuation in traditional cheese export destinations.

The detailed discussion for this chapter is as below and the following research areas could be explored in future research:

(1) There are some endogeneity problems in the intra-EU GVAR model as lots of foreign variables are not subjected to the weak exogeneity hypothesis underlining the foreign variables requirements for GVAR model. In the VAR-France model, all foreign variables failed the weak exogeneity tests thus may also cause the results that cheese export prices of France are less responsive to different shocks, so the results for intra-EU analysis may not be valid enough to reflect the reality. The foreign variables that are not satisfying the weak exogeneity could be removed from the VARX model while the GIRFs analysis on shocks' impact on cheese export prices can still be conducted.
(2) Cheese is the type of dairy product with plenty of varieties. Specially, cheese in the EU is protected by the PDO and PGI that will create the differentiations

among cheese products and avoid price arbitrage. The study on products with different varieties might require a further study at a more disaggregated product level (6-digit product level, HS 040690, the most traded cheese category; or even further research on 8-digit product level) to find out the competitive advantages for cheese exports in different EU countries.

(3) Climate change, especially the unforeseen extreme weather events, such as increased chances of drought, storms and disease threats, could constrain milk yields by affecting the grass growth and feed supply, thereby influencing famers' decisions on cow inventory adjustment thus further increasing the price volatility of milk and dairy products (OECD, 2018). Therefore, weather indicators such as rainfall indices (precipitation), temperature indices and frequency of extreme weather, could be incorporated into the model to decipher the impact of climate change on dairy product price transmission.

(4) A structural model as proposed by Dees et al. (2007) might be used to incorporate economic theory, institutional knowledge and other constraints such as policy variables into the analysis to assess the causal relationships and effects of possible shocks on export prices.

Chapter 7 Conclusion and Discussion

7.1 Conclusion Remarks

The background, literature review and three empirical studies address the core question in this thesis and elaborate on the key sub-questions as proposed in the introduction.

The background provides a thorough analysis of the global dairy market and delves deeply into the export contexts of the three main global dairy exporters, that is the EU, New Zealand and the U.S. It gives an updated understanding of the dairy trade market from the perspective of policy and trade details. Regional trade agreements, domestic policies for the dairy sector, and trade structures reveal close global trade relationships competition, and market domination by the major dairy exporters. Specifically, an overview a key dairy import market, the Chinese market, offers practical information and advice for dairy trade strategies.

The literature comprehensively provides an understanding of current research topics and methodologies on spatial price transmission and its implications in the agri-food area, and also indicates current research limitations for spatial price transmission of global dairy sector. It points out research directions for spatial price transmission analysis for the dairy sector.

The first empirical research focuses on asymmetric spatial price transmission in the Chinese market and from a specific import market to global market using the examples of Ireland and New Zealand exports for skim milk powder. It is the first research that focuses on an import market dominated by one country and studies price leadership between the existing dominator and new entrants to decipher strategies for new entrants to achieve effective market expansion in the Chinese market. In terms of price transmission between New Zealand and Ireland SMP export prices in the Chinese market, it concluded that the export price transmission between New Zealand and Ireland in the Chinese SMP market is asymmetric. SMP export of two geographically separated countries in the Chinese market are well integrated as the adjustments of price changes are rapid. It also finds that New Zealand has been the price leader in the Chinese SMP imported market, and the export prices of Ireland responds more rapidly to decreases than to increases of the export prices of New Zealand. In terms of price transmission of New Zealand and Ireland from Chinese market to global market, it is concluded that the spatial price transmission from Chinese market to global market is asymmetric for both Ireland and New Zealand. Market integration between Chinese market and global market for SMP exports is weak. In the short-run, SMP export price of Ireland in global market has a slower correction speed to positive deviations than to negative deviations from the long-run equilibrium between global price and Chinese price. Oppositely, SMP export price of New Zealand in global market responds faster to positive deviations than negative deviations from long-run equilibrium between global price and Chinese price. SMP export price of Ireland and New Zealand in the Chinese market might converge to the long-run equilibrium symmetrically regardless of the positive or negative deviations as its estimated coefficients are not statistically significant.

The second empirical research contributes to the existing literature for both GAVR model application and dairy price transmission analysis. The success of GVAR application for global butter export price transmission and impacts of influencing factors on price dynamics generalizes the model application scopes from macroeconomics and finance to the agricultural economics. It is the first research that investigates the spatial price transmission of butter (or even dairy) and price dynamics and interactions with influencing factors at global level and with a focus on the trade market. It reveals the strong price linkages between butter export prices and palm oil prices and butter export price transmission mechanisms at the global and spatial levels. This research also sheds light on global integration of the butter trade market as well as price transmission from energy market to the agricultural commodity market. Using generalized impulse response functions, this paper finds that increases in international palm oil price could be swiftly transmitted to the EU, New Zealand and the U.S.'s the butter export prices with the highest transmission intensity on New Zealand price, yet crude oil price merely affects butter export price. It also finds that U.S. dollar depreciations against the Euro and the aggregated RoW currency will cause butter export price upsurge in the U.S., the EU and New Zealand. It is concluded that the spatial price shock spill-over effects are weak and butter export markets are not well-integrated, but New Zealand's butter export price would be more significantly influenced by EU butter price shocks.

The third empirical research explores internal and external markets for EU cheese following market shocks. It explores price transmission among major EU cheese exporters and the impacts of influencing factors on cheese export price dynamics in both intra-EU and extra-EU export market. Using generalized impulse response function, it is concluded that the internal market of the EU is better integrated than its external market in terms of cheese exports. Quality and product differentiations make cheese export prices of Italy and France more resilient to external shocks and could remain unaffected. The vulnerability to raw milk price shocks in the internal market manifests the contagious effects embedded in the creation of the European single market. Interesting results on the Ireland and the UK price interactions after the simulated shocks require reflection on the overestimated negative consequences of Brexit. The intra-EU cheese export prices are not sensitive to global crude oil price shocks, while oil price shocks will have slight effects on extra-EU cheese export prices.

7.2 Discussion

The major contributions, limitations and future research are present in this section for discussion.

7.2.1 Contribution

The thesis focuses on spatial price transmission in trade markets and make the following contributions to the existing literature:

First, this study develops a theoretical Global Vector Autoregressive Models that links the global butter export prices of major exporters with their domestic macroeconomic factors, global input price, substitute price and energy price. It is the first study to conduct research on the spatial price transmission of dairy products incorporating other influential factors into the analysis and addresses the complexity and dynamics of dairy export markets following market shocks. In addition, the application of the GVAR model on the dairy sector extends the scopes of its application and robustness from primarily macroeconomics and finance to the agricultural economics.

Second, the existing literature was limited in its consideration of price dynamics and spatial price transmission of dairy export prices. Dairy products, as major and most protected trade commodities, are highly important for trade in goods in certain countries and regions. This research, with a focus on export prices of multiple dairy products, adds to the current price transmission literature in an essential but neglected area of price transmission in the dairy sector. This study provides a comprehensive understanding of dairy export market mechanisms and price dynamics.

Thirdly, this study contributes an understanding of how influencing factors can affect the dairy export prices in global and in EU trade markets. It formulates a comprehensive dynamic analysis framework and uses innovative time series models to find out the export price mechanism at different spatial levels. So far, to my knowledge, it is the first discussion of market integration and cross-country price dynamics under different market shock scenarios in the global butter export market and in the EU cheese export markets. It is innovative that this research studies differences in the price dynamics after simulated shocks in the intra-EU and extra-EU cheese export markets, which contributes to assessments on the strengths and weaknesses of the EU single market strategy.

Finally, this research provides in-depth analysis on export price transmission asymmetry for New Zealand and Ireland in the Chinese market in the context of emerging important position of the Chinese market for dairy trade and the need to understand price leadership in the Chinese market. It could shed light on dairy trade strategy for the EU to expand market share in the Chinese market by putting New Zealand and Ireland into analysis as they represent the dominator and new entrant in a promising import market, respectively. It is also novel to conduct a country-specific analysis of price transmission for the dairy commodity trade during period of economic policy uncertainty and shifts in global trade patterns periods.

7.2.2 Limitations

The study has accomplished all objectives proposed in the introduction (Chapter 1), however, several limitations need to be addressed, as discussed here:

First, the most important limitation lies in data availability, size and quality in the empirical studies. Due to the time span and data availability, the study only covers the time period from Jan 2010 to Dec 2016. However, there are more striking policy and economic changes relating to the dairy sector globally in 2015 and 2016, especially for the EU. It would be better to conduct a comparative analysis of different time spans, to cover different structural economic and policy changes and gain more understanding the impacts of certain policies.

Secondly, for the country-specific price transmission analysis in the Chinese and international market, it would be better if the other comparable countries in the EU, such as Denmark, Germany and France are also put into the analysis with Ireland and New Zealand, to improve the understanding of market competition and entrance barriers in the Chinese market.

Thirdly, focusing on the time series analysis lessens the economic foundations of this study, which might expose it to criticism by some economists who look to economic theoretical frameworks and mathematical model derivations as the standards. Limitations in economic theoretical supports and rigorous economic analysis probably weaken the economic implications of this study.

7.2.3 Future Research

This study also highlights several areas that require further research as follows:

Firstly, it would be interesting to conduct extended research on spatial price transmission and price dynamics of purely one type of dairy products to analyzing spatial price transmission and market interlinkage among different products (such as the price transmission among dairy products, corn prices, feed prices) and investigate the feedback from different products prices both domestically and across countries.

Secondly, this study mainly employs time series models and provides a framework to conduct the analysis and understand the price dynamics of the dairy trade market. Time series models have unique advantages and little data requirements. However, a well-designed theoretical model with mathematic deviations to reflects the variable causal relationship might be considered and even incorporated into time series models in the future.

Thirdly, the study simulated different market shock scenarios to understand price dynamics and reaches interesting findings. In recent years, there are remarkable policy changes in the dairy sector around the world, especially in the EU. It would underline and better assess the policy impacts if the policy variables are taken into account and address the policy shocks directly relevant to the dairy sector. Innovatively developed models based on the GVAR (such as Bayesian GVAR, Regime-switching GVAR, etc.) might be employed in the future to facilitate the analysis of policy change effects.

Fourthly, the dairy is highly influenced by the precipitation and is a high water-consuming sector. Climate change and increasing scarcity of water raise threats to the sustainable development of dairy industry and might cause severe economic loss. So, it would be meaningful and practical to put climate variables and water price variables into the analysis, to uncover possible impacts of climate change and water shortages.

Appendices

Appendix I Tables for Chapter 2 Background and Chapter 3 Literatur

Table I.1: The US export to Canada and Mexico (can represent Canada and Mexico imports from the
and Mexico at 6-digit product level

HS Subheading Product code	Product description	Preferential Applied Tariff for the US by Canada (at the HS 6-digit level, 2019)		List of Non-AV Duties set by Canada		**US export to Canada in 2018**		Average of AV Duties set by Mexico (2019)	
		List of Non-AV Duties	Duty Free TL (%)	MFN Applied Tariff, 2019	Bound	Value (in million USD)	Share (of total dairy export to Canada)	MFN Applied Tariff	Bound
040110	Milk and cream of a fat content by weight of <= 1%, not concentrated nor containing added sugar or other sweetening matter					0.00	0.00%	10.0	37.5
040120	Milk and cream of a fat content by weight of > 1% but <= 6%, not concentrated	[241% but not less than $34.50/hl]	0	[241% but not less than $34.50/hl]	[241.3%, but not < 34.5$/hl]	18.00	5.45%	10.0	37.5

	nor containing added sugar or other sweetening matter									
040140	Milk and cream of a fat content by weight of > 6% but <= 10%, not concentrated nor containing added sugar or other sweetening matter	[292.5% but not less than $2.48/kg]	0	[292.5% but not less than $2.48/kg]	[292.6%, but not < 247.5¢/kg]	0.08	0.02%	10.0	37.5	
040150	Milk and cream of a fat content by weight of > 10%, not concentrated nor containing added sugar or other sweetening matter					3.01	0.91%	10.0	40.0	

040210	Milk and cream in solid forms, of a fat content by weight of <= 1,5%					8.80	2.67%	45.0	37.5
040221	Milk and cream in solid forms, of a fat content by weight of > 1,5%, unsweetened	[243% but not less than $2.82/kg] [295.5% but not less than $4.29/kg]	0	[243% but not less than $2.82/kg] [295.5% but not less than $4.29/kg]	[243.4%, but not < 282.0¢/kg] [295.7%, but not < 429.0¢/kg] [3.32¢/kg]	4.30	1.30%	27.5	37.5
040229	Milk and cream in solid forms, of a fat content by weight of > 1,5%, sweetened	[243% but not less than $2.82/kg] [295.5% but not less than $4.29/kg]	0	[243% but not less than $2.82/kg] [295.5% but not less than $4.29/kg]	[243.4%, but not < 282.0¢/kg] [295.7%, but not < 429.0¢/kg] [3.32¢/kg]	0.00	0.00%	-	41.3
040291	Milk and cream, concentrated but unsweetened	[259% but not less than 78.9¢/kg]	0	[259% but not less than 78.9¢/kg]	[2.84¢/kg] [259.4%, but not < 78.9¢/kg]	1.00	0.30%	32.5	-

	(excl. in solid forms)									
040299	Milk and cream, concentrated and sweetened (excl. in solid forms)	[255% but not less than 95.1¢/kg]	0	[255% but not less than 95.1¢/kg]	[2.84¢/kg] [255.0%, but not < 95.1¢/kg]					
040310	Yogurt, whether or not flavoured or containing added sugar or other sweetening matter, fruits, nuts or cocoa	[237.5% but not less than 46.6¢/kg]	0	[237.5% but not less than 46.6¢/kg]	[237.5%, but not < 46.6¢/kg]	2.49	0.75%	20.0	37.5	
040390	Buttermilk, curdled milk and cream, kephir and other fermented or acidified milk and cream, whether or not concentrated	[208% but not less than $2.07/kg] [216.5% but not less than $2.15/kg]	0	[208% but not less than $2.07/kg] [216.5% but not less than $2.15/kg]	[208.2%, but not < 207.1¢/kg] [216.5%, but not < 215.4¢/kg] [3.32¢/kg]	1.21	0.37%	20.0	37.5	

	or flavoured or containing added sugar or other sweetening matter, fruits, nuts or cocoa (excl. yogurt)								
040410	Whey and modified whey, whether or not concentrated or containing added sugar or other sweetening matter	[208% but not less than $2.07/kg]	66.67%	[208% but not less than $2.07/kg] [4.94¢/kg]	[208.2%, but not < 207.1¢/kg] [3.32¢/kg] [4.94¢/kg]	35.20	10.66%	15.0	37.5
040490	Products consisting of natural milk constituents, whether or not sweetened, n.e.s.	[270% but not less than $3.15/kg]	0	[270% but not less than $3.15/kg]	[270.1%, but not < 315.2¢/kg]	12.97	3.93%	10.0	37.5
040510	Butter (excl. dehydrated	[298.5% but not less than $4.00/kg]	0	[298.5% but not	[11.38¢/kg] [298.7%,	67.63	20.48%	20.0	37.5

	butter and ghee)			less than $4.00/kg]	but not < 400.1¢/kg]				
040520	Dairy spreads of a fat content, by weight, of >= 39% but < 80%							-	
040590	Fats and oils derived from milk, and dehydrated butter and ghee (excl. natural butter, recombined butter and whey butter)	[313.5% but not less than $5.12/kg]	0	[313.5% but not less than $5.12/kg]	[313.6%, but not < 512.4¢/kg]	2.95	0.89%	10.0	27.8
040610	Fresh cheese "unripened or uncured cheese", incl. whey cheese, and curd	[245.5% but not less than $4.52/kg]	0	[245.5% but not less than $4.52/kg]	[245.6%, but not < 451.5¢/kg] [3.32¢/kg]	5.37	1.63%	45.0	-
040620	Grated or powdered cheese, of all kinds	[245.5% but not less than $3.58/kg] [245.5% but	0	[245.5% but not less than $3.58/kg]	[2.84¢/kg] [245.6%, but not < 358.0¢/kg]	16.57	5.02%	20.0	37.5

		not less than $5.11/kg]		[245.5% but not less than $5.11/kg]	[245.6%, but not < 511.4¢/kg] [3.32¢/kg]					
040630	Processed cheese, not grated or powdered	[245.5% but not less than $4.34/kg]	0	[245.5% but not less than $4.34/kg]	[245.6%, but not < 433.8¢/kg] [3.32¢/kg]	2.00	0.61%	45.0	-	
040640	Blue-veined cheese and other cheese containing veins produced by "Penicillium roqueforti"	[245.5% but not less than $5.33/kg]	0	[245.5% but not less than $5.33/kg]	[245.6%, but not < 532.6¢/kg] [3.32¢/kg]	0.96	0.29%	20.0	45.0	
040690	Cheese (excl. fresh cheese, incl. whey cheese, curd, processed cheese, blue-veined cheese and other cheese containing veins		0			26.61	8.06%	31.4	45.0	

	produced by "Penicillium roqueforti", and grated or powdered cheese)									

Source: WTO Tariff Download Facility. Website: http://tariffdata.wto.org/. The World Integrated
https://wits.worldbank.org/ (the U.S. exports to Mexico and Canada in value) Accessed on 29/11/2019.

Table I.2: Empirical studies on spatial price transmission of agri-food commodities

Reference	Modelling approach	Time-series variables used	Dat fre
(Abdulai, 2000)	TAR, MTAR, C-TAR, C-MTAR	Wholesale prices of maize of two local markets and one central market	Mor
(Abidoye & Labuschagne, 2014)	Threshold cointegration model, nested and non-nested models by Bayes factor	South African maize producer prices and international maize price	Mor
(Acosta et al., 2014)	AVECM	Oceania WMP prices as world price, producer milk prices in domestic market	Mor
(Baquedano & Liefert, 2014)	The single equation error correction model (SEECM)	Consumer price and world price of wheat, rice, maize, and sorghum, Exchange rate	Mor
(Brosig et al., 2011)	TVECM	Grower prices for durum wheat prevailing in the different provinces of Turkey	Mor
(Burke & Myers, 2014)	Threshold SEECM	Informal maize trade volumes, maize grain prices, diesel fuel prices and exchange rates	Mor
(Cudjoe et al., 2010)	Threshold cointegration models	Local rice prices in Ghana and world rice price	Mor
(Esposti & Listorti, 2013)	VECM	Cereal spot prices in the European (Italian) and North American markets	We

(Ganneval, 2016)	TVECM with two regimes; AR-GARCH	Two grain markets (corn and feed barley) and two seed oil markets (rapeseed and protein pea) in a reference market and three producer markets	We
(García-Germán et al., 2016)	Engle–Granger cointegration with ECM	Unprocessed food harmonized index of consumer prices (HICP) for most MSs; the three world price indices: IMF's index, Import-weighted ECB's index, Use-weighted ECB's index. world agricultural markets and consumer food prices in the EU-28 MSs, three different world agricultural commodity price indices and controlling for certain supply and demand shifters.	Mo
(Getnet et al., 2005)	ARDL	Producer price of white teff, the quantity of rainfall around the supply market, the price of commercial fertilizer, the wholesale prices of white teff and white wheat in Addis Ababa (central consumer market).	Mo
(Ghoshray, 2010)	Exponential smooth transition autoregressive (ESTAR) model	Average export price quotations (FOB) of ATP, ASW, U.S. HRW, U.S SRW, U.S. DNS, CWRS and EU.	We
(Hassanzoy et al., 2015)	VECMs	Global and domestic rice prices, consumer price indices (CPIs) and exchange rates coupled with annual data on rice production, consumption and imports	Mo
(Ianchovichina et al., 2014)	Threshold VAR	Domestic food consumer price index, international food price index, lagged growth rates in the domestic exchange rates of 18 Arab countries	Ann
(Ihle et al., 2009)	Markov-switching vector autoregressive (MS-VAR) models	Wholesale maize prices in Nairobi (Nai) in Kenya and four markets in Tanzani	Mo

(Lee & Valera, 2016)	GARCH	domestic rice prices in six Asian countries (Bangladesh, China, India, Philippines, Thailand, and Vietnam) and international rice price	Mor
(McLaren, 2015)	OLS, 2SLS with IV	Export and producer prices, unbalanced panel of 161 items, 117 countries	Ann
(Myers & Jayne, 2011)	Multiple regime threshold models	Maize prices for RSA and Zambia	Mor
(Qiu & Rude, 2016)	Error correction-GJR-GARCH	world market price and Ukrainian wheat and wheat flour prices	We
(George Rapsomanikis & Mugera, 2011)	VEC–GARCH model	the wheat price of Ethiopia, the rice price of India and the maize price of Malawi and the corresponding world prices	Mor
(Rashid, 2011)	Cointegration and GIRMs	Maize, wheat and teff prices of 6 locations	Mor
(Sanjuán & Gil, 2001)	VECM	Pork prices of Den, Ne, Sp, Fr, Ger, UK and It; and lamb prices of Ir, Ne, UK, SP, It, Fr	We
(Santeramo, 2015)	Threshold models	Cauliflower and tomato prices of four cities	We
(Serra et al., 2006)	TVAR with Local polynomial fitting	Pork producer prices for Germany, Spain, France and Denmark	We
(Stephens et al., 2012)	Generalized reduced rank regression (GRRR) techniques	Price and trade flow data for tomato markets in Zimbabwe	Ser wee
(Zakari et al., 2014)	VECM	Wholesale market prices of four main staple crops (millet, sorghum, maize and rice) in Niger	Mor

Table I.3: Summary of the price transmission literature on dairy markets.

Reference	modelling approach	Time-series variables used	Data frequency
(Bakucs, Fałkowski, & Fertő, 2012)	VEMC	Logs of Hungarian (in HUF) and Polish (in PLN) monthly milk retail and producer prices	Monthly
(Tekgüç, 2013)	TAR& M-TAR	relationship between farm-gate (input) and UHT wholesale prices (output), labour productivity index	Monthly
(Bolotova & Novakovic, 2012)	Integrated Houck model-markup pricing model	Milk Price Transmission Elasticities & Marketing Margins	
(Verreth, Emvalomatis, Bunte, Kemp, & Oude Lansink, 2015)	VECM	two different chains: onions and red peppers. producer, wholesale and retail prices	Weekly[104]
(Madau, Furesi, & Pulina, 2016)	the Lloyd et al. (2009) mode	Consumer and production price, market cost, general consumer price, agricultural inputs prices	Monthly
(Liu, Keyzer, van den Boom, & Zikhali, 2012)	retail-price elasticity of the farmgate price. regression	Farm-gate and market prices of different commodities from 170 markets distributed across 29 provinces of China,	Annually

[104] Monthly observed import and export data, in both values and quantities, are retrieved from EUROSTAT. Weekly quantit
linear interpolation. Linear interpolation involves estimating a new value by connecting two adjacent known values with a s
determined from the interpolated quantities and expenditures.

		output of farm products, population, area, length of transport routes by province	
(J.-P. Loy, 2015)	bivariate threshold error correction models	German milk and butter prices at the retail and wholesale levels, including 919 (1,724) individual store retail price series covering 71 (90) brands for milk (butter) in 327 (447) stores belonging to the five discussed store formats	Weekly
(Tifaoui & Cramo-Taubadel, 2016)	Bivariate SVECM&AVECM	Germany Retail and wholesale price of foil-wrapped packages of butter	Weekly
(Fousekis & Trachanas, 2016)	standard linear ARDL (p,q) cointegration model	wholesale prices of SMP of USA, EU & Oceania	Monthly
(Acosta & Valdés, 2014)	two-step single equation ECM	milk price trends at producer and wholesaler levels	Monthly
(Reziti, 2014)	ECM	nominal prices on producers and consumers of cow's milk	Monthly
(Tekgüç, 2013)	TAR&MTAR	farm-gate (input) and UHT wholesale prices (output)	Monthly
(Fałkowski, 2010)	VECM	Farm-gate and retail prices of milk	Monthly

Appendix II Data, Stability Tests and Additional Empirical Results for Chapter 5

This appendix describes sources and details of the data, as well as model stability tests.

II.1 Data Sources and Details

Butter Export Prices (HS-4)

-Butter in the trade market studied in this chapter is categorised according to Harmonized System Chapter 4 (HS-4): 0405-Butter and other fats and oils derived from milk; dairy spreads

European Union-28: EUROSTAT/ UN Comtrade

United States: USDA

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

Note: The Extra-EU28 export values and Extra-EU28 export quantity of the EU28 were used to compute butter export price of the EU.

Index base: using the average value from Jan 2010 to Dec 2010 as the base value to calculate the index

Consumer Price Index-Food Index

United States: OECD

European Union-28: EUROSTAT

New Zealand: Statistics New Zealand

Index base: using the average value from Jan 2010 to Dec 2010 as the base value to calculate the index

Nominal Exchange Rates

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

EU-28: Euro

New Zealand: New Zealand 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 to the total dairy export quantity of these countries.

Index base: using the average value from Jan 2010 to Dec 2010 as the base value to calculate the index

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 base: 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 base: 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 (RoW) includes China, India, Japan, Mexico, Russian Federation and Ukraine.

Table II.1 on the next page details the data sources with database, URL, and date of retrieval for the rest of World countries included in the analysis.

Table II.1: Data sources for the rest of World countries

Variables	Countries	Database	URL	Date of Retrieval
CPI for food	China India Japan Mexico Russia	OECD.STAT/IFS	https://stats.oecd.org/#	2017
	Ukraine	International Financial Statistics (IFS)	https://data.imf.org/regular.aspx?key=61545849	
Exchange Rate	China	FRED	https://fred.stlouisfed.org/series/CCUSSP02CNM650N	
	India		https://fred.stlouisfed.org/series/CCUSMA02INM618N	
	Japan		https://fred.stlouisfed.org/series/CCUSMA02JPM618N	
	Mexico		https://fred.stlouisfed.org/series/CCUSMA02MXM618N	
	Russia		https://fred.stlouisfed.org/series/CCUSMA02RUM618N	
	Ukraine	IFS	https://data.imf.org/regular.aspx?key=61545850	

II.2 Model Stability Test Results

II.2.1 Persistence Profile

Persistence profiles (PPs) is the time profiles of the effects of system or variable-specific shocks on the cointegrating relations in the GVAR model (M Hashem Pesaran & Shin, 1996). The PPs should converge to zero as the horizon n come to infinity if the cointegrating vector is valid, which indicates the speed for the cointegrating relations to converge to equilibrium states.

Figure II.1 draws the PPs of the effect of system-wide shocks to the cointegrating relations of the butter GVAR model. It can be observed that the profiles overshoot for two of the 8 cointegrating vectors before quickly tending to zero.

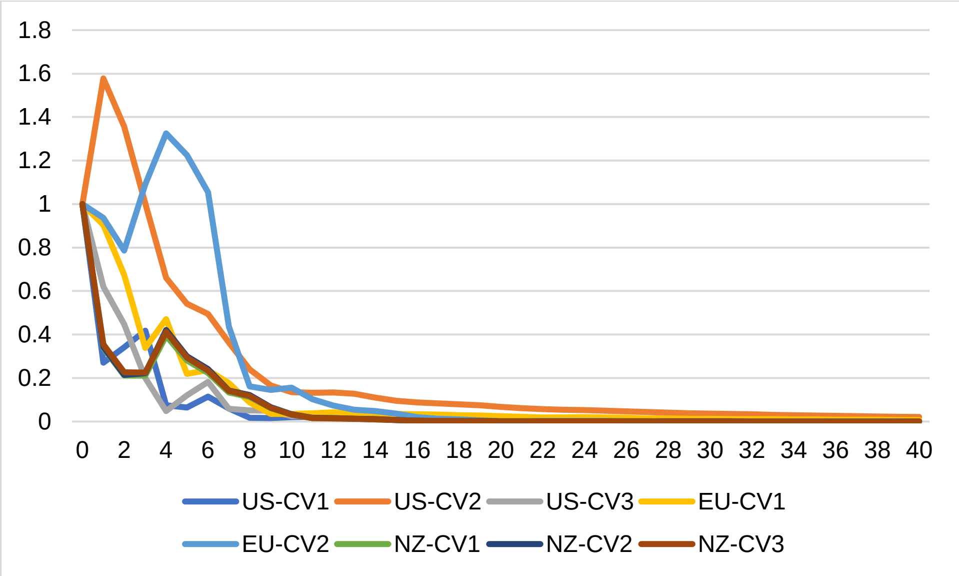


Figure II.1: Persistence profile of the effect of system-wide shocks to the cointegrating relations of the GVAR model

II.2.2 Structural Stability Tests

Structural stability tests are conducted to detect the potential instability of the model parameters over time. The Ploberger and Krämer (1992)'s maximal OLS cumulative sum (CUSUM) statistic, denoted by PKsup and its mean square variant PKmsq, and the test for parameter constancy against non-stationary alternatives proposed by Nyblom (1989). Table II.2 and Table II.3 outlines the statistics and critical values of the the Ploberger and Krämer (1992) and Nyblom (1989) structural stability tests. All the Statistic for each variable is smaller than its corresponding critical value, so the null hypothesis cannot be rejected at 95% confidence level in the PK sup and PK msq tests, which means the series are structurally stable. However, the Nyblom statistics for the fertilizer price of the US, CPI for food and Palm oil price for the rest of world are greater than the critical value at 95% confidence level. However, it is smaller than the critical value at 99% confidence level, which means the null hypothesis of structural stability cannot be rejected at the 1% level of significance but can be rejected at the 5% level of significance. In general, the model parameters have structural stability over time.

Table II.2: The test results of the Ploberger and Krämer (1992) stability tests

Variables	pe	pf	pc	pcoil	zr	ppoil
PK sup						
US	0.562197	0.612246	0.542623	0.420159		
EU 28	0.560042	0.312164	0.547817		0.333003	
New Zealand	0.823021	0.595803	0.469961		0.552805	
Rest of World		0.514447	0.629562		0.815052	0.897473
PK msq						
US	0.060908	0.113427	0.046041	0.031078		
EU 28	0.072549	0.029832	0.083739		0.030514	
New Zealand	0.177403	0.058421	0.02947		0.028662	
Rest of World		0.053132	0.099739		0.173082	0.066432
Nyblom						
US	3.340965	3.933036*	2.456562	3.752514		
EU 28	3.095422	3.33713	3.360818		3.508252	
New Zealand	1.017703	0.950193	1.693672		1.055028	
Rest of World		0.881192	1.95171*		1.393679	1.935099*

Table II.3: structural stability tests: critical values

Critical Values	pe_95%	pf_95%	pc_95%	pcoil_95%	zr_95%	ppoil_95%
PK sup						
US	0.745457	0.811399	0.673178	0.594082		
EU 28	0.953691	0.842149	0.844532		0.931545	
New Zealand	1.023686	0.75806	0.684033		0.588356	
Rest of World		1.132876	1.086826		1.164782	1.098986
PK msq						
US	0.102528	0.17147	0.110757	0.070218		
EU 28	0.217224	0.163652	0.219946		0.243268	
New Zealand	0.263709	0.133501	0.070622		0.058901	
Rest of World		0.416471	0.314476		0.437722	0.33359
Nyblom						
US	4.042526	3.709413 (3.93676)	3.907755	4.102096		
EU 28	4.041117	3.92549	4.126406		3.976451	
New Zealand	1.931933	1.681772	1.847516		1.795777	
Rest of World		1.710117	1.940134 (2.14811)		1.887899	1.87298 (2.71223)

Note: critical value at 99% confidence interval is listed in the ( )

II.3 Benchmark Model and Results

In order to test the robustness of the applied GVAR model in chapter 5 and make a comparison of its effectiveness to conduct high-dimensional cross-section analysis, a benchmark VAR model with only butter export prices variables for the EU, New Zealand and the U.S. is conducted and analysed here.

Firstly, the Granger Causality tests are conducted to find statistical causality relationships among the three butter export prices and the results are outlined in Table II.4 below. This indicates that the causal relationships among the series are weak, and all the null hypotheses of "A does not Granger Cause B" cannot be rejected for most pair-wise relationships at 10% level of significance with the exception of the hypothesis "EU does not Granger Cause NZ" that can be rejected at 5% level of significance. The results imply that only butter export price of the EU can Granger cause butter export price of New Zealand. However, Granger causality tests only have statistical meanings while the results don't reflect the real causality relationships.

Table II.4: Granger causality tests of butter export prices of the EU, New Zealand and the US

Pairwise Granger Causality Tests
Sample: 1 84
Lags: 2

Null Hypothesis:	Obs	F-Statistic	Prob.
NZ does not Granger Cause EU	82	2.32984	0.1041
EU does not Granger Cause NZ		3.99403	0.0224
US does not Granger Cause EU	82	1.55043	0.2187
EU does not Granger Cause US		0.90186	0.4101
US does not Granger Cause NZ	82	0.78581	0.4594
NZ does not Granger Cause US		0.83974	0.4357

As tested in Chapter 5, all the price variables have one unit root, so they are I (1) series. This indicates that there will be cointegration relations among prices. The Table II.5 below outlines the results of cointegration rank test by trace and Maximum Eigenvalue tests. It is assumed that there is a trend and an interception in the cointegration relations in order to be consistent with the GVAR model estimation in Chapter 5. As the results show, there are 2 cointegration relationships in the price series. So, it will be proper to conduct the Vector Error Correction Model analysis.

Table II.5: Results of cointegration rank tests

(a) Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None	0.222527	32.81220	35.01090	0.0844
At most 1	0.094289	12.42398	18.39771	0.2787
At most 2 *	0.052897	4.402169	3.841466	0.0359

Trace test indicates no cointegration at the 0.05 level

* denotes rejection of the hypothesis at the 0.05 level

**MacKinnon-Haug-Michelis (1999) p-values

(b) Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None	0.222527	20.38822	24.25202	0.1496
At most 1	0.094289	8.021813	17.14769	0.6005
At most 2 *	0.052897	4.402169	3.841466	0.0359

Max-eigenvalue test indicates no cointegration at the 0.05 level

* denotes rejection of the hypothesis at the 0.05 level

**MacKinnon-Haug-Michelis (1999) p-values

The estimated Vector Error Correction Model (VECM) is as shown in Equations (1), (2) and (3) and table below.

$$\Delta p_t^{EU} = -0.0064 \times (p_{t-1}^{EU} - 4.0469\, p_{t-1}^{NZ} + 4.2302\, p_{t-1}^{US} - 1.4143\mathrm{t} - 125.6879) + 0.2126\, \Delta p_{t-1}^{EU} + 0.0085\, \Delta p_{t-2}^{EU} + 0.1074\, \Delta p_{t-1}^{NZ} - 0.0011\Delta\, p_{t-2}^{NZ} + 0.1047\, \Delta p_{t-1}^{US} - 0.0092\, \Delta p_{t-2}^{US} + 0.8352 - 0.0177t \quad (1)$$

$$\Delta p_t^{NZ} = 0.0717 \times (p_{t-1}^{EU} - 4.0469\, p_{t-1}^{NZ} + 4.2302\, p_{t-1}^{US} - 1.4143\text{t} - 125.6879\,) + 0.1709\, \Delta p_{t-1}^{EU} + 0.2768\;\; \Delta p_{t-2}^{EU} + 0.3397\, \Delta p_{t-1}^{NZ} + 0.0623\Delta\, p_{t-2}^{NZ} - \; 0.1760\Delta p_{t-1}^{US} - 0.1644\, \Delta p_{t-2}^{US} - \; 1.0545 + 0.0253t \quad (2)$$

$$\Delta p_t^{NZ} = -\,0.0568\;\times (p_{t-1}^{EU} - 4.0469\, p_{t-1}^{NZ} + 4.2302\, p_{t-1}^{US} - 1.4143\text{t} - 125.6879\,) + 0.3711\Delta p_{t-1}^{EU} + \; 0.0970\Delta p_{t-2}^{EU} + 0.0308\Delta p_{t-1}^{NZ} - \; 0.0759\Delta\, p_{t-2}^{NZ} - \; 0.4057\Delta p_{t-1}^{US} - 0.3214\Delta p_{t-2}^{US} - \; 0.1479 \;\; + \; 0.0192t \quad (3)$$

Table II.6: Estimates results of the Vector Error Correction model

Cointegrating Eq:	CointEq1		
EU(-1)	1.000000		
NZ(-1)	-4.046897		
	(0.82690)		
	[-4.89404]		
US(-1)	4.230231		
	(1.29735)		
	[3.26066]		
@TREND(1)	-1.414263		
C	-125.6879		
Error Correction:	**D(EU)**	**D(NZ)**	**D(US)**
CointEq1	-0.006419	0.071676	-0.056805
	(0.01599)	(0.02011)	(0.02834)
	[-0.40141]	[3.56416]	[-2.00437]
D(EU(-1))	0.212606	0.170861	0.371069
	(0.12062)	(0.15169)	(0.21378)
	[1.76257]	[1.12636]	[1.73578]
D(EU(-2))	0.008548	0.276760	0.097045

	(0.11839)	(0.14888)	(0.20982)
	[0.07220]	[1.85892]	[0.46253]
D(NZ(-1))	0.107446	0.339733	0.030816
	(0.08894)	(0.11185)	(0.15762)
	[1.20808]	[3.03745]	[0.19550]
D(NZ(-2))	-0.001138	0.062274	-0.075884
	(0.09048)	(0.11379)	(0.16036)
	[-0.01257]	[0.54727]	[-0.47321]
D(US(-1))	0.104666	-0.175968	-0.405664
	(0.07465)	(0.09388)	(0.13230)
	[1.40205]	[-1.87437]	[-3.06615]
D(US(-2))	-0.009218	-0.164412	-0.321380
	(0.06631)	(0.08340)	(0.11753)
	[-0.13901]	[-1.97147]	[-2.73451]
C	0.835218	-1.054524	-0.147915
	(1.03041)	(1.29583)	(1.82617)
	[0.81057]	[-0.81378]	[-0.08100]
@TREND(1)	-0.017749	0.025270	0.019150
	(0.02108)	(0.02651)	(0.03736)
	[-0.84207]	[0.95331]	[0.51264]
R-squared	0.144648	0.298627	0.316458
Adj. R-squared	0.049609	0.220696	0.240508

Note: Standard errors in ( ) & t-statistics in [ ]

The Figure II.2 below depicts the impulse response functions (IRFs) of butter export prices after price shocks. The top row represents the response of EU butter export prices after a positive one-standard-deviation shock to butter export prices of the EU, New Zealand (NZ) and the US, respectively. The middle row represents the response of New Zealand butter export price and the bottom row represents the responses of the US butter export price. Compared with the GIRFs estimation from the GVAR model, the responses of the countries' butter export prices display a similar pattern to the results of the GVAR model estimation: (a) the price of EU responds positively to price shocks of New Zealand and the US at small levels but respond significantly to price shocks from itself; (b) the response of New Zealand price is positive and increases to a high level, and then the price is significantly and positively impacted by price shocks from the EU 10 months after the shocks and the response stabilizes in the long term. It will be affected immediately and significantly by price shocks from itself for the first 5 months and then reach to a long-term stable level. (c) the price of the US experiences significant impact after price shocks from itself for only 2 months, then the impact of price shocks from itself declines and reaches the same level as impact from EU and New Zealand price shocks.

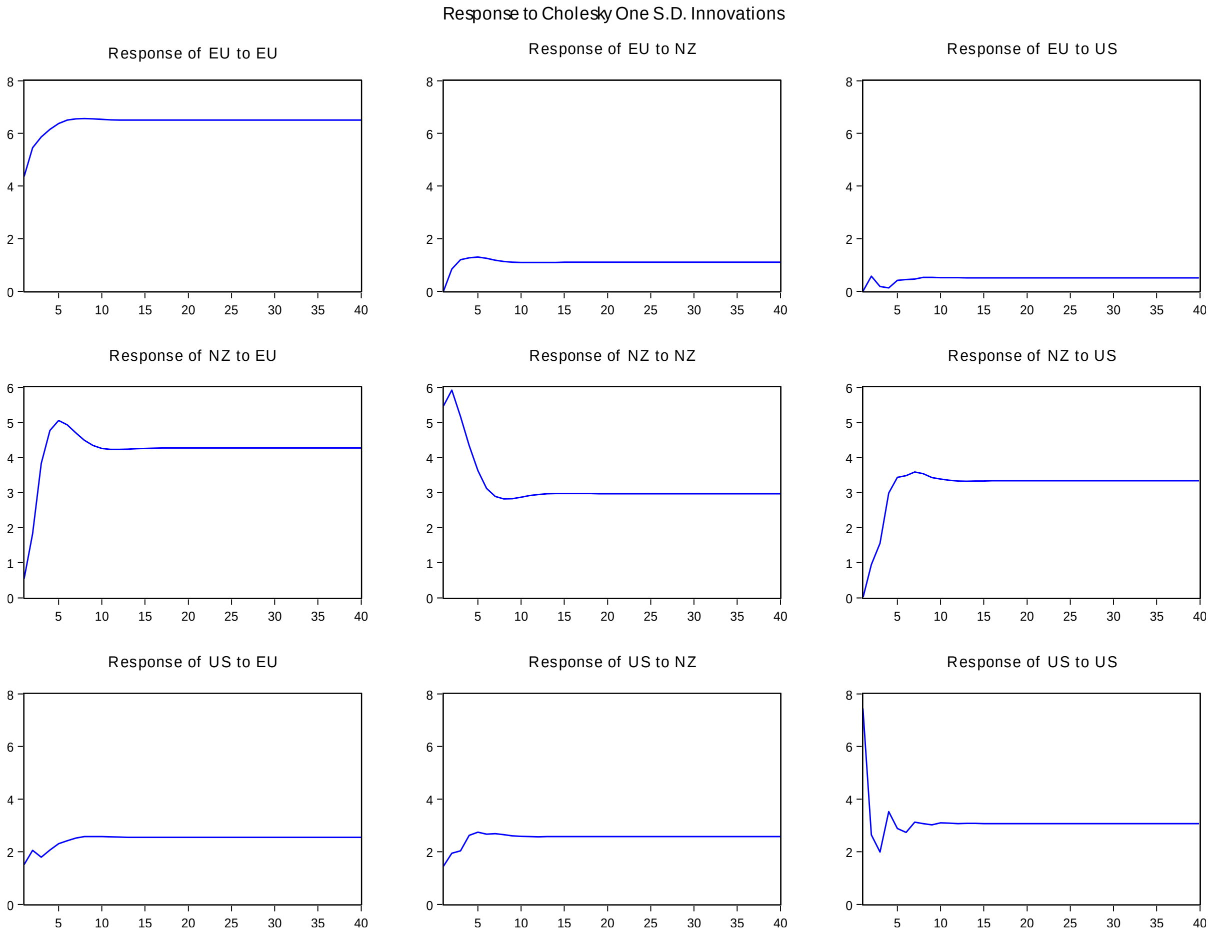


Figure II.2: Cholesky impulse response to one-standard-deviation shocks

The results are consistent with results estimated from the GVAR model, so the GVAR model analysis is quite robust.

Appendix III Data, Stability Tests and Benchmark Study for Chapter 6

III.1 Structural Stability Tests

Structural tests were conducted in the analysis to check for potential instability of model parameters over time. Table III.1&3 and Table III.2&4 outline the statistics and critical values of the applied structural stability tests proposed by Ploberger and Krämer (1992).

The statistic for each variable in intra-EU GVECM is smaller than its corresponding critical value, so the null hypothesis can't be rejected. So, all the series are structurally stable in our analysis.

Table III.1: Structural stability tests for intra-EU GVECM: statistics

Variables	pex	pro	hicpf	pf	poil
			PK sup		
UK	0.463694	0.8314	0.74255	0.941864	0.605639
Ireland	0.340478	0.645837	0.579837	0.611149	
Netherlands	0.432776	0.489759	0.468543	0.467494	
Italy	0.784771	0.692224	0.573054	0.27915	
Germany	0.707873	0.559412	0.85324	0.555987	
France	0.676779	0.360939	0.530133	0.603389	
Rest of EU	0.792665	0.714418	0.98315	1.024304	
			PK msq		
UK	0.025343	0.191054	0.156352	0.283167	0.119887
Ireland	0.026055	0.096732	0.039636	0.079477	
Netherlands	0.038238	0.04151	0.047248	0.035731	
Italy	0.201022	0.128603	0.112031	0.024663	
Germany	0.133299	0.067007	0.223563	0.089999	
France	0.080725	0.031602	0.054723	0.088671	
Rest of EU	0.098799	0.129659	0.36196	0.231079	

Table III.2: Structural stability tests for intra-EU GVECM: critical values

Critical Values	pex_90%	pro_90%	hicpf_90%	pf_90%	poil_90%
			PK sup		
UK	0.897416	0.905347	0.98611	1.017793	0.923818
Ireland	0.874901	0.790495	0.806877	0.837865	
Netherlands	0.901752	0.919272	1.01729	0.761882	
Italy	1.050474	0.886111	0.774586	0.993005	
Germany	0.935659	0.947594	0.965402	0.667643	
France	0.906599	0.59459	0.804358	0.859856	
Rest of EU	0.894507	1.098827	1.021138	1.001084	
			PK msq		
UK	0.20909	0.182905	0.258218	0.29313	0.228361
Ireland	0.188175	0.16106	0.160689	0.171427	
Netherlands	0.204018	0.188362	0.27233	0.120657	
Italy	0.266705	0.191774	0.146847	0.261703	
Germany	0.250349	0.265227	0.236297	0.089392	
France	0.246314	0.076773	0.183384	0.214443	
Rest of EU	0.159505	0.307603	0.274201	0.262245	

Figure III.1 depicts the persistence profile of the effect of system-wide shocks to the cointegrating relationship of the GVAR model. It can be observed that the speed of convergence fast for the Rest of EU, the Netherlands, Germany and Italy. However, the speed of adjustment was very slow for the France and Ireland.

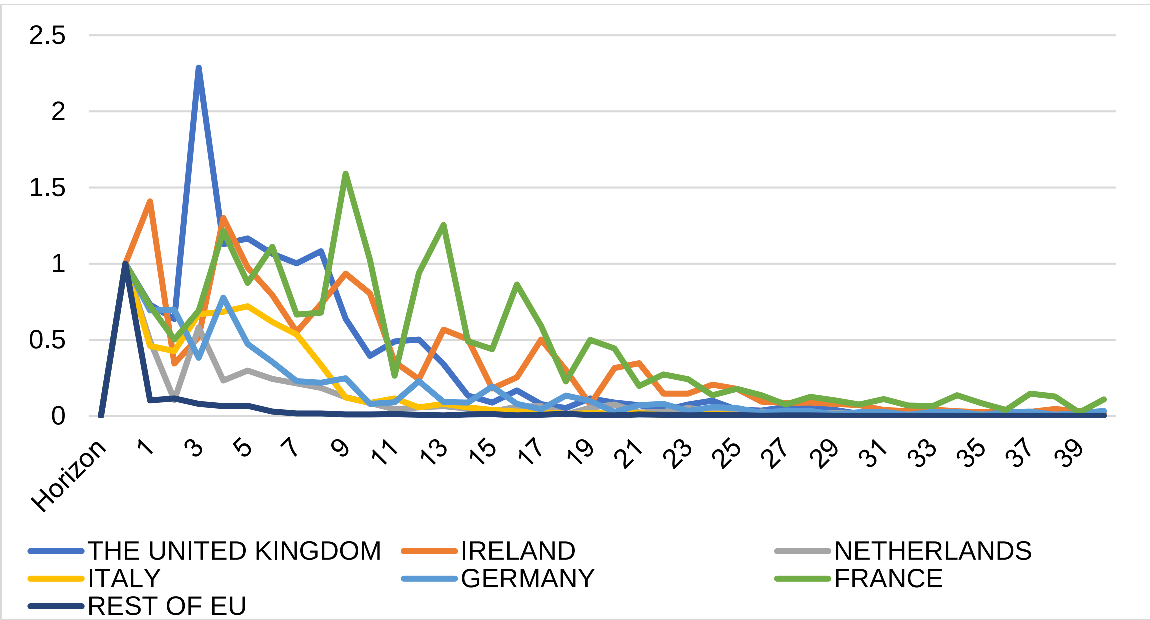


Figure III.1: Persistence profile of the effect of system-wide shocks to the cointegrating relations of the intra-EU GVAR model

As reported in Table III.3 and Table III.4, the statistic for each variable in extra-EU GVECM is smaller than its corresponding critical value, so the null hypothesis can't be rejected. So, all the series are structurally stable in our analysis.

Table III.3: Structural stability tests for extra-EU GVECM: statistics

Variables	pex	pro	hicpf	pf	poil
			PK sup		
UK	0.903102	0.95222	0.859617	0.887978	0.487304
Ireland	0.556062	0.55685	0.997763	0.452633	
Netherlands	0.520766	0.78265	0.843414	0.626127	
Italy	0.505215	0.700167	0.406689	0.713595	
Germany	0.619687	0.689697	0.57601	0.58145	
France	0.565724	0.59363	0.621403	0.543569	
Rest of EU	0.666355	0.40087	0.983137	0.512081	
			PK msq		
UK	0.156232	0.223775	0.228553	0.195099	0.046937
Ireland	0.038956	0.037861	0.228477	0.041554	
Netherlands	0.040555	0.093031	0.130051	0.065953	
Italy	0.079996	0.041545	0.032675	0.131871	
Germany	0.119449	0.071015	0.041657	0.056514	
France	0.100109	0.044648	0.082583	0.033416	
Rest of EU	0.134005	0.019042	0.298026	0.038923	

Table III.4: Structural stability tests for extra-EU GVECM: critical values

Critical Values	pex_90%	pro_90%	hicpf_90%	pf_90%	poil_90%
			PK sup		
UK	1.002966	0.951037	1.009028	0.953285	1.00214
Ireland	0.978034	0.733827	1.029252	0.904821	
Netherlands	1.084848	0.890726	1.031816	0.966088	
Italy	1.05471	0.934134	0.959599	1.116367	
Germany	0.942283	0.988631	0.93383	0.745155	
France	0.944595	0.593392	0.860866	1.057197	
Rest of EU	0.80429	1.004234	0.952274	0.743777	
			PK msq		
UK	0.261357	0.251381	0.244638	0.229542	0.271005
Ireland	0.248853	0.118944	0.283955	0.224651	
Netherlands	0.305206	0.209448	0.308843	0.227954	
Italy	0.269976	0.199697	0.245641	0.340598	
Germany	0.256489	0.27992	0.242966	0.139537	
France	0.213078	0.072333	0.217016	0.274276	
Rest of EU	0.183509	0.237285	0.230599	0.154522	

The figure III.2 below indicates that the speed of convergence fast for all countries, so the model is stable over time.

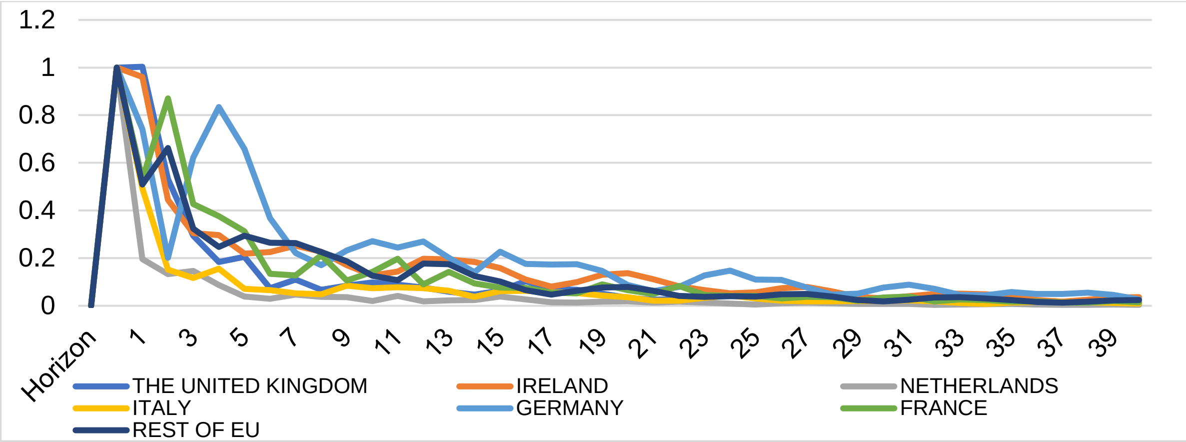
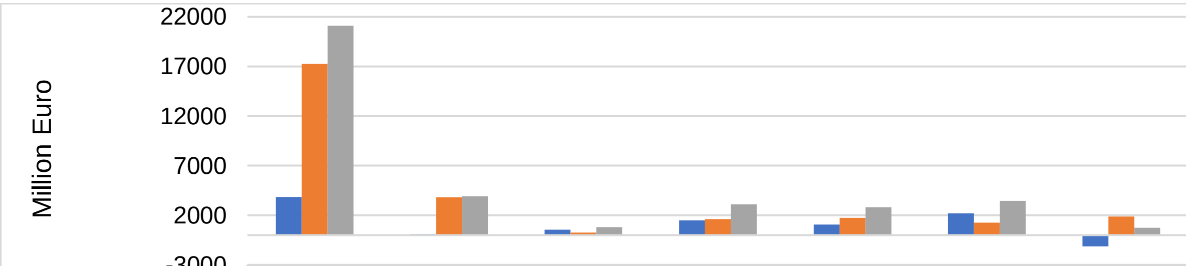


Figure III.2: Persistence profile of the effect of system-wide shocks to the cointegrating relations of the intra-EU GVAR model

III.2 Major Cheese Trade Situation of The Studied EU Countries

In this part, the top 5 cheeses types of the studied countries in terms of export, import and balance of trade are listed, the disaggregated cheese types are categories by the 8-digit Combined Nomenclature (CN)[105] codes in the EU trade. In general, the major exported cheese varieties vary for the studied countries. Figure III.3 outlines the imports, exports and balance of trade for the 6 studied EU countries and the EU28 by value in 2018.



	EU28	GERMANY	IRELAND	FRANCE	ITALY	NETHERLANDS	UK
Balance of Trade	3848	85	568	1486	1076	2191	-1114
Imports	17257	3832	246	1604	1748	1254	1866
Exports	21106	3917	814	3090	2824	3446	752

Figure III.3: Cheese trade situation of the EU in 2018

Source: Eurostat Dataset. Accessed on 22/12/2019.

[105] For definition and details of CN, please check at: https://ec.europa.eu/taxation_customs/business/calculation-customs-duties/what-is-common-customs-tariff/combined-nomenclature_en

As shown in Figure III.4 and Table III.5, the Netherlands owns the largest net export quantity, with Gouda (CN 04069078), Edam (CN04069023) and Emmentaler (CN 04069013) as the main exported and net exported cheeses. Gouda is a Dutch cheese originated from Gouda in the Netherlands and is the most popular cheese in the world[106]. However, the name of Gouda is not protected, so it is now a genetic classification of certain cheese. In 2018, the Gouda export quantity in the Netherlands is 249.87 million kilogram, accounting of around 55% of intra-EU cheese export of the Netherlands[107]. Figure III.4 plots the intra-EU export price series of the top 3 most exported cheeses in the Netherlands. Price series have co-movement pattern over the time period.

Table III.5: The Top 5 cheese types of export, import and trade balance of the Netherlands' intra-EU trade in 2018

Export			**Import**			**Balance of Trade**		
CN codes	Quantity in 100 kg	Cheese types	CN codes	Quantity in 100 kg	Cheese types	CN codes	Quantity in 100 kg	Cheese types
04069078	2,498,719	Gouda	04069078	452,950	Gouda	04069078	2045769	Gouda
04069023	601051	Edam	04069021	355756	Cheddar	04069023	456910	Edam
04069013	369440	Emmentaler	04069001	211442	For processing	04069013	262511	Emmentaler
04069001	317154	For processing	04069093	161,891	Other cheese[108]	04069032	119243	Feta
04069021	276931	Cheddar	04069023	144141	Edam	04069001	105712	For processing

Source: Eurostat Dataset. Accessed on 22/12/2019.

[106] Gouda: https://cheese.com/gouda/
[107] Source: calculated using data from Eurostat
[108] of a water content, by weight, in the non-fatty matter: Exceeding 72 %

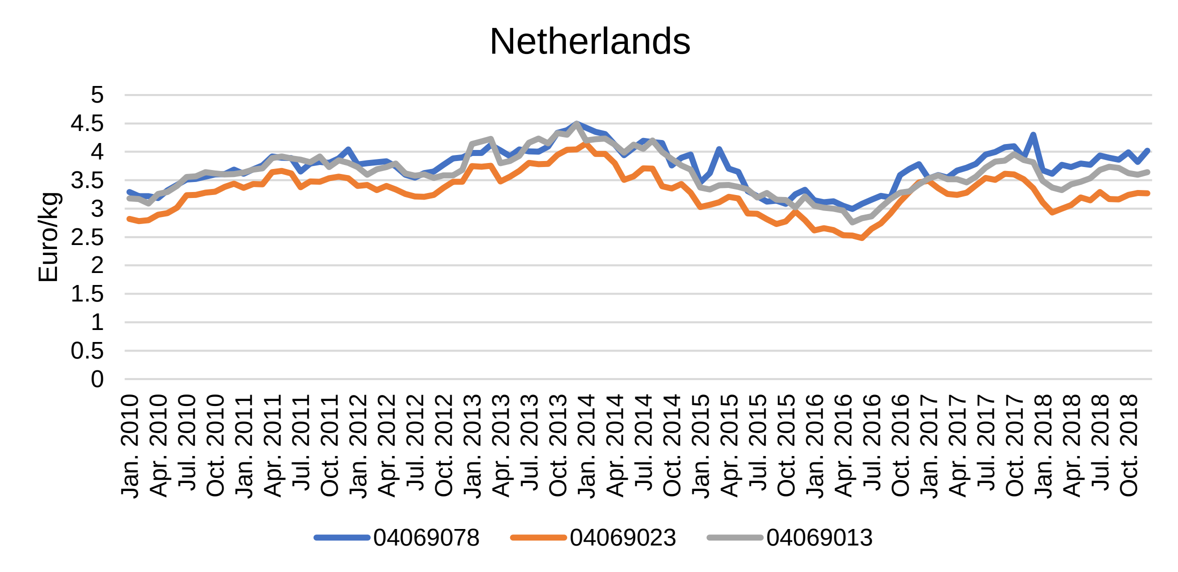


Figure III.4: The intra-EU export prices of top 3 most exported cheeses in Germany from Jan 2010 to Dec 2018

Note: Gouda (CN 04069078), Edam (CN04069023) and Emmentaler (CN 04069013)

France is at the second place as the net exporter of cheeses, with Brie (CN 04069084), Emmentaler (CN04069013), Camembert (CN 04069013) and Other processed cheese, not grated or powdered (CN 04063039) as the main exported and net exported cheese types. Brie is the best-known French cheese and is called "The Queen of Cheeses"[109]. In 2018, the intra-EU export quantity of Brie from France is 66.77 million kilograms, accounting for around 25% of total intra-EU cheese exports of France. As depicted from Figure III.5, Brie has a relatively stable and flat price movement pattern over the study period with an average price at 4.40 Euro/kg, while the export prices of Camembert (CN 04069013) and Other processed cheese, not grated or powdered (CN 04063039) display co-movement pattern.

Table III.6: The Top 5 cheese types of export, import and trade balance of France in 2018

Export			**Import**			**Balance of Trade**		
CN codes	Quantity in 100 kg	Cheese types	CN codes	Quantity in 100 kg	Cheese types	CN codes	Quantity in 100 kg	Cheese types
0406 9084	667,714	Brie	0406 9078	175,023	Gouda	0406 9084	662474	Brie

[109] Brie: https://cheese.com/brie/

0406 9013	241530	Emmentaler	0406 9013	424317	Emmentaler	0406 9082	217465	Camembert
0406 3039	233287	Other processed cheese, not grated or powdered[110]	0406 3031	283728	Other processed cheese, not grated or powdered [111]	0406 3039	214712	Other processed cheese, not grated or powdered
0406 9082	219,791	Camembert	0406 1080	156505	Other fresh cheese	0406 9079	170901	Esrom, Italico, Kernhem, Saint-Nectaire, Saint-Paulin, Taleggio
0406 9079	183,028	Esrom, Italico, Kernhem, Saint-Nectaire, Saint-Paulin, Taleggio	0406 9021	128751	Cheddar	0406 9099	80347	

Source: Eurostat Dataset. Accessed on 22/12/2019.

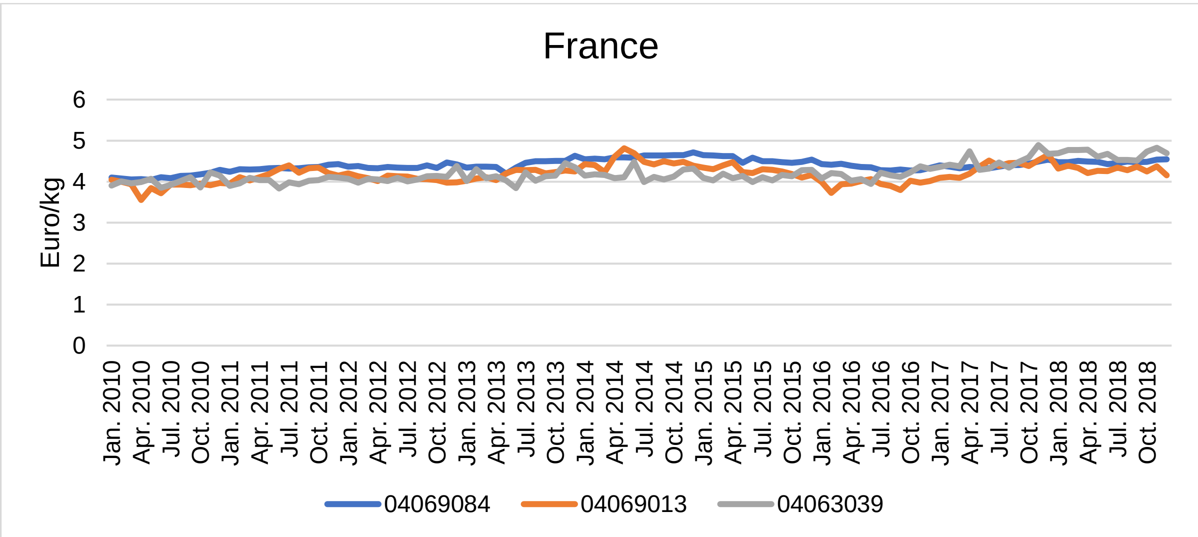


Figure III.5: The intra-EU export prices of top 3 most exported cheeses in France from Jan 2010 to Dec 2018

Note: Brie (CN 04069084), Camembert (CN 04069013) and Other processed cheese, not grated or powdered (CN 04063039)

[110] Of a fat content, by weight, not exceeding 36 % and of a fat content, by weight, in the dry matter: Exceeding 48 %

[111] Of a fat content, by weight, not exceeding 36 % and of a fat content, by weight, in the dry matter: Not exceeding 48 %

Italy is at the third place as the net exporter of cheeses, with Grana Padano, Parmigiano Reggiano (CN 04069061), Other fresh cheese (CN 04061080) and Cheese of sheep's milk or buffalo milk (04064050) as the main exported cheese types. Grana Padano is protected under the DOP and is relatively inexpensive compared with the "King of Cheeses", Parmigiano-Reggiano that is considered to be among the top cheeses by cheese connoisseurs and also protected under the DOP[112]. In 2018, the intra-EU export quantity of CN subheading 04069061 "Grana Padano, Parmigiano Reggiano" is 61.13 million kilograms, accounting for 39.68% of total intra-EU cheese export. As shown in Figure III.6, the intra-EU export price of cheese categorized as CN subheading 04069061 "Grana Padano, Parmigiano Reggiano" fluctuated greatly during the period with an average price at 7.75 Euro/kg.

Table III.7: The Top 5 cheese types of export, import and trade balance of Italy in 2018

Export			**Import**			**Balance of Trade**		
CN codes	Quantity in 100 kg	Cheese types	CN codes	Quantity in 100 kg	Cheese types	CN codes	Quantity in 100 kg	Cheese types
0406 9061	611,336	Grana Padano, Parmigiano Reggiano	0406 9001	671061	For processing	0406 9061	611241	Grana Padano, Parmigiano Reggiano
0406 1080	269089	Other fresh cheese	0406 3031	312042	Other processed cheese, not grated or powdered	0406 4050	184290	Gorgonzola
0406 4050	187188	Cheese of sheep's milk or buffalo milk	0406 9023	299888	Edam	0406 1080	54584	Other fresh cheese
0406 9069	91,811	Other	0406 9069	261,515	Other	0406 9063	43784	Fiore Sardo, Pecorino
0406 9063	52,405	Fiore Sardo, Pecorino	0406 1080	214505	Other fresh cheese	0406 9050	33822	Cheese of sheep's milk or buffalo milk

Source: Eurostat Dataset. Accessed on 22/12/2019.

[112] Grana Padano: https://cheese.com/grana-padano/ and Parmesan: https://cheese.com/parmesan/

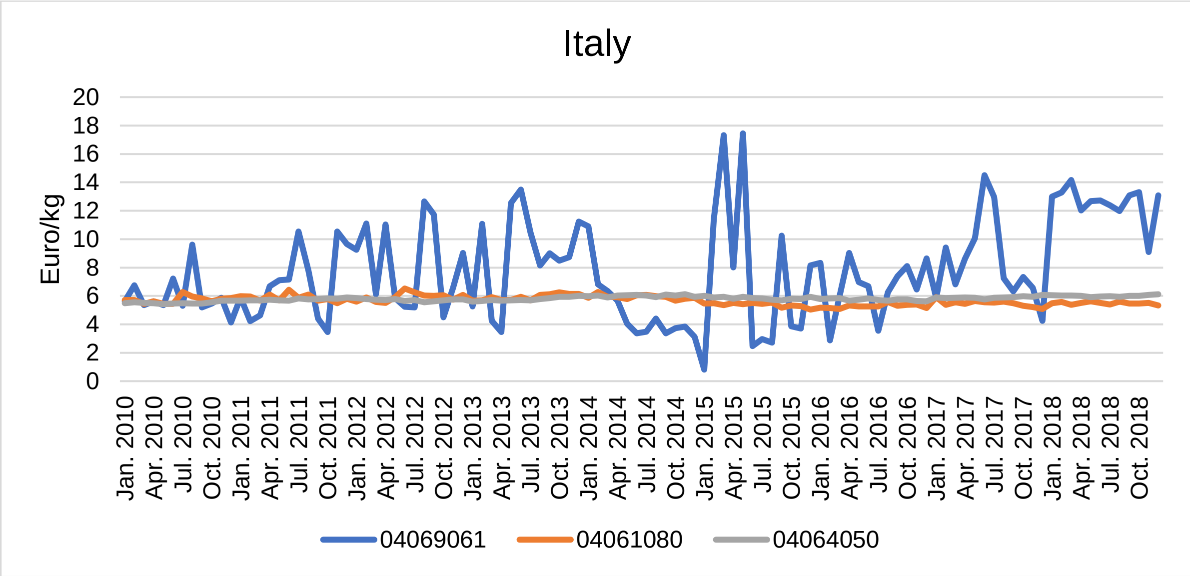


Figure III.6: The intra-EU export prices of top 3 most exported cheeses in Italy from Jan 2010 to Dec 2018

Note: Grana Padano, Parmigiano Reggiano (CN 04069061), Other fresh cheese (CN 04061080) and Cheese of sheep's milk or buffalo milk (04064050)

Ireland ranks the fourth place as a net exporter, with Cheddar (CN 04069021), Other processed cheese, not grated or powdered (CN 04063031) and Jarlsberg (CN 04069013) as its top 3 net exported products. Cheddar cheese is the most widely consumed cheese in the world made from cow's milk and this name is not under protection[113]. In 2018, the export quantity of Cheddar is 129.12 million kilograms, accounting for around 81.5% of total intra-EU cheese export of Ireland. As shown in Figure III.7, the intra-EU export price series of Cheddar are quite stable over the period with an average price level at 3.14 Euro/kg and has co-movement with the price series of Emmentaler.

[113] Cheddar: https://cheese.com/cheddar/

Table III.8: The Top 5 cheese types of export, import and trade balance of Ireland in 2018

Export			**Import**			**Balance of Trade**		
CN codes	Quantity in 100 kg	Cheese types	CN codes	Quantity in 100 kg	Cheese types	CN codes	Quantity in 100 kg	Cheese types
04069021	1281239	Cheddar	04069021	156411	Cheddar	04069021	1124828	Cheddar
04063031	59858	Other processed cheese, not grated or powdered	04069001	111600	For processing	04063031	45693	Other processed cheese, not grated or powdered
04069013	48244	Emmentaler	04069013	29156	Emmentaler	04069039	40699	Jarlsberg
04063039	42708	Other processed cheese, not grated or powdered	04063010	22288	Processed cheese, not grated or powdered[114]	04069086	38982	Other cheese
04069086	41,413	Other cheese[115]	04063039	18326	Jarlsberg	04063039	24382	Other processed cheese, not grated or powdered

Source: Eurostat Dataset. Accessed on 22/12/2019.

[114] In the manufacture of which no cheeses other than Emmentaler, Gruyère and Appenzell have been used and which may contain, as an addition, Glarus herb cheese (known as Schabziger); put up for retail sale, of a fat content by weight in the dry matter not exceeding 56 %

[115] of a water content, by weight, in the non-fatty matter: Exceeding 47 % but not exceeding 52 %

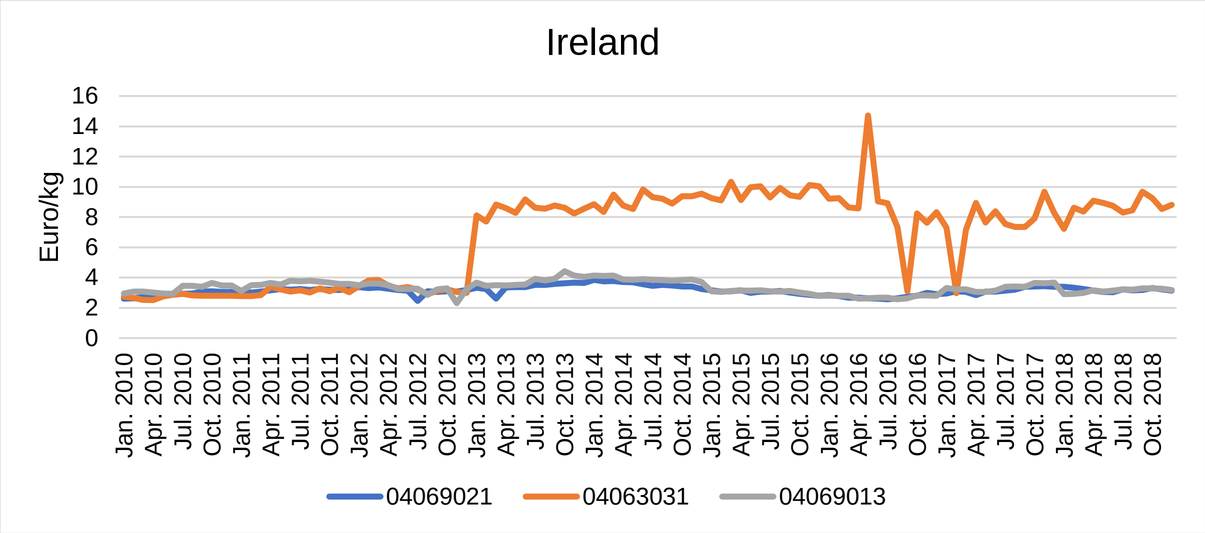


Figure III.7: The intra-EU export prices of top 3 most exported cheeses in Ireland from Jan 2010 to Dec 2018

Compared with other countries, Germany is both the largest cheese exporter and importer in the EU. It is at the fifth place as a net exporter in our studied 6 EU member states. Among various exported and imported cheese types, Gouda (CN 04069078), Edam (CN 04069023), Other processed cheese, not grated or powdered (CN 04063031) and Emmentaler (CN 04069013) are the top 4 exported cheeses, while Gouda (CN 04069078), Cheddar (CN 04069021) and Edam (CN 04069023) are the top 3 imported cheeses of Germany. Edam (CN 04069023)[116] is at the first place for the net export of intra-EU cheese trade of Germany. In 2018, the intra-EU export quantities of Gouda and Edam are 124.28 million kilogram and 123.44 million kilograms, respectively. As illustrated in Figure III.8, Edam and Gouda displayed consistent movement patterns over the studied period with an average price at the levels of 3.02 Euro/kg and 2.96 Euro/kg, respectively.

[116]Edam: https://www.cheese.com/edam/

Table III.9: Export, import and trade balance of the Top 5 cheeses of Germany in 2018

Export			**Import**			**Balance of Trade**		
CN codes	Quantity in 100 kg	Cheese types	CN codes	Quantity in 100 kg	Cheese types	CN codes	Quantity in 100 kg	Cheese types
04069078	1,242,814	Gouda	04069078	1,496,451	Gouda	04069023	915468	Edam
04069023	1234400	Edam	04069021	505894	Cheddar	04063031	616669	Other processed cheese, not grated or powdered
04063031	774341	Other processed cheese, not grated or powdered	04069023	318932	Edam	04069013	533855	Emmentaler
04069013	722893	Emmentaler	04069099	314,391	Other	04061080	297246	Other fresh cheese
04061080	382726	Other fresh cheese	04069032	248945	Feta	04069001	82486	Other cheese for processing

Source: Eurostat Dataset. Accessed on 22/12/2019.

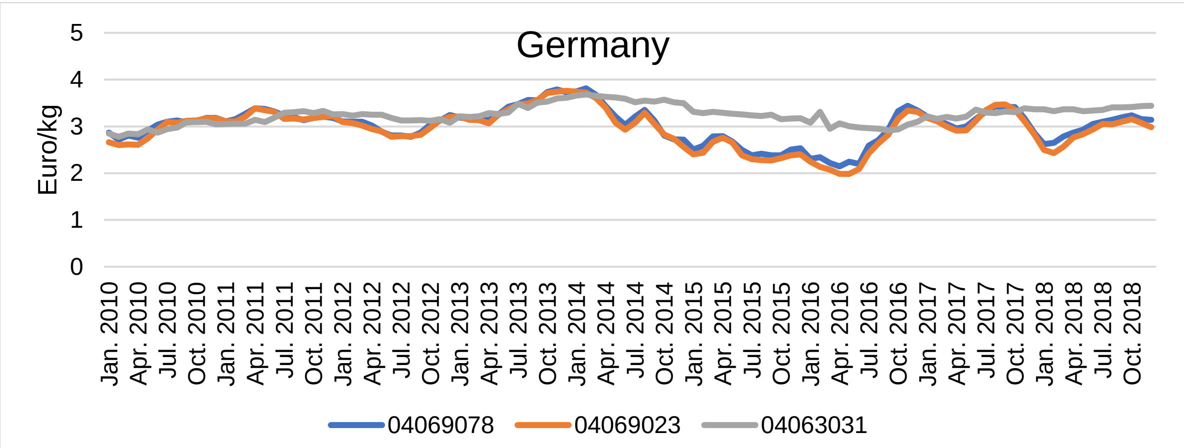


Figure III.8: The intra-EU export prices of top 3 most exported cheeses in Germany from Jan 2010 to Dec 2018

Different from other countries, the UK is a net importer of cheese and imports Cheddar most. Other fresh cheese (CN 04061080) and Kefalograviera, Kasseri (CN 04069085) are the only two categories of cheeses that has positive net exports for the UK.

Table III.10: The Top 5 cheese types of export, import and trade balance of the United Kingdom in 2018

Export			**Import**			**Balance of Trade**		
CN codes	Quantity in 100 kg	Cheese types	CN codes	Quantity in 100 kg	Cheese types	CN codes	Quantity in 100 kg	Cheese types
0406 9021	689324	Cheddar	0406 9021	1080986	Cheddar	0406 1080	304386	Other fresh cheese
0406 1080	434924	Other fresh cheese	0406 3031	254888	Other processed cheese, not grated or powdered	0406 9085	1189	Kefalograviera, Kasseri
0406 3031	36422	Other processed cheese, not grated or powdered	0406 9099	147332	Other processed cheese	0406 9025	-41	Tilsit
0406 3010	34493	Processed cheese, not grated or powdered	0406 1080	130538	Other fresh cheese	0406 9017	-55	Bergkäse, Appenzell
0406 9099	16096	Other processed cheese	0406 9032	124367	Feta	0406 9076	-2272	Danbo, Fontal, Fontina, Fynbo, Havarti, Maribo, Samsø

Source: Eurostat Dataset. Accessed on 22/12/2019.

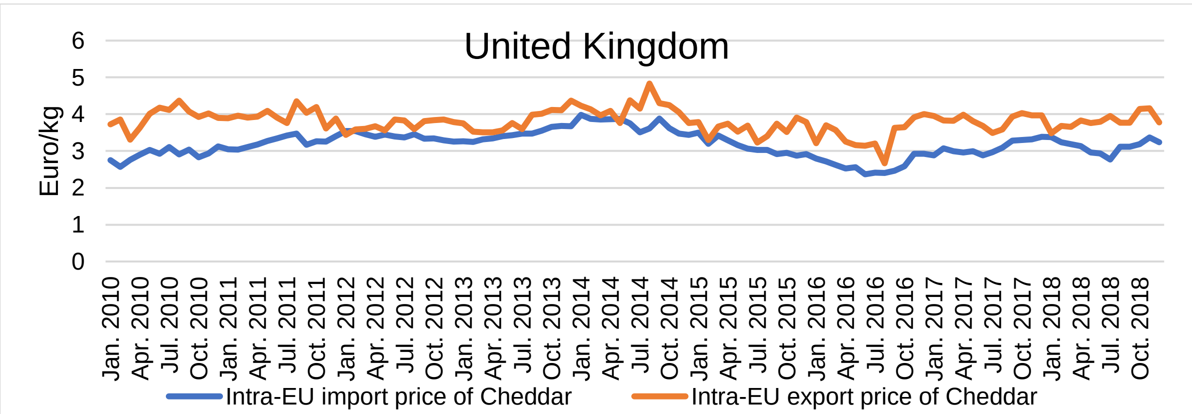


Figure III.9: The intra-EU import and export prices of Cheddar in the UK from Jan 2010 to Dec 2018

III.3 Benchmark Study on Spatial Price Transmission of Main Exported Cheeses

The most exported cheese at 8-digit product levels are studied from Jan 2010 to Dec 2018, that is, Brie (CN 04069084) for France, Gouda (CN 04069078) for the Netherlands, Grana Padano, Parmigiano Reggiano (CN 04069061) for Italy, Cheddar (CN 04069021) for Ireland, Gouda (CN 04069078) for Germany, and Cheddar (CN 04069021) for the UK. Figure III.10 below depicts the price series of different countries. It can be observed that Italy cheese price series fluctuate a lot over the years, while prices series of the other countries remain relatively stable and display co-movement patterns.

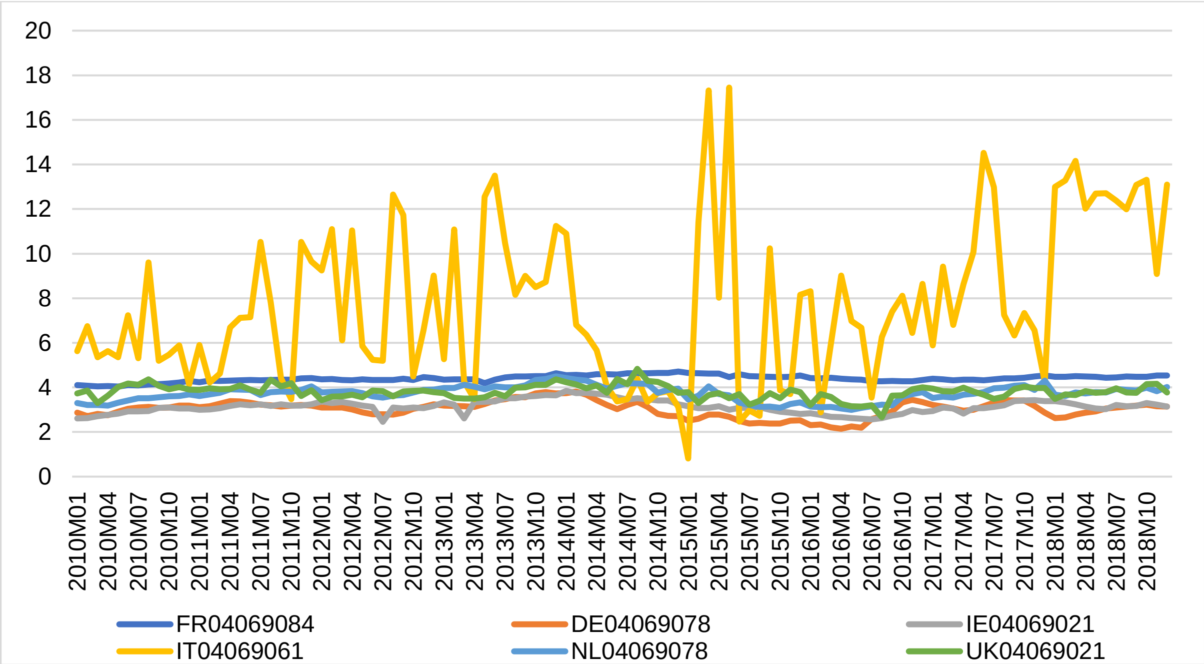


Figure III.10: Cheese export price series of studied countries from Jan 2010 to Dec 2018

The descriptive statistics of the price series are outlined in Table III.11 below. Italy has the highest cheese export price over the years, but the price is not stable. France cheese export price is the second highest and most stable over the years. The most export cheese types of Netherlands and Germany are the same, that is, Gouda (CN 04069078). However, the average export price of Gouda in the Netherlands is higher than in Germany. Similarly, the most exported cheese types of Ireland and the UK are the same, that is, Cheddar (CN 04069021), yet the average price in the UK is higher than in Ireland.

Table III.11: Descriptive statistics of the price series for the 6 studied countries

	FR 04069084	DE 04069078	IE 04069021	IT 04069061	NL 04069078	UK 04069021
Mean	4.401826	3.024766	3.141330	7.753211	3.729595	3.806247
Maximum	4.712453	3.813983	3.845046	17.44625	4.495399	4.832893
Minimum	4.040711	2.145514	2.457004	0.813261	2.994229	2.667450
Std. Dev.	0.147944	0.370025	0.292448	3.515856	0.346205	0.313122
Skewness	-0.350706	-0.307396	0.004512	0.514651	-0.234798	-0.279406
Kurtosis	2.934922	2.831958	2.793218	2.584295	2.511468	4.485320

The cheese export price series of the studied countries are put into analysis to analyze the price integration. The Augmented-Dicken Fuller test is conducted to test the stationarities of each price series. The ADF results indicate that the cheese export prices of France, Ireland, the Netherlands and the UK are non-stationary series that has a unit root, and cheese export price series of Italy is stationary. Therefore, there should be cointegrating relationship among the price series.

Table III.12: ADF test results of cheese export price series for the studied countries.

Price Series	Lag order	t-statistic	p-value
FR04069084	4	-2.5686	0.3408
DE04069078	4	-2.2852	0.4583
IE04069021	4	-2.3631	0.426
IT04069061	4	-3.7564	0.02363
NL04069078	4	-2.2034	0.4923
UK04069021	4	-3.499	0.04553

The Granger Causality pairwise tests are conducted, and the results are listed in Table III.13 as following. The causality test results indicate that price of Germany Granger cause prices of Ireland, the Netherlands and the UK. The prices of Ireland, the Netherlands and the UK Granger cause prices of France. The price of Ireland Granger cause price of the UK and price of the Netherlands Granger cause price of Ireland.

Table III.13: Results of Granger causality pairwise test

Null Hypothesis:	Obs	F-Statistic	P-Value
DE04069078 does not Granger Cause FR04069084	106	6.51768	0.0022
FR04069084 does not Granger Cause DE04069078		2.47347	0.0894
IE04069021 does not Granger Cause FR04069084	106	10.9020	5.E-05
FR04069084 does not Granger Cause IE04069021		1.71480	0.1852
IT04069061 does not Granger Cause FR04069084	106	1.30863	0.2747
FR04069084 does not Granger Cause IT04069061		0.21709	0.8052
NL04069078 does not Granger Cause FR04069084	106	5.61783	0.0049
FR04069084 does not Granger Cause NL04069078		1.62242	0.2025
UK04069021 does not Granger Cause FR04069084	106	4.51432	0.0132
FR04069084 does not Granger Cause UK04069021		0.52816	0.5913
IE04069021 does not Granger Cause DE04069078	106	2.05851	0.1330
DE04069078 does not Granger Cause IE04069021		14.5705	3.E-06
IT04069061 does not Granger Cause DE04069078	106	0.84042	0.4345
DE04069078 does not Granger Cause IT04069061		0.40122	0.6706
NL04069078 does not Granger Cause DE04069078	106	0.83138	0.4384
DE04069078 does not Granger Cause NL04069078		15.6966	1.E-06
UK04069021 does not Granger Cause DE04069078	106	2.73147	0.0699
DE04069078 does not Granger Cause UK04069021		8.36971	0.0004
IT04069061 does not Granger Cause IE04069021	106	0.75510	0.4726
IE04069021 does not Granger Cause IT04069061		1.03245	0.3599
NL04069078 does not Granger Cause IE04069021	106	17.2422	4.E-07
IE04069021 does not Granger Cause NL04069078		0.37262	0.6899
UK04069021 does not Granger Cause IE04069021	106	0.84904	0.4309
IE04069021 does not Granger Cause UK04069021		3.38199	0.0379
NL04069078 does not Granger Cause IT04069061	106	0.60085	0.5503
IT04069061 does not Granger Cause NL04069078		0.28445	0.7530
UK04069021 does not Granger Cause IT04069061	106	0.13864	0.8707

IT04069061 does not Granger Cause UK04069021		0.69638	0.5008
UK04069021 does not Granger Cause NL04069078	106	1.57935	0.2112
NL04069078 does not Granger Cause UK04069021		2.07276	0.1312

The Granger Causality results are illustrated in the Figure III.11 below. Italy price is estimated to have no causality relationship with others, Germany price is not Granger caused by any prices, and France price cannot Granger cause any price.

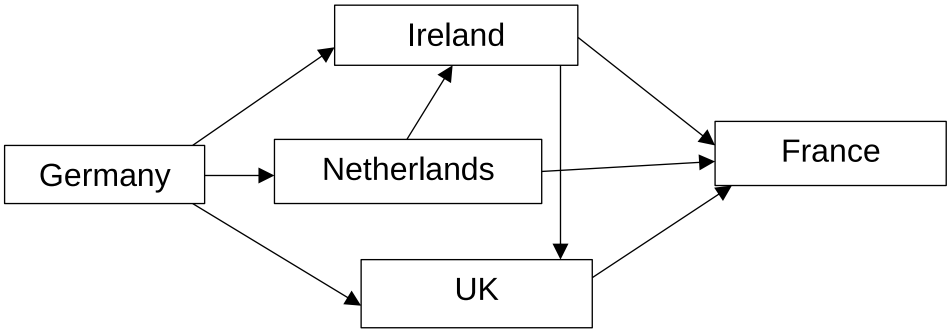


Figure III.11: Granger causality relationships

Table III.14 below outlines the Trace cointegration rank test. The test assumes there is intercept and trend in the cointegration equations, and the lag interval is from 1 to 4. The trace test indicates 2 cointegrating relations at the 0.05 level for the six series. Therefore, the vector error-correction models can be estimated for the price series.

Table III.14: Unrestricted cointegration rank test (trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.276279	125.2425	117.7082	0.0153
At most 1 *	0.266903	91.93748	88.80380	0.0291
At most 2	0.202210	59.95833	63.87610	0.1022
At most 3	0.137587	36.68960	42.91525	0.1822
At most 4	0.108453	21.44344	25.87211	0.1614
At most 5	0.089163	9.619307	12.51798	0.1455

* denotes rejection of the hypothesis at the 0.05 level

**MacKinnon-Haug-Michelis (1999) p-values

The vector error-correction model (VECM) is estimated and the results are shown is the following equation and Table III.15.

Cointegrating Equation is:

$$p_{t-1}^{fr} - 0.4893p_{t-1}^{de} - 0.1713p_{t-1}^{ie} + 0.0417p_{t-1}^{it} + 0.1501p_{t-1}^{nl} - 0.4131p_{t-1}^{uk} - 0.0044t - 1.4551=0$$

Table III.15: The Vector Error Correction estimates

Error Correction:	D(FR04069084)	D(G04069078)	D(IE04069021)	D(IT04069061)	D(NL04069078)	D(UK04069021)
CointEq1	-0.097836	0.116276	-0.110710	-2.851007	-0.158311	-0.003163
	(0.02150)	(0.05488)	(0.06757)	(1.67350)	(0.06725)	(0.11994)
	[-4.55101]	[2.11877]	[-1.63852]	[-1.70362]	[-2.35424]	[-0.02637]
D(FR04069084(-1))	-0.350335	0.001508	0.243547	-4.862235	0.097838	-0.286795
	(0.10025)	(0.25593)	(0.31510)	(7.80435)	(0.31360)	(0.55933)
	[-3.49446]	[0.00589]	[0.77292]	[-0.62302]	[0.31198]	[-0.51274]
D(FR04069084(-2))	-0.116156	0.165525	0.510150	-9.541863	0.029400	-0.002163
	(0.09881)	(0.25223)	(0.31054)	(7.69154)	(0.30907)	(0.55125)
	[-1.17560]	[0.65625]	[1.64276]	[-1.24057]	[0.09513]	[-0.00392]
D(G04069078(-1))	0.040745	0.531299	0.272227	4.274939	0.739364	0.483167
	(0.04632)	(0.11825)	(0.14559)	(3.60591)	(0.14489)	(0.25843)
	[0.87962]	[4.49306]	[1.86984]	[1.18554]	[5.10278]	[1.86960]
D(G04069078(-2))	0.062815	-0.089448	0.274982	-5.211389	0.085473	0.339675
	(0.04697)	(0.11989)	(0.14761)	(3.65604)	(0.14691)	(0.26203)
	[1.33747]	[-0.74606]	[1.86287]	[-1.42542]	[0.58181]	[1.29634]
D(IE04069021(-1))	-0.035393	0.126628	-0.485419	-0.319060	-0.023234	0.184103
	(0.03259)	(0.08321)	(0.10244)	(2.53729)	(0.10195)	(0.18185)
	[-1.08587]	[1.52187]	[-4.73845]	[-0.12575]	[-0.22789]	[1.01241]
D(IE04069021(-2))	0.022338	-0.003287	-0.242773	-5.479969	-0.072340	0.038450
	(0.03280)	(0.08373)	(0.10309)	(2.55330)	(0.10260)	(0.18299)
	[0.68103]	[-0.03925]	[-2.35498]	[-2.14623]	[-0.70509]	[0.21012]

D(IT04069061(-1))	0.003722	1.40E-05	0.004017	-0.344762	0.006894	0.003350
	(0.00143)	(0.00366)	(0.00450)	(0.11148)	(0.00448)	(0.00799)
	[2.59878]	[0.00382]	[0.89241]	[-3.09259]	[1.53889]	[0.41928]
D(IT04069061(-2))	0.001632	-0.002336	0.007342	-0.208917	0.003029	-0.001935
	(0.00137)	(0.00350)	(0.00431)	(0.10665)	(0.00429)	(0.00764)
	[1.19148]	[-0.66799]	[1.70499]	[-1.95892]	[0.70692]	[-0.25315]
D(NL04069078(-1))	-0.005341	-0.061216	0.041755	-2.884927	-0.624093	-0.113619
	(0.03836)	(0.09794)	(0.12058)	(2.98648)	(0.12000)	(0.21404)
	[-0.13922]	[-0.62506]	[0.34629]	[-0.96600]	[-5.20059]	[-0.53083]
D(NL04069078(-2))	-0.086016	-0.039369	-0.126111	2.589252	-0.336961	-0.208233
	(0.03893)	(0.09937)	(0.12235)	(3.03027)	(0.12176)	(0.21718)
	[-2.20968]	[-0.39618]	[-1.03076]	[0.85446]	[-2.76733]	[-0.95881]
D(UK04069021(-1))	-0.026172	0.037788	-0.078350	-0.512372	0.004291	-0.478511
	(0.02140)	(0.05462)	(0.06725)	(1.66560)	(0.06693)	(0.11937)
	[-1.22322]	[0.69183]	[-1.16508]	[-0.30762]	[0.06411]	[-4.00855]
D(UK04069021(-2))	-0.009933	-0.016874	-0.055830	0.379721	-0.026372	-0.086275
	(0.02024)	(0.05167)	(0.06361)	(1.57555)	(0.06331)	(0.11292)
	[-0.49076]	[-0.32660]	[-0.87766]	[0.24101]	[-0.41655]	[-0.76405]
C	0.006816	0.000688	0.003842	0.190139	0.009921	0.005095
	(0.00442)	(0.01129)	(0.01390)	(0.34425)	(0.01383)	(0.02467)
	[1.54135]	[0.06092]	[0.27641]	[0.55233]	[0.71721]	[0.20649]
R-squared	0.343455	0.304919	0.294026	0.278488	0.321724	0.261922
Adj. R-squared	0.249662	0.205622	0.193172	0.175415	0.224827	0.156482
Sum sq. resids	0.181534	1.183012	1.793278	1100.082	1.776231	5.650573
S.E. equation	0.044664	0.114018	0.140379	3.476897	0.139710	0.249187
F-statistic	3.661866	3.070772	2.915377	2.701847	3.320282	2.484090
Log likelihood	184.9257	86.52102	64.68201	-272.3205	65.18345	4.427130

Note: Standard errors in ( ) & t-statistics in [ ]

The generalized impulse response functions can be used for dynamic analysis in the long run. Figures III.12 to Figure III.17 illustrate the impulse responses of prices of each country to a positive and simulated one-standard-error shock.

Figure III.12 illustrates the impulse responses of price series of each country to a positive shock to France cheese export price. It can be seen that: (1) the positive shock increases the France price immediately at a level of 0.043 and then France price stabilizes at the level of 0.033 after 9 months; (2) the UK price increases immediately at a level of 0.045 and fluctuates for 5 months, and then stabilizes at the level of 0.02 after 10 months; (3) Germany price increases immediately at a level of 0.003 at first then to the level of 0.010 for the 5 months, then decreases after 10 months and stabilizes at the level of -0.004; (4) the Ireland price decreases immediately at first 3 months and then increases and stabilizes at the level of 0.002; (5) Italy price decreases after a positive shock to France price at a level of -0.83, and then stabilizes at a level of -0.68; (6) the Netherlands price increases immediately at a level of 0.012 and fluctuates for 10 months, and then stabilizes at the level of 0.011.

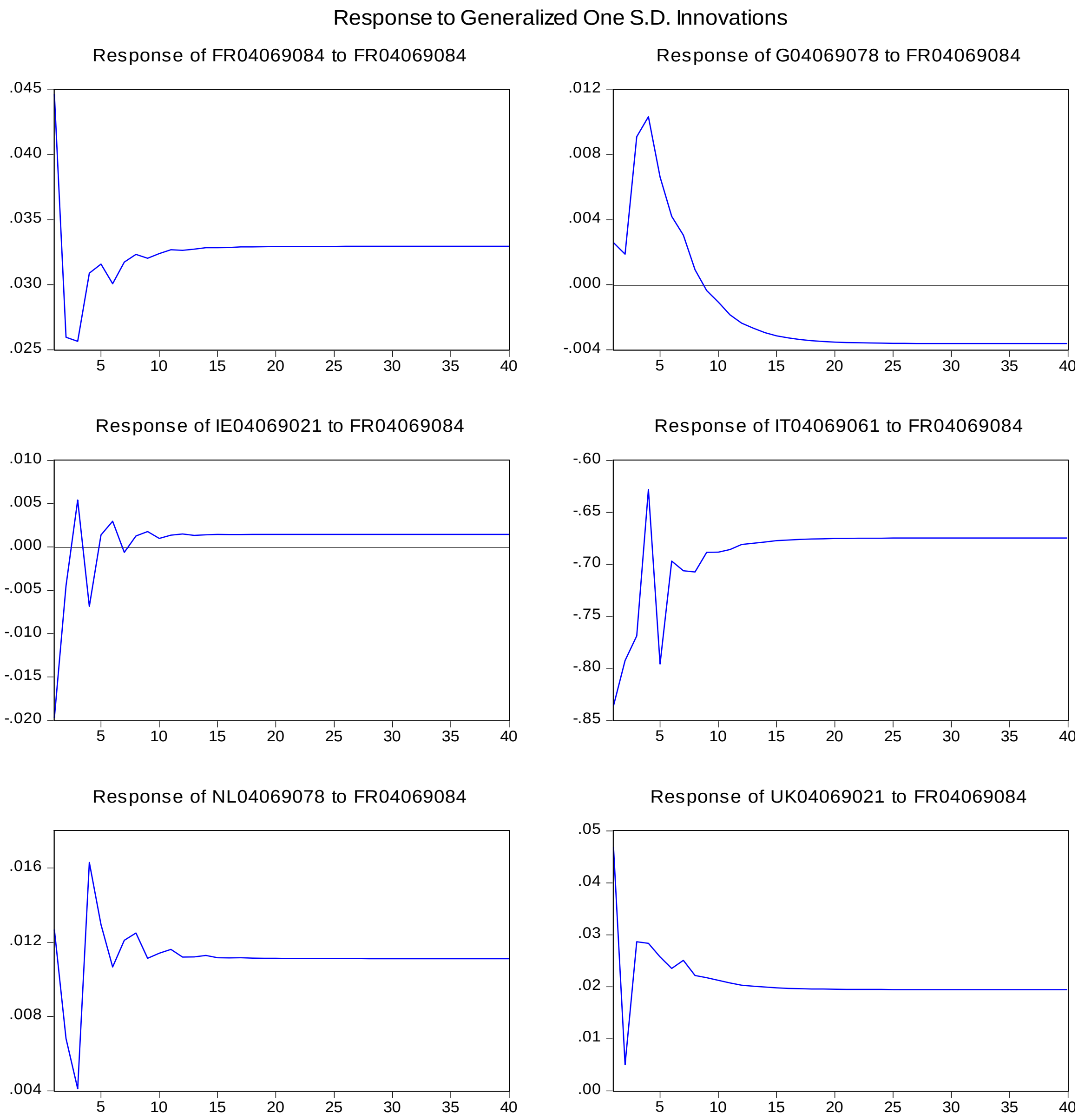


Figure III.12: The responses to generalized one-standard-deviation positive shock to cheese export price of France

Figure III.13 depicts the responses of cheese export prices to a positive shock to cheese export price of Germany. It can be observed that all the prices reach to positive equilibrium levels: (1) Italy price increases significantly and swiftly after a positive shock to Germany price and its increase converge to an equilibrium level after 12 months; (2) the responses of Germany price and the UK price are of similar pattern with Germany price responding at a higher level: the increases in prices of Germany and the UK reach the equilibrium level after 15 months; (3) France price doesn't respond immediately after a shock to Germany price and the increases in France price continue to rise and then stabilizes at the level of 0.04 after 15 months; (5) Ireland price increases immediately at a level of 0.02 and then reaches the equilibrium level after

10 months; (6) the Netherlands price increases immediately at a level of 0.08 and then reach the equilibrium level of 0.12 after 10 months.

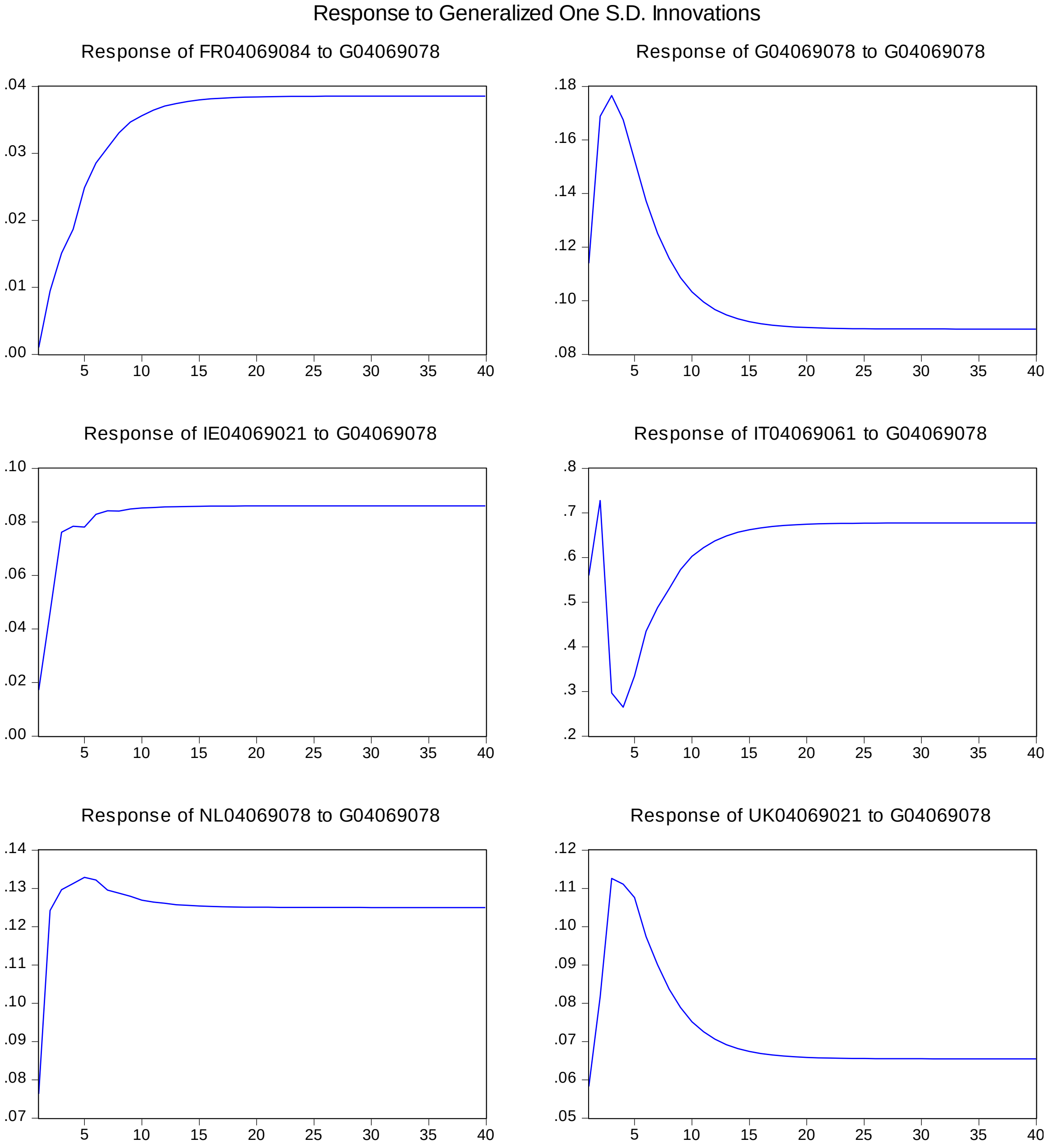


Figure III.13: The responses to generalized one-standard-deviation positive shock to cheese export price of Germany

Figure III.14 depicts the impulse responses of each price to a positive shock to Ireland price. The responses of different prices vary: (1) The positive shocks to Ireland price cause rapid increases in its own price and the price of the UK, then prices reach equilibrium after around 10 months and 15 months at a level of 0.1, respectively; (2) the prices of France and the Netherlands decrease at first two months and then reach to the equilibrium after 10 months at the levels of 0.10 and 0.12, respectively; (3) Germany price respond positively at first and then reach to a negative level and converge to equilibrium after 15 months; (4) Italy price responds positively and immediately at a level of 0.4 and reach to equilibrium after 10 months at a level of 0.2.

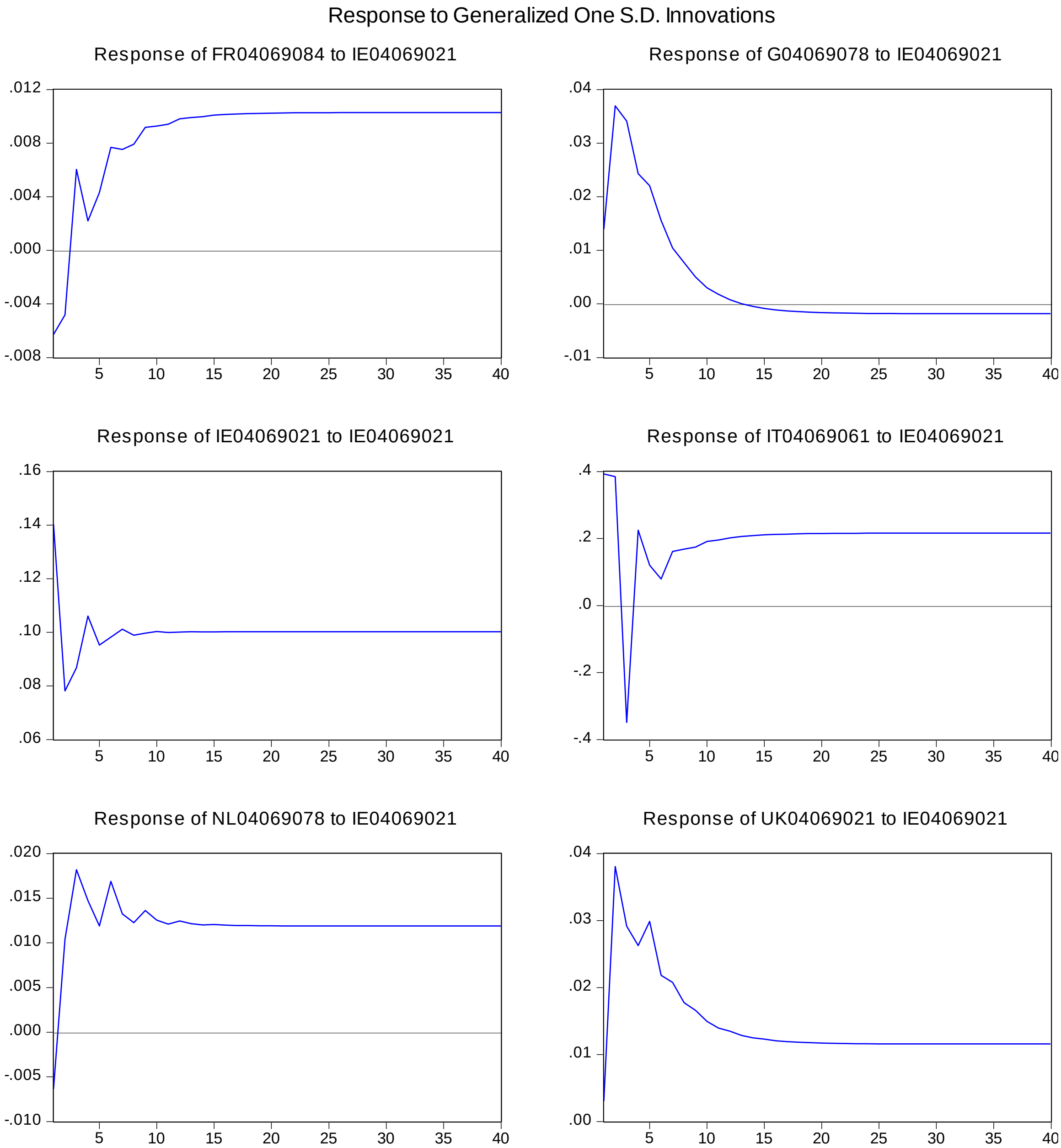


Figure III.14: The responses to generalized one-standard-deviation positive shock to cheese export price of Ireland

Figure III.15 depicts the impulse responses of each price to a positive shock to Italy price. It can be seen that: (1) France price responds negatively after a positive shock to Italy price, and reach equilibrium after 15 months; (2) Germany price respond positively at a level of 0.02 and then the response gradually increases to the equilibrium at around 0.08 after 10 months; (3) Ireland price respond positively and reach to equilibrium after 10 months at a level of 0.16; (4) Italy price responds positively at level of 3.4 immediately after the shock and then reach to equilibrium rapidly after 6 months at a level of 1.7; (5) the price of the Netherlands respond positively and immediately, then converge to equilibrium at a level of 0.026 after 15 months; (6) the price of the UK respond negatively for the first 5 months, then reach equilibrium after 10 months at a level of 0.02.

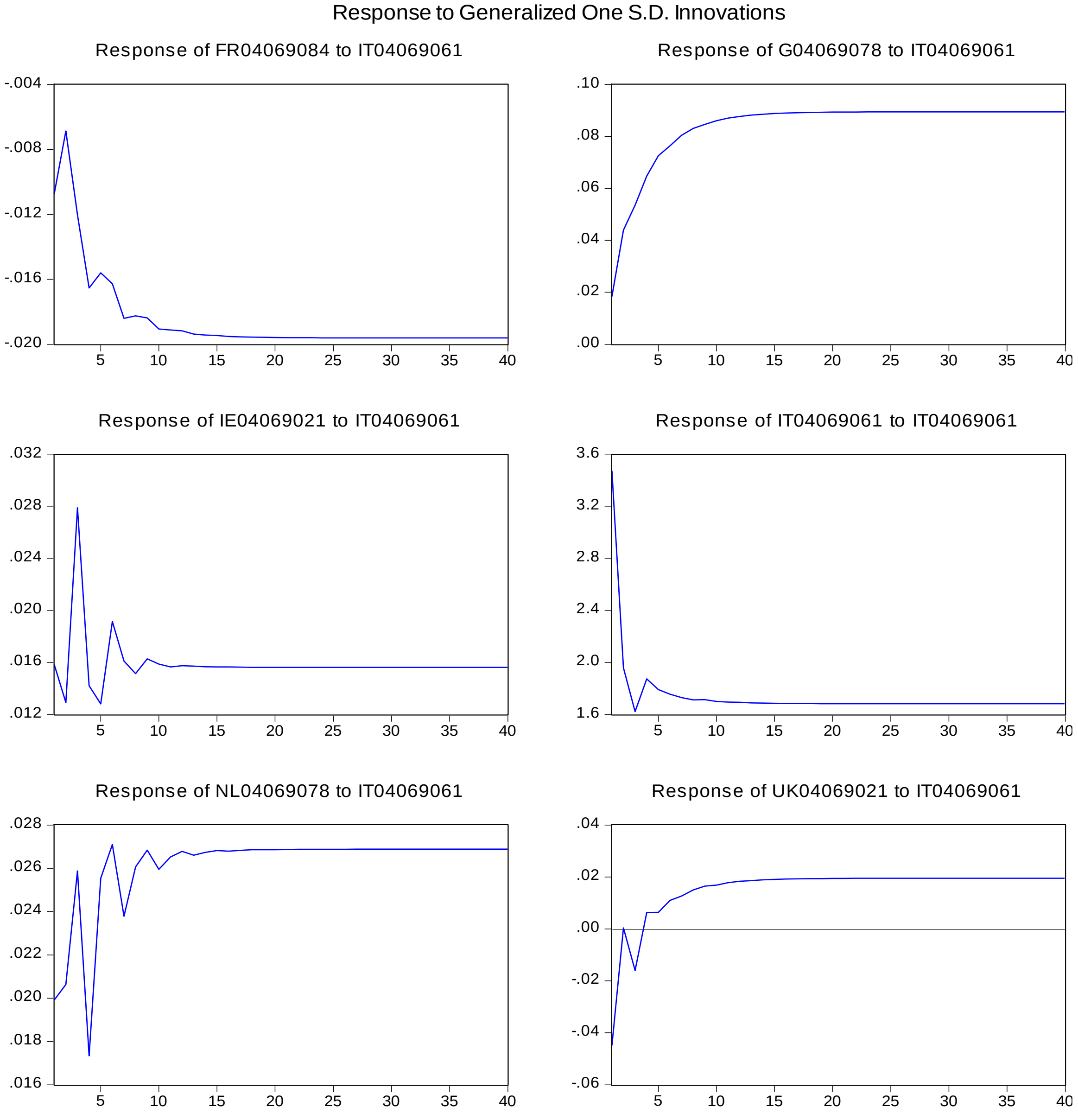


Figure III.15: The responses to generalized one-standard-deviation positive shock to cheese export price of Italy

Figure III.16 depicts the impulse responses of each price to a positive shock to Netherlands price. It can be seen that all the prices reach positive equilibrium levels: (1) France price respond immediately at a level of 0.004, then reach equilibrium after

10 months at a level of 0.014; (2) Germany price respond immediately and positively, then reach equilibrium after 15 months at a level of 0.055; (3) Ireland price responds negatively at first, and then reach equilibrium at a level of 0.028 after around 8 months; (4) Italy price responds swiftly and positively and then reach equilibrium at a level of 0.4 after 10 months; (5) the Netherlands price shock cause increases in its own price immediately at a level of 0.137 and then price reaches equilibrium level of 0.115 after 10 months; (6) the UK price responds positively and then reaches equilibrium level of 0.042 after 15 months.

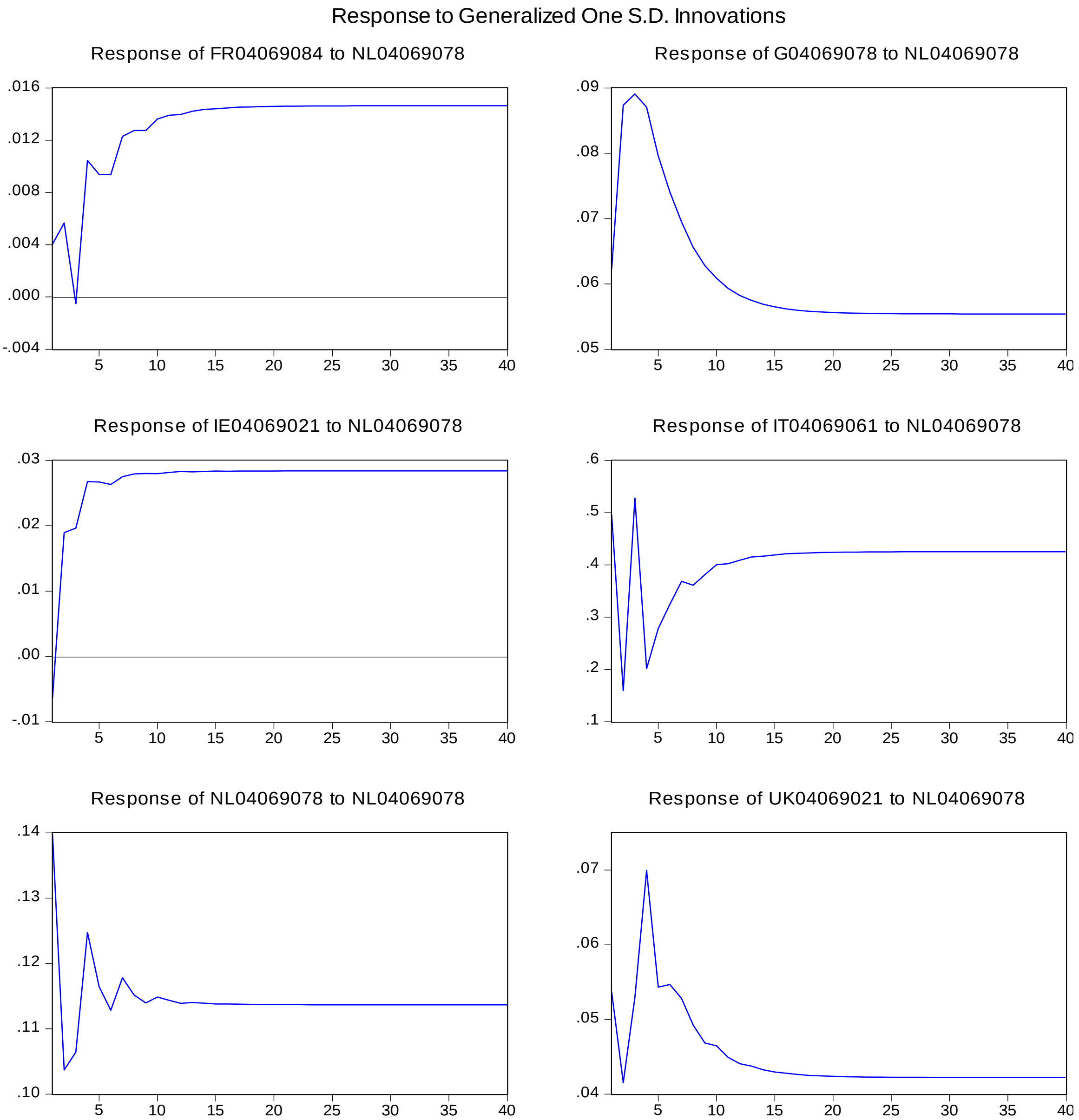


Figure III.16: The responses to generalized one-standard-deviation positive shock to cheese export price of the Netherlands

Figure III.17 depicts the impulse responses of each price to a positive shock to UK price. The responses of different prices vary: (1) France price respond immediately at a level of 0.008, then reach equilibrium level of 0.029 after 10 months; (2) Germany price respond immediately and positively for the first 5 months, then reach equilibrium level of -0.039 after 15 months; (3) Ireland price responds positively and reach equilibrium level of 0.020 after around 8 months; (4) Italy price responds swiftly and negatively for the first 6 months and then reach equilibrium at a level of 1 after 12 months; (5) the UK price shock cause increases in Netherlands price immediately at a level of 0.033 and then price reaches equilibrium level of 0.035 after 10 months; (6) the UK price responds swiftly to its own price shocks at a level of 0.24 and then reaches equilibrium level of 0.13 after 10 months.

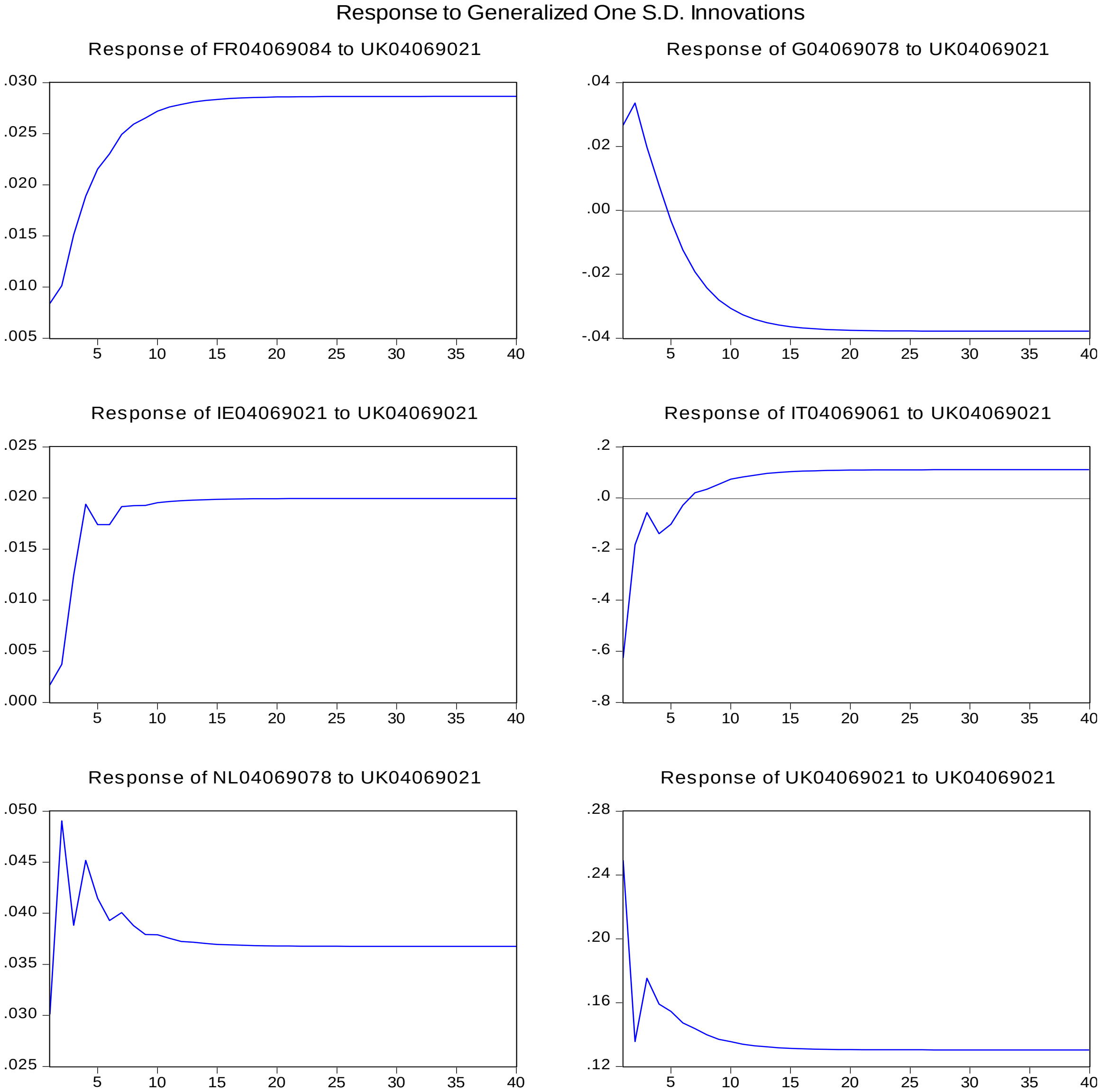


Figure III.17: The responses to generalized one-standard-deviation positive shock to cheese export price of the UK

Appendix IV List of Conference Papers Published During My PhD Study

1. Huidan Xue, Chenguang Li and Liming Wang (2018). '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', 2018 AAEA Annual Meeting (Aug 3-7, 2018). Washington DC, US
2. Huidan Xue (2017). 'Spatial Price Dynamics and Asymmetric Transmission in the Skim Milk Powder (SMP) International Trade: Evidence from New Zealand and Ireland Export Prices', the 7th EAAE PhD workshop (Nov 2017, Grants received). Barcelona, Spain.
3. Huidan Xue, Liming Wang (2017). 'The Analysis of World Butter Export Prices and Market Shocks: An application of GVAR model', Chinese Economic Association's (CEA) Annual Conference (Sep 1-3, 2017) Manchester, the UK.

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