Doctoral Thesis

Essays on European agricultural and trade policies, and their effects on agricultural markets

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Für Filiz, Fiete, Carla et al.

Summary

The Common Agricultural Policy of the European Union (CAP) has a long tradition. After World War II, agricultural and food production in Europe was substantially weakened and unable to provide sufficient food for the domestic population. The CAP emerged from this situation, with the objectives of increasing agricultural productivity and thereby ensuring the standard of living of the population engaged in agriculture, as well as stabilizing markets and ensuring a supply of food for the population at reasonable prices. With substantial market interventions, effective external protection as well as a considerable financial effort, the EU has thereby promoted a structural change in European agriculture. The various measures ultimately led to overproduction, negative effects on other countries, especially developing countries with little domestic support, and an explosion of the budget for the CAP.

The Uruguay Round resulted in the Agreement on Agriculture (AoA) in 1994 which can be seen as a significant step in reducing market-distorting mechanisms in agricultural and trade policies. Although the CAP's support for domestic agriculture has been adjusted in a series of successive reforms in line with the requirements of the AoA, several mechanisms are still in place today that are in fact incompatible with the AoA.

This thesis examines the effects of these mechanisms on agricultural markets at home and abroad and helps to gain an understanding of the harmful effects of market interventions and to quantify them. It consists of two essays, each addressing a component of the overarching question. The first paper, "Effects of variable EU import levies on corn price volatility", analyzes the effects of the EU's variable import levy for corn imports on corn price volatility in the EU and Argentina, a large exporter of corn. Using a multivariate asymmetric GARCH model, we quantify the effect of the levy on volatility. Consistent with theoretical expectations from the literature, the results show that the variable import levy reduces corn price volatility in the EU and increases it in Argentina to the exact same extent. It therefore confirms the theoretical assumption that price insulating instruments, such as variable tariffs, are not able to prevent price volatility, but shift it abroad.

In the second article of this dissertation, "Price formation in the European sugar market", we analyze the price transmission processes on the EU sugar market. Despite an ongoing liberalization of agricultural trade in numerous agricultural commodities and the reduction of market distorting interventions by the CAP, the sugar market is still affected by market interventions to a large extent. In addition

to a protective import tariff and a complex system of preferential trade agreements and tariff rate quotas, the sugar market is characterized by partially coupled direct payments and oligopolistic market structures among sugar producers. Until 2017, there was also a production quota in place. Presumably, this had a considerable effect on market integration with the world market and thus on price transmission processes. We have therefore used an asymmetric price transmission model in error correction form to estimate the dynamics that arise in the relationship between the reported factory price for white sugar in the EU on the one hand and the world market price, the ACP import price and the EU spot market price on the other. The results show that the EU price is decoupled to a large extent from the world market price and that movements in the world market price affect the reported factory price in the EU only into one direction. This is explained by effective price insulation through EU market intervention and by market power among sugar producers.

Based on these contributions, we draw several conclusions. First, studies have shown that the EU still partially ignores effects in countries outside the EU when supporting domestic agriculture - although distortions have been substantially reduced since the AoA. However, nearly 30 years after the completion of the AoA, we can reaffirm the importance of consistently implementing and pursuing commitments to reduce market-distorting policy instruments. The effects of domestic market interventions can still reach far beyond national borders. It should therefore be acknowledged by policy makers that a well functioning global trade with agricultural and food commodities is essential to achieve market stability in a global context and to buffer shocks to regional supply and demand.

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Contents

List of Abbreviations

ADF	**A**ugmented **D**ickey **F**uller
ACP	**A**frican, **C**aribbean and **P**acific
AoA	**A**greement **o**n **A**griculture
ARDL	**A**uto**r**egressive **D**istributed **L**ag Model
BDI	**B**altic **D**ry **I**ndex
BMEL	**B**undes**m**inisterium für **E**rnährung und **L**andwirtschaft
CAP	**C**ommon **A**gricultural **P**olicy
DCC	**D**ynamic **C**onditional **C**orrelation
eGARCH	**e**xponential **G**eneralized **A**utoregressive **C**onditional **H**eteroscedasticity
EU	**E**uropean **U**nion
FTAs	**F**ree **T**rade **A**greements
GARCH	**G**eneralized **A**utoregressive **C**onditional **H**eteroscedasticity
GSP	**G**eneralised **S**ystem of **P**references
KPSS	**K**wiatowski **P**hillips **S**chmidt **S**hin
MY	**M**arketing **Y**ear
MMT	**M**illion **M**etric **T**ons
NARDL	**N**on-linear **A**uto**r**egressive **D**istributed **L**ag Model
SDGs	**S**ustainable **D**evelopment **G**oals
SMO	**S**ugar **M**arket **O**rganisation
USD	**U**nited **S**tates **D**ollar
VECM	**V**ector **E**rror **C**orrection **M**odel
WTO	**W**orld **T**rade **O**rganisation
ZA	**Z**ivot **A**ndrews

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1 General Introduction

The Common Agricultural Policy (CAP) of the European Union has a long history and its origins lie in the 1957 Treaty of Rome. At that time, the economic power of the member states was still severely weakened by the aftermaths of World War II, and agriculture was unable to provide sufficient food for the domestic population. To this end, the member states agreed on the pursuit of concrete goals with a Common Agricultural Policy (BMEL, 2014). According to Article 39 of the Treaty on the Functioning of the European Union, the objectives of the CAP are, among others, to increase agricultural productivity in order to guarantee a fair standard of living for the agricultural community. It also aims to stabilize markets and ensure that the population is supplied with food at reasonable prices. These objectives have their origins in the post-war period and are strongly focused on productivity growth and income support, while agriculture has undergone a considerable structural change since then and the challenges for agriculture (and the CAP) have changed substantially. More than 60 years later, however, these objectives are still the officially quoted objectives of the CAP - objectives for which the expenditures still account for about 38% of the total EU budget (Heinemann and Weiss, 2018).

The structural change in European agriculture was achieved through a number of policy interventions; agricultural policy in the EU at that time was characterized by a high degree of market management, more precisely by domestic price support and substantial subsidies, and the insulation of domestic agricultural commodity prices from fluctuations in world market prices by a system of variable import levies. Among other things, this led to massive overproduction, which had to be counteracted with cost-intensive storage and export restitutions in order to keep prices in the domestic prices at an artificially high level. This led to significant distortions in international markets, conflicts with trading partners and an enormous pressure on EU budget (Bureau et al., 2012). However, this did not apply exclusively to the CAP, but to national policies of several industrialized countries. Moyer and Josling (2018, p.1) conclude that "Industrial country agricultural policy in the post-World War II era has been highly protectionist, commodity based, market distorting and dominated by domestic politics."

Agricultural and food policy has always been politically sensitive and concerns about the domestic agricultural and food sector tend to be more important than international trade relations. While trade barriers for industrial goods have been increasingly reduced under the General Agreement on Tariffs and Trade (GATT) in the decades following World War II, little was achieved for trade in agricultural products (Tangermann, 2018; Hudec, 1998). Yet, a milestone was eventually reached in the Uruguay Round negotiations of the GATT in 1994, where the global tradings partners established the Agreement on Agriculture (AoA) that fundamentally changed the regime of multilateral rules for agricultural trade and domestic support (Tangermann, 2018). It marked a turning point in the CAP, which until then had largely ignored externalities on international markets, developing countries, and the environment.

1.1 The Path to less Distortions[1]

The internal pressure from the exploding budget as well as the external pressure from negotiations in the Uruguay Round and the resulting AoA led to a fundamental change in the European agricultural policy, which initiated a whole process of reforms (Bureau et al., 2012). Starting with a successive reduction of intervention prices and the introduction of direct payments in the MacSharry reform in 1992, followed by the introduction of the second pillar and thus a beginning focus on environmental aspects and rural development in Agenda 2000, which was strengthened in continued reforms. The decoupling of direct payments from production was decided in the 2003 reform, followed by subsequent reforms in which, for example, the end of production quotas for most products were decided (BMEL, 2014; Bureau et al., 2012).

At the product level, a substantial reduction in the EU's Single Commodity Transfers for major commodities can be observed for this period, with exceptions for sugar, rice and meat (OECD, 2021). The degree of decoupling of direct payments was not uniform and exceptions were allowed for member states, resulting in varying degrees of decoupling depending on the product and the EU country. As a result, Mittenzwei et al. (2014) find only minor distortive effects on production and trade of the remaining support instruments in the CAP that are notified to the WTO green box. While results from Gohin and Latruffe (2006) suggest that both fully and partially decoupled payments have only limited distortive effects on production and trade, a number of studies show that the decoupling of direct payments was able to reduce the negative effects on production which are described a loss in productivity. However, the studies report some remaining effects of current subsidies on production (e.g. due to partial decoupling) (Rizov et al., 2013; Latruffe et al., 2017; Minviel and Latruffe, 2017). Adding to this, in the recent CAP-period 2014-2020, we find between 10 to 15% of the direct payments still being coupled to the production, with varying degrees among the member states and products - most importantly beef and veal, milk and milk products, sheep and goat, and protein crops (European Commission, 2020b).

Furthermore, there is still a risk of exporting instability and increasing volatility on international markets by market measures that insulate EU markets from shocks on international markets. A substantial reduction of these support measures that insulated domestic prices from international shocks – as implemented in past

[1]I received valuable comments on this subsection from Sebastian Lakner.

CAP-reforms – is expected to have a positive impact on international market stability and price volatility (cf. Pinstrup-Andersen, 2013; Swinnen et al., 2013; Tangermann, 2011b; Ledebur and Schmitz, 2009; Rudloff, 2009; Matthews, 2008; Tyers and Anderson, 1992).

In 2013, the EU agreed to stop the use of export restitutions which were strongly criticized for their price-dumping effects (Bureau and Swinnen, 2018). Yet, consequences especially for developing countries are mixed: On the one hand, net-importing countries can benefit from price-dumping effects of export refunds at least in the short-run. On the other hand, low prices can have disadvantages for net-exporting countries (Bureau and Swinnen, 2018; Boysen et al., 2016; Swinnen and Squicciarini, 2012; Swinnen, 2011; Bureau and Gohin, 2009; Matthews, 2008). Net effects of low food prices also differ between producers and consumers: while consumers will most likely benefit from low prices, producers rather benefit from high prices (Bureau and Swinnen, 2018; Swinnen and Squicciarini, 2012).

Overall, the recent CAP-reforms were successful in liberalizing agricultural markets and reducing market distortions by shifting from subsidizing production to subsidizing farm income. The negative socioeconomic impacts of the CAP have been reduced in the course of the CAP-reforms since 1992 (Bureau and Swinnen, 2018; European Commission, 2013). Despite these achievements, there are still existing mechanisms and instruments in the mix of agricultural policies and trade policies related to agricultural commodities in the EU, that have the potential to negatively affect other countries in various ways. This was recently emphasized in a statement by a group of 20 WTO members, highlighting that the reduction of distorting domestic agricultural support should continue in order to establish the foundation for a market-oriented agricultural trading system (WTO, 2021).

1.2 Exporting Volatility: the Variable Import Levy for Corn

Chapter 2 deals with the effect of the EU's variable import levy for corn on domestic and international price volatility. The variable import levy was made possible due to a exemption for the EU in the AoA but is technically not compatible with the principle of tariffication - which is an important element of the Agreement. The levy aims to create a floor for grain prices, i.e., to prevent price movements below a politically defined threshold. It can therefore be viewed as a classic tool for insulating domestic prices from shocks in international markets. Although there seems to be widespread consensus in the literature regarding the theoretically framework stating that price insulating policies are capable of causing instability on international markets and are capable of exporting volatility (cf. Martin and Anderson, 2012; Anderson, 2012), the actual effects of these policies on price volatility have rarely been quantified. Although Rude and An (2015) find empirical evidence that trade restrictions during price spikes contribute to food price volatility, there is no empirical link to specific policies but to a mix of policies implemented during the food price crisis. In particular with regard to the EU's variable import levy for grains, which is still in use today, to our knowledge there are no empirical studies for the post-AoA period. The first essay closes this gap: the objective is to explicitly quantify the effect of the EU's variable import levy on corn price volatility. It provides evidence of the empirical extent to which the levy affected corn price volatility in the EU and in Argentina, a large exporter of corn.

1.3 A Complex System of Interventions: the EU Sugar Market

Chapter 3 analyzes the horizontal price transmission processes in the European sugar market, a market that suffers from strong strong interventions, an oligopolistic market structure, and is rather intransparent (Aragrande et al., 2017; Areté, 2012; Tangermann, 2012). There are reasons to assume that market integration of EU and world markets was hampered and prices in the EU were kept at a high level compared to the world market price level. In addition to a production quota that ended in 2017, the mix of agricultural and trade policies on the EU sugar market consists most importantly of an extremely high MFN import tariff, a complex system of tariff rate quotas, and preferential market access for various countries. Altogether this presumably had a considerable effect on market integration. Although there is a large number of studies on vertical price transmission for agricultural products including sugar in the EU, there is lack of horizontal price transmission studies for the EU sugar market. Aragrande et al. (2017) find asymmetric price transmissions in the EU sugar market and link this with the concentration in the EU sugar market but their study analyzes horizontal price transmission among EU member states. The second essays addresses this research gap by estimating horizontal price transmission between the EU sugar price, the world market price and the ACP import price for sugar. The EU price series examined is officially reported by the EU Commission and represents an average of the prices that were reported by European sugar factories. It represents the only publicity accessible source of sugar prices in the EU and these prices are likely to serve as the basis for political consultations and decisions regarding sugar market policies in the EU (Tangermann, 2012). Hence, it is particularly important to understand the underlying mechanisms of price formation.

After I discuss important directions for future research, including a research agenda to analyze agricultural related policies in terms of their coherence with development policy objectives and their effects on developing countries in chapter 4, I provide a conclusion of the key findings of the studies in chapter 5 to summarize the thesis. In this last chapter I also discuss limitations and connect the findings to derive more thorough policy recommendations.

2 Effects of Variable EU Import Levies on Corn Price Volatility

Abstract:

The variable import levy for corn imports in the European Union aims to support European producers by insulating domestic prices from low international prices. Such price-insulating policies have been associated with an increase in global market volatility. Eliminating these distortions has been one of the key issues in international negotiations on agricultural trade liberalization, e.g., the commitment of WTO member states to follow the principle of tariffication as part of the Uruguay Round Agreement on Agriculture. Nevertheless, the Blair House Agreement effectively allowed the EU to maintain a variable import levy regime for grain imports, although the magnitude of this levy is substantially smaller than in the past. Notwithstanding that this policy has been a cornerstone of the EU's Common Agricultural Policy, empirical evidence on the magnitude of its effects on price volatility is largely missing. This paper employs a multivariate asymmetric volatility model to assess these effects on domestic and foreign corn markets, using Argentina – a large exporter of corn – as an example. In line with the relevant theoretical literature, we find empirical evidence for the 2002–2017 period that the variable import levy reduced corn price volatility in the EU market, while significantly increasing volatility to the same extent in Argentina. In a distorted sense, the import levy of the EU has thus been a success, as its variable application rate has stabilized prices in the EU domestic market. However, our results show that this policy has merely shifted price volatility abroad since it has led to increases in price volatility in Argentina. A less distortionary policy to target the problems of agricultural price volatility should shift its focus away from direct price interventions. For instance, domestic policies that improve farmers' ability to cope with price-related risks would avoid the negative effects of domestic price stabilization in foreign countries.

This paper has been published in *Food Policy* (https://doi.org/10.1016/j.foodpol.2021.102063) and is joint work of Jurij Berger (JB), who is the lead author, Bernhard Brümmer (BB) and Bernhard Dalheimer (BD). The contributions of each author are as follows: JB and BB conceptualized the research idea. JB developed the theoretical framework, with contributions from BD. JB and BD developed the empirical strategy and implemented the econometric modelling. BD led the data management with contributions from JB. JB interpreted the results, with contributions from BD and BB. Policy implications were derived by JB. JB and BD wrote the paper.

2.1 Introduction

The World Trade Organization (WTO) Agreement on Agriculture (AoA) established the principle of tariffication as one major component for improving market access in agricultural trade. As Josling et al. (1996) point out, footnote 1 to Article 4 of the AoA explicitly includes the long-standing practice of using variable import levies in the EU as one of the measures that explicitly should be converted into a tariff. Nevertheless, the European Union (EU) still operates a variable import levy for major grains including wheat, barley and corn as a price insulation mechanism during low price periods. Whenever import prices are below a certain threshold, the EU uses the variable import levy to compensate the gap between the import price and the targeted minimum price. In effect, domestic grain prices can be expected to remain fixed above this price floor constructed by the levy (Martin, 2018; Rapsomanikis, 2011). This mechanism was one of the mix of policy measures used by the EU to maintain prices for most agricultural commodities at artificially high levels, which were based on political decisions. The variable import levy combined with export restitutions or public intervention was not only used to support domestic producers by keeping prices high but also by insulating domestic markets from international price volatility. In contrast to a fixed ad valorem tariff that at least allows for partial transmission of price signals into protected markets, such price insulation as introduced by the variable import levy can completely prevent any transmission of price signals between markets (Thomson, 2018; Swinnen et al., 2013; Tangermann, 2011b; Matthews, 2010). Moreover, Martin (2018, p.194) states, that "[...] All it [*price insulation*] can ever achieve is to redistribute volatility from one country to another", which implies that domestic price insulation not only affects price volatility in the country that introduces the policy but it also creates a collective-action problem, incentivizing the affected countries to implement counter-active policies to offset increased volatility. Thus, when implemented by large importers, these policies are subject to criticism for being of a *beggar-thy-neighbor* nature and distorting the price formation process (Martin, 2018; Anderson and Nelgen, 2012a; Tothova, 2011).

While theoretical considerations allow understanding the basic mechanisms at play, the empirical extent of the effects has rarely been addressed in the existing literature. Rude and An (2015) and Dalheimer et al. (2017) find empirical evidence that export restrictions contribute to food price volatility. However, their results are derived from a global approach in which policy strategies are pooled together instead of examining individual policies and their effects. Furthermore, they are concerned with export restrictive policies, which by nature are usually implemented when prices are high. To our knowledge, the volatility dynamics during low price periods and their respective drivers – including policy shocks – remain empirically undetermined. Notwithstanding this, there are reasons to assume that the dynamics of policy impacts during times of low prices significantly differ from those during high price periods (Stigler, 2011; Tangermann, 2011a).

This study adds to the existing body of literature by empirically quantifying the effects of the EU's variable import levy on corn price volatility in both import and export markets. It specifically addresses the effects on both domestic corn price volatility and on the corn price volatility of a large exporter. Corn plays an important role in the global trade with agricultural commodities and the EU is one of the largest net importers of corn. Argentina – which was one of the EU's major trading partners between 2002 and 2008 and heavily affected by the import levies – is chosen as an exemplary large trading partner for the EU. Argentina is a specifically interesting case due to the strong policy attention devoted to this issue by the Argentinian government. For instance, Argentina already raised substantial objections to the EU import levy through the Group of Rio (Group of Rio, 1993) in the process of the Uruguay Round negotiations. The AoA came into force with the establishment of the WTO in 1995. However, developed countries were allowed to phase in the required changes in market access – in particular the tariff reductions –, over six years. Hence, we focus on a time period in which all commitments of the AoA were fully effective in the EU, i.e., starting from July 2000. Given that Argentina's Great Depression began in 1998 only ended at the beginning of 2002, we look at the price formation and the policy effects from 2002 until 2017.

In the following section, an overview of the global corn market with a closer look at the EU is provided, followed by a brief review of the theoretical mechanisms of price insulation policies and their effects on markets. Section 2.4 derives the chosen empirical approach, while section 2.5 describes the data and model specification. In the subsequent sections 2.6 and 2.7, the results of the application and the policy implications that arise from these results are discussed in detail. A summarizing perspective of the most important policy implications concludes the paper.

2.2 Global Corn Market and the EU

Corn ranks among the most traded agricultural commodities. The average annual domestic production (marketing year (MY)[2] 2002 to 2017) of corn in the EU is around 61 million metric tons (MMT), while consumption levels are at around 67 MMT, revealing a substantial dependency on imports from international markets. In the period under consideration, the EU was the largest net importer of corn, with average imports of around 8 MMT per MY. The relevance of imports for domestic consumption has increased in recent decades: while imports of corn were only 2 MMT in MY 2002, they reached 18 MMT in 2017 (USDA FAS, 2018).

Regarding intra-EU trade, France is the largest producer of corn, exporting large amounts to other EU countries. Spain and the Netherlands are the largest importers of EU corn (ITC, 2018). Looking at extra-EU trade, the most relevant origins of corn imports substantially changed in the period under consideration: as depicted in figure 2.1, in the first half from 2002 to 2008 between 23% and 65% of the total value of EU corn imports came from Argentina, while from 2009 onwards corn imports from Argentina substantially declined and ranged only from 2% to 17% of total imports. Imports from Ukraine and Serbia gained importance (ITC, 2018). The production in Ukraine considerably increased from 7.4 MMT

[2]The USDA FAS (2018) defines country-specific marketing years for corn. For the EU the MY is from September to August while for Argentina the MY is from March to February.

in 2007 to 11.5 MMT in 2008, and to well above 20 MMT after 2011, increasing Ukraine's export capacity (USDA FAS, 2018). In 2008, Regulation (EC) No 396/2005 came into force, which harmonized food standards in the EU, and it was particularly important for maximum residue limits and thus relevant for imports of corn. Stricter maximum residue limits can lead to substantial increases in trade costs for exporters to the EU market (Fiankor et al., 2020). However, for Ukrainian exporters, the effects of stricter maximum residue limits were mitigated by the so-called "Agreement on Association" that Ukraine and the EU signed in 2012. This agreement granted Ukraine a prominent status in the EU's Neighborhood Policy, and may have led to a simplification of administrative processes in the trade of goods. Especially in comparison with corn imports from Argentina, lower trade costs (transport and reduced transaction costs) are likely. This illustrates the comparative advantage of Ukraine and can be seen as an additional driver of export growth to the EU.

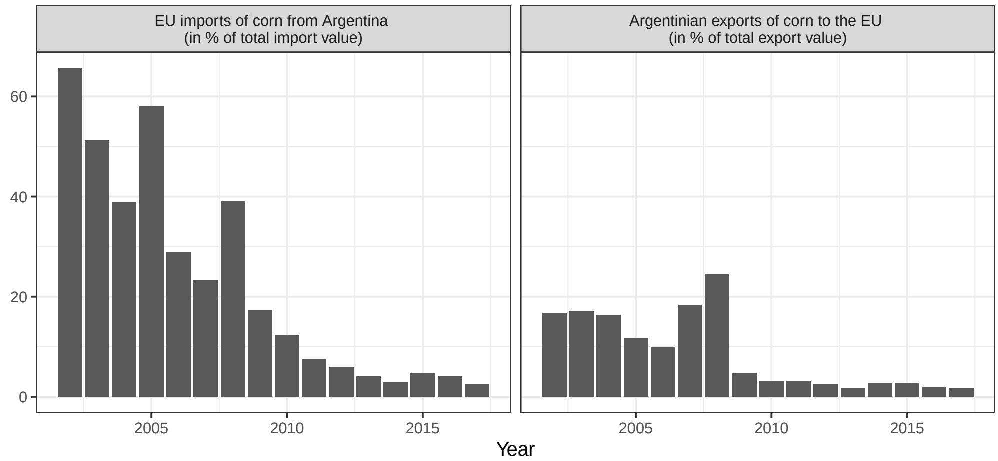

Figure 2.1: Share of corn imports and exports between EU and Argentina
Source: Own production based on data from ITC (2018).

The predominant global exporter of corn is the US, with average yearly exports of 48 MMT. However, US exports to the EU are negligible. With average exports of 16 MMT, Argentina is the second largest exporter. In the period considered, Argentinian exports of corn doubled from 11 MMT in MY 2002 to 23 MMT in MY 2017 (USDA FAS, 2018). As depicted in figure 2.1, the shares of Argentinian export values dedicated to the EU ranged from 10% to 25% between 2002 and 2008. During this period, the EU was the largest importer of Argentinian corn, followed by Chile (export shares between 7% and 11%) and Egypt (export shares between 1% and 11%). After 2008 the Argentinian exports of corn to the EU substantially declined, with shares ranging from 5% to 1% (ITC, 2018).

Over the period of the most intense use of variable import levies between 2002 and 2008, the EU imported substantial amounts of corn from Argentina (see figure 2.1 and 2.2). During this time, the EU was one of the most relevant destinations for Argentinian corn, with export shares of around 20%. After 2008, the trade with corn between the two trading partners and the variable import levy substantially declined. However, given the relative importance of the EU as an importer of corn, it is likely that the EU continues to play a substantial role in price formation processes. Moreover, the fact that Argentina raised objections to the implementation of the variable import levy to the AoA through the Group of Rio (Group of Rio, 1993) highlights the importance for domestic policy in Argentina at that time.

2.3 Policy Background

The AoA established a more market-oriented trading system for agricultural and food commodities (Josling and Tangermann, 1999). It was one of the major results of the Uruguay Round negotiations that took place from 1986 to 1994 under the General Agreement on Tariffs and Trade (GATT). The negotiation process encouraged the EU to implement several reforms of the CAP to prepare for the AoA requirements. Although the agreement came into force in 1995, its full implementation took until 2000 because developed countries were granted an implementation period of six years (WTO, 2009). Hence, with the MacSharry reform in 1992, an entire reform process of the CAP began that focused on increased market integration between EU and world markets. The reform process contributed to the fact that price formation in the EU increasingly takes place through the international markets rather than political decisions.

Before 1995, the cereal trade regime was built on a mix of variable import levies, export restitutions, and public storage at politically-fixed intervention prices substantially above international price levels. In the area of market access, the AoA contained two commitments that required substantial changes to the then-existing EU policy regime for cereals: first, the AoA principle of tariffication explicitly lists variable import levies as a non-tariff measures that should be turned into an ad valorem tariff of equivalent protection; and second, the resulting tariff rates were to be reduced by 36% in six annual steps of equal size starting from 1995, whereby the last step came into effect at the beginning of July 2000 (WTO, 2009). As a result, many of the existing distorting non-tariff measures for agricultural commodities were converted into fixed ad valorem tariffs (Josling, 1998). A fixed ad valorem tariff rate is less distorting than a variable levy, because the former allows price signals to be transmitted between markets, leaving relative prices unchanged (Martin, 2018; Newton, 2016; Thompson et al., 2000). However, as a consequence of the Blair House Agreement in 1992[3], the EU was allowed to protect producers from low prices on international markets and ensure a minimum import price (Agra Europe, 2010). According to the agreement, the price for importing major cereals to the EU should not fall below 155% of the corresponding intervention price. In order to ensure this minimum import price, the EU continued to use a variable import levy, which compensates for the difference between the reference price and the minimum import price. For corn, the level of the levy is determined based on the sum of the US corn price (Central Illinois, CME), a premium, and shipping costs to Rotterdam. The levy is automatically triggered on a biweekly basis if the ten-day average of the reference price is below the determined threshold (Agra Europe, 2010; European Commision, 2014). Thus, a price floor is established for domestic prices, which supports corn producers in the EU. However, since the EU is a large importer of corn, the price insulation is likely to

[3]An accord between the EU and the US in view of the faltering GATT negotiations of the Uruguay Round that became part of the AoA.

affect price formation not only on domestic markets but also international markets (Martin, 2018; Thompson et al., 2000; Josling, 1998).

The effect of causing instability on international markets and amplifying price responses to exogenous shocks is an important argument against domestic price insulation policies (Martin, 2018; Pinstrup-Andersen, 2013; Tangermann, 2011b; Tangermann, 2011a; Martin and Anderson, 2012; Tyers and Anderson, 1992; Sampson and Snape, 1980). In the literature, this is commonly referred to as the effect of 'exporting' volatility because for economically large countries these policies are suspected to destabilize international markets. Martin and Anderson (2012) provide a theoretical framework to explain the effect of domestic price insulation policies on international markets and prices. The authors assume an exogenous shock resulting in an *increase* of international prices. However, high-income countries usually protect their producers rather than consumers (e.g. Anderson and Nelgen, 2012b). In light of this, an exogenous shock that results in a *plunge* of international prices is more suitable to explain the effect of domestic price insulation in high-income economies, and we transform the given theoretical framework to a situation in which price insulation is designed to protect from low international prices.

As a response to a negative price shock, the government imposes a policy such as a quota, tariff or ban to impede price transmission from international to domestic markets. The policy raises the domestic price, relative to the reduced international price. Compared with the initial signal from the international market, the trade policy incentivizes producers to produce more and consumers to demand less. In the case of an economically large importer[4], the domestic policy exerts pressure on international markets which amplifies the price response to the initial shock. The rest of the world faces an even lower price level compared with a situation without the trade policy. Furthermore, import restrictive measures might encourage net-exporting countries to impose retaliation policies to offset price dumping effects. If many countries intervened to the exact same extent, the policies would simply offset each other. Domestic prices in the intervening countries remain at the pre-policy level, but prices for the rest of the world further decrease (Martin and Anderson, 2012; Sharma, 2011; Feenstra and Taylor, 2017; Tyers and Anderson, 1992). In fact, it is very unlikely that all countries intervene to the exact same extent. The disparity reduces international trade and thereby erodes the buffering effect of trade to domestic or regional supply and demand shocks. Consequently, price responses of international markets to exogenous shocks are amplified. For instance, Tyers and Anderson (1992) estimate that trade restrictive policies in high-income countries before the AoA reduced international trade volumes by 7% for coarse grains and 26% for rice. The thinning of international markets makes them more vulnerable to external shocks and contributes to an increase in price volatility (Anderson and Nelgen, 2012b; Anderson, 2012; Pinstrup-Andersen, 2013; Rude and An, 2015; Tangermann, 2011a; Tothova, 2011).

While food price volatility is rarely noticeable to consumers in developed countries, the effects on market participants in developing economies are much more critical. In contrast to price levels – for which shocks are usually beneficial for either the producer or the consumer (Swinnen and Squicciarini, 2012) – excessive

[4]Which can be either a single large importer or a group of net-importing countries

and frequent price fluctuations impose a threat to both. For producers, food price volatility generates economic uncertainty and impedes their long-term investment and production decisions, which in turn can depress production. Moreover, price volatility increases the costs of managing the associated risks and thereby reduces the income (Tadesse et al., 2014; Hajkowicz et al., 2012; Tothova, 2011). Simultaneously, consumers in low-income settings – who typically spend a large share of their income on food – are placed at risk of experiencing sudden and unexpected hardship. Food price volatility hampers their long-term budget strategies and threatens the reduction of poverty (Martin, 2017; Hajkowicz et al., 2012). Thus, price volatility is a critical aspect for achieving the UN's Sustainable Development Goals (SDGs). More precisely, SDG 1 concerning eradicating poverty is at risk as food price fluctuations have proven capable of quickly pushing large proportions of populations below poverty lines (De Hoyos and Medvedev, 2009). Moreover, since food price volatility is a serious threat to the *stability* dimension of food security, achieving SDG 2 (zero hunger) could also be at stake.

2.4 Methodology

Price insulation policies can affect volatility. They are suspected to shift volatility from one country to another. Because volatility cannot be measured directly (cf. Brümmer et al., 2016a), it is necessary to establish an appropriate estimator to examine the development of volatility over time and the effect of potential exogenous variables, as well as time-varying interdependence between volatilities. Generalized autoregressive conditional heteroscedasticity (GARCH) models introduced by Engle (1982) and Bollerslev (1986) are commonly used to describe the conditional variance of the residuals of some mean process. In agricultural price analysis, GARCH models have been widely applied to model price processes (e.g. Apergis and Rezitis, 2011; Minot, 2014; Gilbert and Morgan, 2010; Shively and Thapa, 2016). However, agricultural commodity prices often exhibit asymmetry in the sense that positive price shocks generate higher volatility than negative shocks (Stigler, 2011; Tangermann, 2011a; Abdelradi and Serra, 2015). The GARCH model in its initial form does not allow for asymmetry in price volatility. In order to account for asymmetry, several extensions have been introduced including the exponential GARCH (eGARCH) proposed by Nelson (1991), which has been frequently applied in agricultural price analysis. In order to examine the effects of the variable import levy on price volatility, we estimate the GARCH model in a multivariate framework, namely a dynamic conditional correlation (DCC-)GARCH model that was introduced by Engle (2002). Compared with the univariate GARCH specifications, the DCC additionally allows us to explore the time-varying interdependence of the two volatilities. In a first step, we apply the univariate eGARCH(1,1) specification with additional exogenous variables (eGARCH-X). In a second step, we estimate the multivariate DCC-GARCH.

Since the EU and the Argentinian corn markets and thus their prices are highly interlinked, the underlying mean price processes are estimated by means of a vector error correction model (VECM) under the assumption of heteroscedasticity of the residuals. Subsequently, the residuals serve as the basis for the GARCH analysis. Following Engle and Granger (1987), for the case of two cointegrated price series p_{1t} and p_{2t}, a VECM can be written as:

$$\begin{pmatrix}\Delta p_{1t}\\ \Delta p_{2t}\end{pmatrix} = \begin{pmatrix}\mathrm{a}_1\\ \mathrm{a}_2\end{pmatrix}(p_{1t-1} - \mathrm{b}_0 - \mathrm{b}_1 p_{2t-1}) + \sum_{i=1}^{k} \mathrm{G}_i \begin{pmatrix}\Delta p_{1t-i}\\ \Delta p_{2t-i}\end{pmatrix} + \begin{pmatrix}\varepsilon_{1t}\\ \varepsilon_{2t}\end{pmatrix} \tag{2.1}$$
$$\varepsilon_t|\Omega_{t-1} \sim N(0, h_t^2),$$
$$t = 1, ..., T$$

where b_1 represents the cointegrating parameter of the long-run equilibrium, while the lagged deviations from the equilibrium are given by $p_{1t-1} - \mathrm{b}_0 - \mathrm{b}_1 p_{2t-1}$. The error correction parameters a_1 and a_2 are interpreted as the speed at which prices adjust towards the long-run equilibrium, while the parameters in matrix G measure short-run effects. In case of cointegrated variables, the residuals of the VECM must be stationary and are represented by $\varepsilon_{1,t}$ and $\varepsilon_{2,t}$. The variance h_t^2 of the residuals is conditional on information Ω at $t-1$, and it is interpreted as a measure of volatility (Enders, 2015; Rapsomanikis, 2011). The residuals ε_t are used for the estimation of the eGARCH model as given in equation (2.2).

In general, GARCH models allow volatility to depend on previous shocks in the mean equation and previous volatilities (clustering). The eGARCH-X$(1,1)$[5] introduced by Nelson (1991) can be expressed as:

$$log(h_t^2) = \omega + \lambda x_t + \alpha \left|\frac{\varepsilon_{t-1}}{h_{t-1}}\right| + \gamma\left(\frac{\varepsilon_{t-1}}{h_{t-1}}\right) + \beta log(h_{t-1}^2) \tag{2.2}$$

where α measures the effect of previous standardized shocks on the volatility. In the eGARCH literature, it is also referred to as the magnitude effect because it measures the effect of a standardized shock regardless of its direction. The degree of persistence of volatility is measured by β. It accounts for the effect of the lagged conditional variance. Its estimate should be less than one to fulfill the stationarity condition. The effect of the sign of the lagged price shocks on volatility is captured by γ. For $\gamma < 0$, a leverage effect is present, i.e., negative shocks have a stronger effect on volatility than positive shocks. However, for storable goods such as agricultural commodities, we suspect an inverse leverage and $\gamma > 0$ because positive shocks usually reduce stocks and markets become more vulnerable. By contrast, negative shocks are usually related to increased stocks, which can act as a buffer for price shocks and thus for volatility (Stigler, 2011). λ measures the effect of an exogenous variable x on volatility.

In order to explore the time-varying correlation among the two volatilities, we apply the DCC model introduced by Engle (2002). The time-varying conditional covariance matrix is decomposed into

$$H_t = D_t R_t D_t, \tag{2.3}$$

[5] A GARCH(1,1) usually represents the best dimensional choice (Hansen and Lunde, 2005).

where $D_t = diag\{h_{1,t}, h_{2,t}\}$ represents the estimated standard deviations for both price series from the eGARCH-X model as specified in equation (2.2). R_t is the DCC matrix, which contains the time-varying correlations of the standardized residuals. The estimation procedure is divided into two steps. First, the volatility of the price series is estimated using the eGARCH as specified in equation (2.2) to obtain D_t and the standardized residuals $E_t = D_t^{-1}\varepsilon_t$. In a second step, Q_t is derived to finally compute R_t, which contains the DCC estimates:

$$Q_t = (1 - a - b)\overline{Q} + a(E_{t-1}E'_{t-1}) + b(Q_{t-1}) \tag{2.4}$$

$$R_t = diag\{Q_t\}^{-\frac{1}{2}}\, Q_t\, diag\{Q_t\}^{-\frac{1}{2}} \tag{2.5}$$

where Q_t is a positive-definite matrix representing the conditional variance-covariance of the standardized residuals, while $\overline{Q}$ represents the unconditional variance-covariance matrix.

2.5 Data and Model Specifications

For the analysis, we use spot prices on a business-day basis from January 2002 until September 2017, which sum up to a total of 3,895 observations. The price in the EU p_t^{EU} is represented by the French (Bordeaux) price and the Argentinian price p_t^{ARG} is quoted as a free-on-board (fob) export price. Both price series were retrieved from Datastream (2018) and converted into USD per metric ton. Figure 2.2 shows the two price series in question. For most observations, the EU price is higher than the Argentinian price series. Particularly in times of low price levels before the beginning of the food price crisis in 2007/08 – when the levy was above zero – the price gap is substantial. During the second half of the period, the price difference is rather small and periods of an active levy are less frequent.

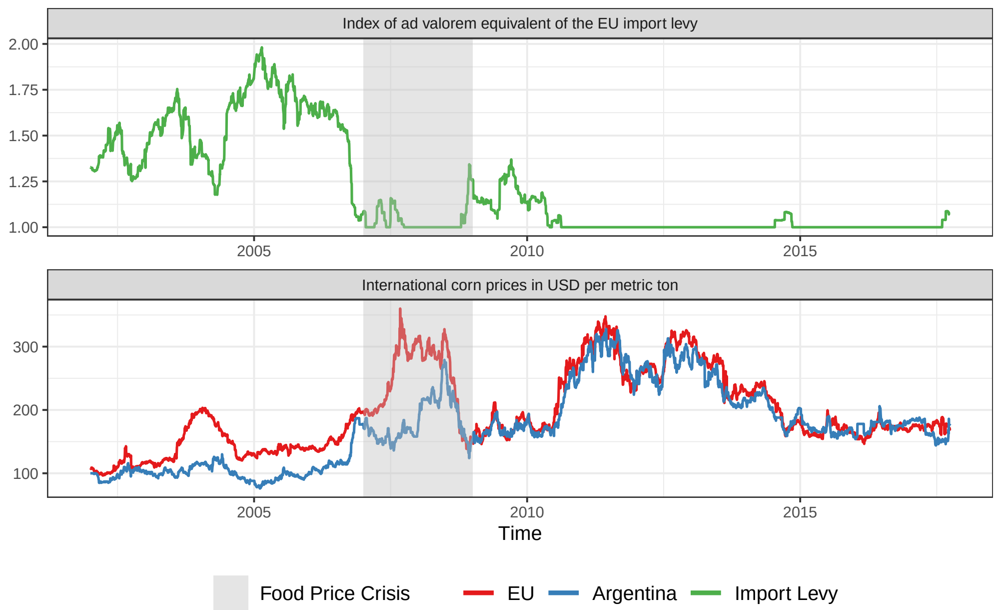

Figure 2.2: International corn prices and variable import levy

In order to evaluate the effect of the import levy, we look at the ad valorem equivalent of the EU import levy L^{av} given at time point t. The levy was retrieved from from the TARIC database (European Commission, 2018). It accounts for corn (other than seeds) imported by land, inland waterway, sea, or air, and is provided in EUR per metric ton. The protective effect of a given levy is dependent on the price level, and hence the levy was transformed to an index of the ad valorem equivalent. Even with a constant levy, the ad valorem equivalent and its potential effects on price volatility change with fluctuations in the price level (Martin, 2018). The ad valorem equivalent is calculated as $L_t^{av} = \frac{L_t^{abs} * s_t}{p_t^{ARG}} + 1$, where L_t^{abs} is the levy in Euro per metric ton and s_t is the exchange rate in Euro per USD at time t. As discussed above, the variable levy is determined on a specific rule, given the level of international prices and not its variance. Hence, potential endogeneity issues related to reverse causality are unlikely.

Table 2.1: Summary statistics of corn prices and ad valorem equivalent of import levy

Variable	Mean	Std. Dev.	Min	Max
European Union (in USD per metric ton)	197	62	96	360
Argentina (in USD per metric ton)	173	62	76	328
Import levy (in %)	119	27	100	198

T = 3895

As shown in table 2.1, the two price series are distributed similarly around means of 197 USD and 173 USD for the EU and Argentina, respectively, with an equal standard deviation of 62 USD. The index of the levy ranges between 1 (no Levy, ad valorem equivalent is 0%) and 1.98 (the ad valorem equivalent of the tariff is 98%). In the following analysis, both prices are expressed in logarithms.

2.5.1 Order of integration

A mere visual inspection of the price series already leads to the presumption of non-mean reversion of the two price series. Dickey and Fuller (1979) (ADF) propose a test in which unit root is present under the null hypothesis, whereas Kwiatkowski et al. (1992a) (KPSS) suggest a routine that considers stationarity under the null hypothesis. Both tests are employed to assess the order of integration of the two time series. In addition, in order to determine whether the results from ADF and KPSS tests are robust in the presence of potential structural breaks, we consider the statistics proposed by Zivot and Andrews (2002). Table 2.2 depicts the test statistics under constant and trend impositions. In both cases, the hypothesis of unit root cannot be rejected in levels with and without trend. Applying the same routine to the data in first differences, we find strong evidence for mean reversion under both no trend as well as trend conditions. Regarding structural breaks, we find unit roots in levels as well as no broken trend at different break points. Given these test statistics, we conclude that both series are integrated of order 1 and the order of integration is in turn robust to structural breaks.

Table 2.2: Univariate order of integration tests

	European Union		Argentina	
	Level	1st Diff	Level	1st Diff
ADF				
Statistic	-1.73	-45.64^{***}	-1.75	-41.18^{***}
KPSS				
Statistic	4.99^{***}	0.04	6.08^{***}	0.05
Zivot-Andrews				
Statistic	-2.9	-69.11^{***}	-3.44	-59.59^{***}

$^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$

The results are also robust for other specifications.

2.5.2 Cointegration and stability testing

Shifting from the univariate to the bivariate analysis of the data over the time period under consideration, four particular factors should be taken into account regarding the relationship between the two variables: (i) the costs of transportation (i.e., shipping costs), which have substantially fluctuated, thereby altering the price relationships at a given point in time; (ii) the presence of the EU import levy; (iii) export-related policies in Argentina (i.e., export quotas and taxes); and (iv) potential structural breaks in the cointegrating relationships of the prices. The former two factors can be accounted for by introducing control variables to the long-run relationship: the development of the costs of shipping dry bulk commodities using the Baltic Dry Index (BDI) (e.g. Lin and Sim, 2013) and the ad valorem equivalent of the levy as described in chapter 2.5. Argentinian export policies are considered in the model in two ways: first, the Argentinian price is reported as a fob export price, which already includes export duties; and second, during the food price crisis, a variety of policy measures were implemented by important market participants that may have led to changes in international corn price relations. Argentina in particular had implemented short-run policy measures such as export prohibitions or quotas within the crisis. Additionally, both import and export policy measures of other countries are likely to have influenced the price dynamics within this period. In order to capture these short-run policy effects of the food price crisis, we include a dummy controlling for shifts in the short-run dynamics of the VECM in 2007 and 2008 (D^{FPC}).

Similar to the order of integration, the cointegration relationship may be subject to structural breaks. In order to formally allow for a structural change that might have occurred in the long-run relationship, the test procedure proposed by Gregory and Hansen (1996) is applied to assess the statistical significance of these events for the cointegrating relationship. This residual-based test for cointegration specifically allows testing for cointegration under a supposed (single) shift in the level of the relationship:

$$p_t^{EU} = \mathrm{b}_0 + \mathrm{b}_1 p_t^{ARG} + \mathrm{b}_2 D_t^{\tau} + \mathrm{b}_3 \mathrm{BDI}_t + \mathrm{b}_4 L_t^{av} + \mu_t. \tag{2.6}$$

Here, τ denotes the hypothesized structural break, which determines the dummy variable D. The parameters b_0 to b_4 are to be estimated. Following Gregory and Hansen (1996), the presence of a structural break is determined by means of testing for the stationarity of the error term μ, which can be carried out based on the conventional ADF as well as the Z_α and Z_t (Phillips, 1987) test statistics. Estimating the model recursively allows determining the most likely breakpoint by minimizing the respective test statistics. Narayan (2005) suggests using a time window of $0.15T \leq \tau \leq 0.85T$ to test each observation in this range for a structural break. This procedure not only narrows down the most likely shift in the cointegration relationship of the prices, but it also remedies the risk of omitting some significant structural break at another point in time, serving as an additional robustness check.

The *ADF* statistic points towards a statistically significant structural break on April 22, 2008, while Z_α and Z_t both find a significant structural break on January 23, 2008. Both breakdates are during the 2007/08 food price crisis, a period of global price surges during which commodity price relationships have been shown to be substantially altered (Headey, 2011). Furthermore, as depicted in figure 2.1, trade between the two countries substantially declined at this time, indicating that EU imports became less important for Argentinian exporters and vice versa, as discussed in section 2.2. We select τ = January 23, 2008 for the date of the structural break in the estimation.[6]

We estimate the VECM of the European and Argentinian price series including twelve lags in accordance with the Akaike information criterion. In the short-run equation of the model, we include the crisis dummy D^{FPC}. In the long-run dynamics, we control for fluctuations in the shipping costs and the import levy, and allow for a single structural break in the constant using the dummy variable D^τ. The final VECM is hence given as:

$$\begin{aligned}\begin{pmatrix}\Delta p_t^{EU}\\ \Delta p_t^{ARG}\end{pmatrix} &= \begin{pmatrix}\mathrm{a}_1\\ \mathrm{a}_2\end{pmatrix}\left(p_{t-1}^{EU} - \mathrm{b}_0 - \mathrm{b}_1 p_{t-1}^{ARG} - \mathrm{b}_2 D^\tau - \mathrm{b}_3 \mathrm{BDI}_t - \mathrm{b}_4 L_t^{av}\right)\\ &+ \sum_{i=1}^{12} \mathrm{G}_i \begin{pmatrix}\Delta p_{t-i}^{EU}\\ \Delta p_{t-i}^{ARG}\end{pmatrix} + \begin{pmatrix}c_1\\ c_2\end{pmatrix} D^{\mathrm{FPC}} + \begin{pmatrix}\varepsilon_{1t}\\ \varepsilon_{2t}\end{pmatrix}. \end{aligned} \tag{2.7}$$

While tests on the residuals ε_{1t} and ε_{2t} in levels from equation (2.7) do not indicate degrees of autocorrelation for any reasonable lag length, the squared residuals show substantial degrees of serial correlation. Therefore, the use of GARCH models is appropriate to describe the volatility. Furthermore, the CUSUM test on recursive residuals (Kuan and Hornik, 1995) did not reveal any evidence of parameter instability in the specified system of equations (see Appendix, figure A.1).

[6] Considering the total number of 3,895 observations, the two dates are reasonably close to each other. Further checks confirmed the robustness of results regardless of the choice of dates out of the two.

Table 2.3: Long-run dynamics

	p^{EU}
Intercept	−0.6655
	(0.0568)
p^{ARG}	1.0146
	(0.0096)
L^{av}	0.0596
	(0.0120)
BDI	0.1032
	(0.0025)
D^{τ}	−0.1762
	(0.0065)

Standard errors in parentheses.

2.6 Empirical Results

The resulting coefficients of the cointegrating relationship are depicted in table 2.3. Most notably, the coefficient of p^{ARG} is very close to unity, suggesting that the markets are perfectly integrated in the long run. Furthermore, trade costs and import levy contribute to the price gap with the expected sign. The regime shift in the constant is negative, supporting the visual suspicion from figure 2.2 that prices move closer together after the structural change. Regarding the short-run dynamics, the speed of adjustment substantially differs between the European and Argentinian prices (see Appendix, table A.1). On average, the EU price corrected only 0.57% of the divergence from its long-run equilibrium with the Argentinian corn price per day. By contrast, the Argentinian corn price corrected 1.32% of the deviations per day on average.

The coefficients of the eGARCH-X model are depicted in table 2.4. In both series, β is close to 1, which indicates that volatility is persistent and highly dependent on its own lags. This is in line with previous studies on the volatility of agricultural commodities (Brümmer et al., 2016b). The magnitude effect α is positive and statistically significant, suggesting that the absolute size of new shocks positively affects volatility. Regarding the sign effect γ, we find asymmetry to be statistically significant for the Argentinian price series where negative shocks have a greater effect on volatility than positive shocks. This stands in contrast to the findings of Stigler (2011) for storable agricultural commodities or Zheng et al. (2008) for food items, where positive price shocks tend to destabilize markets more than negative ones. A possible explanation could be the effect of the price insulation policy in the EU in a falling market, which cuts off the downward price risk in the EU at a certain point and in turn amplifies the price response to the shock in the Argentinian market.

The main interest lies in the effect of the import levy λ, which is significantly negative for the EU and significantly positive for Argentina: import levies reduce the corn price volatility in the EU domestic market and simultaneously contribute to increases in the corn price volatility of Argentinian exports. This confirms the hypothesis that price insulation cannot prevent price volatility but rather shifts

Table 2.4: eGARCH-X results and DCC parameters

	European Union	Argentina
ω	-0.2643^{***}	-0.0904^{***}
	(0.0157)	(0.0125)
α	0.1816^{***}	0.4148^{***}
	(0.0023)	(0.0582)
β	0.9645^{***}	0.9896^{***}
	(0.0007)	(0.0009)
γ	0.0090	-0.0762^{**}
	(0.0131)	(0.0316)
λ	-0.0281^{***}	0.0264^{***}
	(0.0108)	(0.0086)
Shape	3.2786^{***}	2.0382^{***}
	(0.2305)	(0.0019)
Skew	1.0201^{***}	1.0173^{***}
	(0.0180)	(0.0064)
a [*DCC*]	0.0061	
	(0.0076)	
b [*DCC*]	0.9886^{***}	
	(0.0104)	

***, **, * denote significance at the 1%, 5% and 10% levels, respectively. Standard errors in parentheses.

it from one country to another. In other words, granting support to European corn producers by providing a price floor and cutting off the price risk at the lower end comes at the cost of exposing Argentinian corn exporters to higher levels of price volatility. A rise of the ad valorem equivalent of the import levy by one standard deviation is expected to reduce the daily volatility in the EU corn price by 0.75% while the daily price volatility in the Argentinian corn price is expected to increase by 0.72%[7]. Interestingly, the magnitude of the effects is nearly identical and differences in the absolute values cannot be rejected by a Wald test.

Figure 2.3 shows the estimated annualized volatility and the time-varying conditional correlation of the DCC-eGARCH estimation, as well as the constant conditional correlation.[8] In general, volatility in Argentina is substantially higher than in the EU. During the period of most intensive use of variable import levies between 2002 and 2008, price volatility in the EU appears to be lower compared with the period after 2008. During the same period, we can observe that the conditional correlation is substantially lower, suggesting that the levy impedes spillovers of volatility. This pattern can also be observed in the second period of levies between late 2008 and mid-2010, where the conditional correlation retracts.

[7]It is worth mentioning that these reflect the average effects of the levy. In light of the extended periods when the levy equals zero (cf. figure 2.2), the small magnitude of the effect is not remarkable.

[8]The constant conditional correlation is represented by the average of the time-varying conditional correlation.

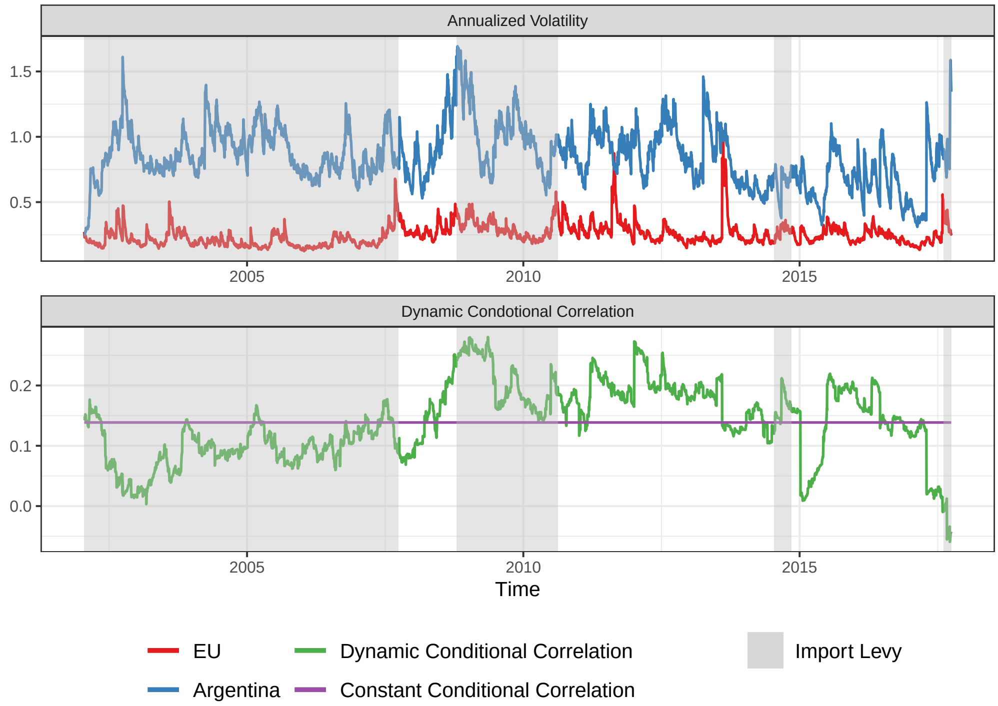

Figure 2.3: Annualized volatility and dynamic conditional correlation

Figure 2.4 depicts the news impact curve that relates past shocks (news) in the mean equation to its conditional variance (Engle and Ng, 1993). The panels display the impact of a positive and a negative lagged standardized shock on the current volatility for the EU (left panel) and Argentina (right panel). The figure illustrates two important results: first, the volatility of Argentinian prices reacts asymmetrically to a past shock whereas the volatility of EU prices reacts almost symmetrically; and second, if an average level for the levy is assumed, the impact of the standardized shock on the volatility in the EU is diminished, while the impact of the shock on price volatility in Argentina is exacerbated. In figure 2.4, the dashed red line shows the news impact for the average levy in those periods where the levy was different from zero.

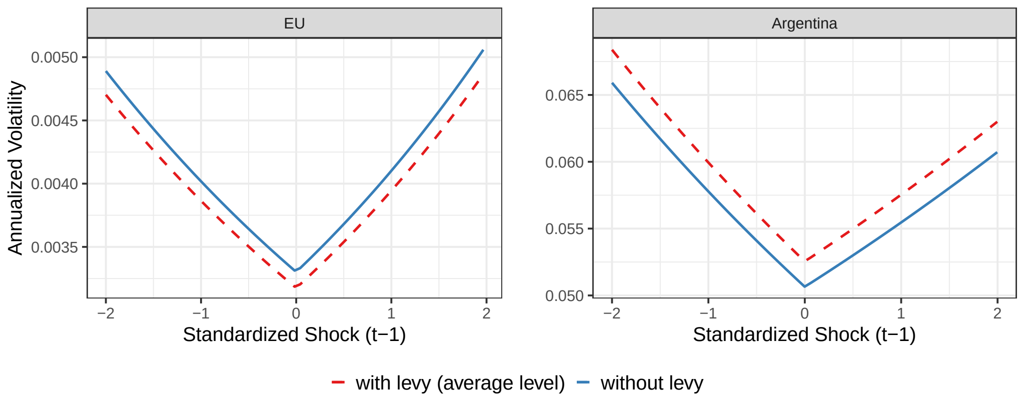

Figure 2.4: News impact curves for EU and Argentinian volatility

2.7 Policy Implications

Price volatility of agricultural and food commodities challenges all market stakeholders. It threatens the achievement of the SDGs – most notably SGD 1 and SDG 2 (Hajkowicz et al., 2012) – and it remains a predominant topic on national and international policy agendas, as well as a focus of research (Brümmer et al., 2016c). The G20 agricultural ministers have highlighted the importance of international trade and well-functioning markets to reduce food price volatility and food insecurity. Trade distorting policies are recognized as obstructions to international trade and food price stability, and hence as a target of necessary reductions (G20, 2011). This implies the eradication of domestic price insulation mechanisms, including the variable import levy of the EU. For this purpose, the WTO already provides a framework on limiting price insulation policies through the AoA. According to Article 4.2 of the agreement, the continued use of variable import levies is prohibited. The preservation of the variable import levy for cereals is an exception, which the EU representatives negotiated with the US government to settle their differences during the Uruguay Round. The Group of Rio – an association of Latin American countries including Argentina – has subsequently called out the Blair House Agreement to weaken the Draft Final Act of the AoA (Group of Rio, 1993). Nevertheless, since the acceptance of the Blair House Agreement was substantial for the success of the Uruguay Round, it was eventually approved by all WTO members. However, the results of this paper show that introducing exceptions to the prohibition of variable (import) tariffs comes at the cost of increased price volatility, which stands in contrast to the efforts made towards increased market stability. Variable import levies affect export price volatility of a large exporter, and thereby are likely to further transmit into domestic markets of importing countries. In order to improve international food price stability, price-insulating policies with a "beggar-thy-neighbor" nature should be abolished.

Regarding the justification of the tariffs in the EU, the objectives of the CAP are formulated in Article 39 of the Treaty on the Functioning of the EU. Among other objectives, the CAP shall stabilize markets. Market stabilization can be viewed as a justification for domestic price insulation as long as domestic policy-makers are willing to ignore the international consequences of their choices of policy instruments. However, this view neglects the fact that price movements coming from international markets – which reflect changes in supply and demand fundamentals – are important signals for domestic market participants to adjust supply and demand accordingly. Hence, prices should be allowed to transmit across markets when implementing policies that aim to stabilize domestic markets or income. This allows trade to act as an important buffer for domestic or regional supply and demand shocks that can be absorbed by international markets. The empirical findings of this study show that insulating domestic prices during periods of low prices reduces domestic price volatility but concurrently contributes to price volatility in another country. Market stability – interpreted as an integrated market that makes use of the buffering effect of international trade – is not ensured.

The implications of the findings are not only relevant for politicians in the EU. Indeed, policy-makers around the globe should consider the destabilizing effects of any sort of trade-reducing policies, especially in times when import tariffs and trade wars regain popularity. Concerns of increased price volatility, and price and income risks for producers could be addressed using other supporting tools to manage price-related risk and cope with volatility, or directly grant non-distortive income support (Brümmer et al., 2016b; Tothova, 2011). Such measures are capable of granting producer support without restricting trade and fixing price levels. Anderson and Nelgen (2012b) illustrates that most of the policies aiming to stabilize the income of producers from negative price shocks in fact occurred at the border in terms of price support instead of direct income support. While the former is only beneficial for a comparable small group of stakeholders (i.e., farmers), it comes at the costs of exposing a relatively large group (i.e., domestic consumers) to a higher price level. Foreign market participants are exposed to a higher level of price volatility. By contrast, safety nets – which have been observed during high price periods such as the 2007/08 food price crisis (Götz et al., 2013) – have a large group of beneficiaries (i.e., domestic consumers), which can at least be justified in countries with a large share of poor consumers (Tangermann, 2011b).

Even if the import levy equals zero – which has been the case for more than five years – the mere existence of the mechanism can already have a trade-reducing effect: the closer the reference price moves towards the threshold price, the more likely the activation of the levy automatism becomes. Consequently, the margin for trading corn to the EU could substantially shrink, without the levy eventually being active. The increased likelihood of a loss leads to a reduced expected profit and hence a reduction in trade. Ultimately, markets become more vulnerable to supply or demand shocks contributing to an increase in price volatility.

2.8 Conclusion

Price volatility is an inherent feature of agricultural markets and it remains a relevant issue of political discussions. Previous studies have identified several factors that contribute to price volatility, including trade restrictive policies. Despite the achievements from past reforms of the CAP and trade liberalization from the AoA, the EU still operates a variable import levy to maintain a minimum import price for grains. Domestic price insulation such as the variable EU import levy is expected to amplify price shocks on international markets and shift volatility from one country to another. With the EU being a large importer of corn, the policy is likely to destabilize international markets. In this paper, we have analyzed the effect of the variable import levy on corn price volatility in the EU as well as for Argentinian exports. We provide empirical evidence that the variable import levy of the EU exports volatility, which is often mentioned in the literature but – to our knowledge – has not been addressed empirically.

We find an effect of the variable import levy on corn price volatility in both countries. The levy reduces volatility in the European corn prices, while concurrently it contributes to corn price volatility in Argentinian export prices to the same extent. Thereby, it is also likely to affect prices of other importers, although the extent remains to be assessed in future research. Additionally, we find an asymmetry in the Argentinian price volatility suggesting that on average negative shocks have a stronger effect on volatility than positive shocks. This stands in contrast to previous findings on agricultural commodity markets but is in line with our expectations regarding the price insulation policy of the EU: negative shocks are amplified by the price insulation policy, while positive shocks can be fully transmitted across the markets. These findings highlight the importance of enforcing the prohibition of variable import levies and eliminating all kinds of price insulation mechanisms, as already requested by the WTO and affirmed by the G20 agricultural ministers. In order to reduce excessive food price volatility, all exceptions should be eliminated.

3 Price Formation in the European Sugar Market

Abstract:

The sugar market in the EU has been highly regulated for decades. In addition to high levels of external protection and a complex system of preferential trade regimes, there was also a production quota until 2017 and direct payments continue to be partially coupled. This is likely to have a considerable effect on price formation processes in the EU. This paper examines price transmission in the European sugar market using an asymmetric cointegration model. The officially quoted EU price for white sugar is used, which is reported to the EU Commission by European sugar producers. This price series is of particular interest as it is also the only publicly available source of white sugar prices in the EU and lays the basis for political decisions. The results indicate that the price signals from the world market asymmetrically affect the EU price reported by the factories in the long run and that the markets are only weakly integrated, whereas the price is influenced in the short run by the price of imports from ACP countries as well as delayed changes in the spot market price. The study shows that the sugar regime has effectively insulated the EU price from movements on the world market and kept sugar prices in the EU at higher levels compared to the world market.

This paper is joint work of Jurij Berger (JB), who is the lead author, Bernhard Brümmer (BB), Dela-Dem Doe Fiankor (DF), and Thomas Kopp (TK). The contribution of the authors are as follows: JB and BB conceptualized the research idea. JB developed the theoretical framework, with contributions from BB. TK and DF summarized the EU sugar policies with contributions from JB and BB. JB developed the empirical strategy, and implemented the econometric modeling and data management. JB interpreted the results and wrote the paper. All authors revised the paper.

3.1 Introduction

The European Union looks back at a long tradition of intervention on agricultural markets, involving substantial trade policy components. At the time of their first implementation, after the experiences of severe food shortages during World War II, the desire to become self-reliant on food motivated the EU's Common Agricultural Policy (CAP). For sugar, this was most importantly realized via a complex system of financial support of the European farmers and protection from outside competition, bundled in the Sugar Market Organisation (SMO). The SMO defined the political target in the form of a reference price which was to be achieved by a prohibitively high import tariff, as well as a production quota for European sugar farmers.

International sugar markets are currently experiencing substantial structural changes. Since a historical low in 2018, mainly caused by important supply side changes in major exporting countries that are mostly driven by substantial policy adjustments, prices fluctuated at relatively low levels throughout 2019 and 2020. Since the beginning of 2021, international prices have followed a stronger upward trend, and have reached 4-year highs in February 2021.

Developments on the demand side in the past years have been much less dramatic. Global sugar consumption continues to grow, with most increases in per capita demand in Asia. Health related aspects, which tend to dampen demand growth, are mainly operational in industrialised countries, although awareness for negative side effects of excessive sugar consumption is increasing in emerging economies, too. The demand for sugar has not been drastically affected by the Covid-19 pandemic, although changes in consumption patterns toward higher at home consumption have led to some adjustments in the structure of sugar deliveries.

In the EU, the sugar marketing year (MY) 2017/18 was the first without any production quota and without most of the price support of the past - although in a number of member states, partial coupling of direct payments to sugar beet production is still common. At the same time, the restrictions on sugar exports from the Uruguay round negotiations were no longer relevant, and the EU turned temporarily to a net exporter in MY 2017/18 (rank number four in net export terms after Brazil, Thailand, and Australia). As EU sugar production decreased substantially in the MY 2018/19, it fell back to rank six in international export quantity, becoming a net importer, again. While in a net-export situation, price signals from the world market are supposed to be at least partially transmitted to the EU in the absence of policy instruments like export restitutions, returning to a net-import situation means that price formation will most likely be affected by the still existing import-related policies, i.e., import quotas, preferences, and the prohibitively high import tariff for most countries. In addition, the structure of the sugar market in the EU, which is characterized by a pronounced concentration on the supply side, probably affects domestic price formation. Although there is a large number of studies on horizontal price transmission for agricultural products, to the best of our knowledge, very few studies exist on price transmission in the European sugar market. However, Aragrande et al. (2017) find asymmetric vertical price transmissions and link this with the concentration in the EU sugar market. The authors also point out the lack of price transmission studies for the EU sugar.

The present study analyzes price transmissions on the European sugar market, a market that is rather intransparent and tended not to be in line with requirements from the Agreement on Agriculture (AoA). In particular, it analyzes how the price formation for sugar in the EU is influenced by various factors. The EU price series examined is officially reported by the EU Commission and represents an average of the prices, that were reported by European sugar factories. This is also the only publicly accessible source of price data on the European sugar market. Since these prices are used as the basis for political consultations and decisions regarding sugar market policies (Tangermann, 2012), it is particularly important to understand the underlying mechanisms of price formation. The paper is structured as follows. An overview of trends and developments in the global and European sugar markets will be given first, followed by the description of the price data. In section 3.4 the empirical approach is derived, more specifically the analysis of market integration between global and EU sugar markets which is based on an asymmetric price transmission analysis followed by the results. In the subsequent section, the conclusion that arise from these results are discussed in more detail.

3.2 European Sugar Policies

The level of the EU reference price in the EU was substantially above world market price level in last decades. To achieve this high domestic price level, the EU used, among other measures, an extremely high import tariff and a production quota for sugar in the EU. While the reference price has been successively reduced in recent years, the quota was completely abolished in 2017. Since the implementation of the Agreement on Agriculture (AoA) more than two decades ago, there has been no change in the EU schedule of bound tariffs for sugar. However, the EU made use of discretionary adjustments to applied tariffs during episodes of extremely high sugar prices in 2012 and 2013.

In parallel to the SMO and the high MFN import tariff, a system of preferential trade agreements co-evolved. First, preferential market access was granted under the Economic Partnership Agreements to former colonies of European countries, the so-called African, Caribbean, Pacific (ACP) countries. From 2009, within the framework of the Everything But Arms Agreement, the 50 Least Developed Countries were granted unlimited, duty free access; their export quantities were thus merely bound by their production capacities. A detailed summary over the development programs that are summarised within the Generalised System of Preferences (GSP) is provided in Kopp et al. (2016). In addition to the development-motivated import channels, a number of tariff rate quotas are in place, e.g., the Balkan quota (mainly for Serbia), the CXL quota (mainly for Brazil, Cuba, and other countries), and some sugar preferences granted under bilateral Free Trade Agreements (FTAs). Due to the preference erosion caused by the past reforms, these tariff rate quotas are currently not fully used. The sugar sector is one where the EU has imported under various preferential schemes. The current geographical representation of the various preference beneficiaries are shown in Figure 3.1 and table 3.1 specifies the tariff and capacity levels granted under each of the preference regimes.

The intervention on the European sugar market was at the expense of domestic consumers and manufacturers of sugar containing products in the EU, who paid a higher price for sugar compared to a situation without market interventions. Additionally, sugar producing countries outside the EU faced world market prices that were pushed down by the subsidized EU exports. Due to increasing external and internal pressures, the EU committed to reducing the level of intervention as part of the Uruguay Round. This included a stepwise reduction in export subsidies on agricultural products in terms of volumes and budget. In 2004, however, the WTO's dispute settlement body ruled against the EU: Australia, Brazil, and Thailand had accused the EU of exporting more subsidized sugar than they had committed themselves to in the Uruguay Round. This verdict led to an adjustment of the SMO, including a reduction of the EU's reference price, a limit on the quantities that were exported with subsidies, and a restructuring of EU sugar production and processing.

In 2017, the production quota for sugar and the export subsidies were eventually abandoned completely. For the future it is assumed that the international price will continue to remain at low levels, while the EU production will decrease further, solidifying the EU's position as a net importer (Haß, 2020). After all, the sugar market can still be affected by an intervention price, the complex system of

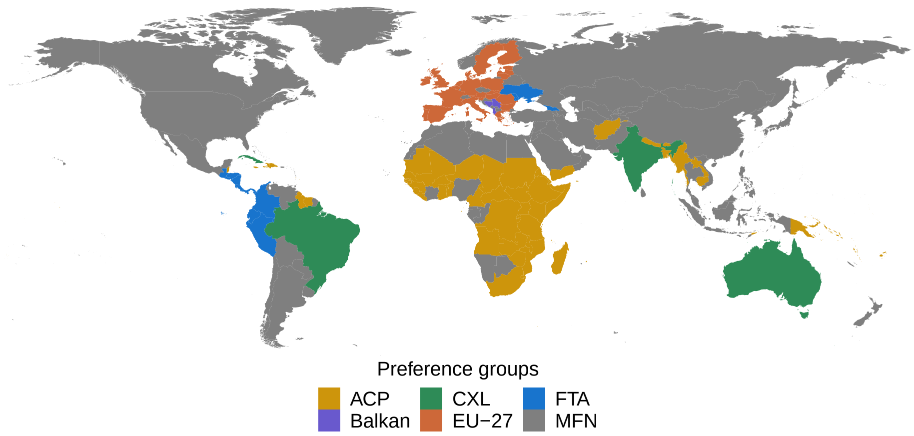

Figure 3.1: EU sugar preferences in 2019
Source: Own production based on data from Comext (2020).

Table 3.1: EU sugar reference groups and allocated quantities (MY 2019/20)

Preference group	Tariff level	Capacity (1000 tonnes)
ACP (EBA/EPA)	Zero tariff, zero quota	Unlimited
FTA	TRQs, zero tariffs	531
CXL	TRQ, Euros 98/tonne	791[a]
Balkans	TRQ, zero tariffs	202

Source: Own production, based on data from European Commission (2020a).
[a] Including 78,000 tonnes that can be imported at Euros 11/tonne from Brazil.

preferential trade agreements and the very high MFN import tariff. In situations in which the EU is a net exporter, the latter only plays a minor role. However, in the likely event that the EU remains a net importer, the very high MFN import tariff plays a critical role in the price formation which can prevent or at least hamper price transmission with the world market.

3.3 Data

The price analysis in this study uses different monthly averages for sugar from March 2010 until the end of MY[9] 2018/19. All prices are quoted in Euro per tonne. The dependent variable is the EU price which is given by an average ex-work[10] price for white sugar over different regions within the EU which is reported by the European Commission (2020a). Additionally, we use the spot market price (delivered) for EU white sugar as one explanatory variable which is quoted by Platts Kingsman and is not publicly available. However, since the majority of the sugar in the EU is sold under supply contracts the ex-work price represents a large part of the sugar sold in the EU. The spot price, in contrast, reflects the price for the remaining quantities, which are traded free of supply contracts. Other explanatory variables are i) the world market price for white sugar, represented by the monthly average of the London No.5 (continuous, nearest future) which was retrieved from Datastream (2020) and ii) the monthly average price (CIF) of preferential raw sugar[11] imports from ACP countries to the EU as reported by the European Commission (2020a). Table 3.2 reports the summary statistics of these prices.

Table 3.2: Summary statistics for sugar prices

Variable	Mean	Std. Dev.	Min.	Max.
EU (ex-work)	505.070	128.619	312.000	738.000
EU (spot market)	580.784	155.988	326.125	895.000
London No. 5	388.993	83.059	272.806	586.519
ACP	454.322	84.346	286.000	677.000

The total number of observations is 114.

Figure 3.2 depicts the prices series in question over the observed period. Most of the time the EU prices are substantially above the world market price and the plot already indicates that the difference (margin) between the EU and the world market is fluctuating over time. As reported in Table 3.2 the prices are distributed with means of different levels, which illustrates the findings of Figure 3.2. The ACP and the world market prices have similar standard deviations while the standard deviation of both EU prices is considerably higher. In the econometric analysis all prices are expressed in logarithms.

[9] October - September.

[10] The term "ex-work" refers to a price officially reported by the sugar producers and does not include the costs for transportation.

[11] The monthly imported quantities of white sugar from ACP countries are rather small compared to raw sugar (24 thsd. tonnes against 108 thsd. tonnes monthly average) and have mostly been imported from Mauritius. Hence the average import price for white sugar from ACP countries is not representative for ACP imports.

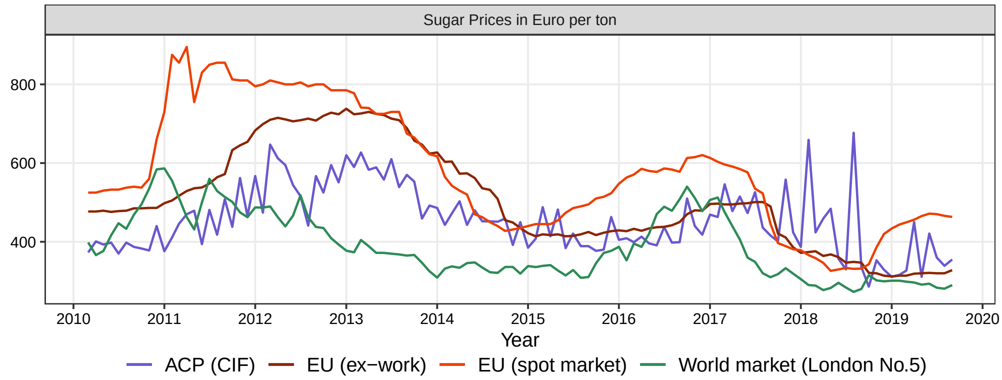

Figure 3.2: EU and world market prices for white sugar and ACP raw sugar price

3.4 Methodology

Price transmission analysis is based on the spatial arbitrage condition which is also known as the *Law of One Price* in its weak form. Spatial arbitrage means that in a situation of price differences for a specific good between two geographic areas (e.g. domestic and international), traders will move these goods between the two locations if the price difference (margin) is larger than the expected trade costs. This increases the demand at the location with the lower price level, which in turn increases the price. When selling, it increases supply at the location with the previously higher price, driving prices at this location down. As a result, the prices in the two regions converge. Hence, the Law of One Price suggests that at any point in time the price of a commodity in one location should equal the market price in another location. Differences between those prices may be credited towards the costs of trading the good between the two locations (including transportation costs, transactions costs, tariffs and others). However, the LOP has to be interpreted as a long-run relationship while short-run deviations from the equilibrium due to exogenous shocks are likely and can have different sources. This will again incentivize arbitrageurs to take action which moves prices back towards the long-run equilibrium (Fackler and Goodwin, 2001). As long as the commodity is homogeneous (i.e., quality differences are neglectable which can be assumed for the majority of white sugar), a long-run relationship between the prices is expected to exist. Variations in prices due to changes in supply and demand in one of the regions will affect prices in both regions. Hence, we expect these markets to be fully integrated which means that price signals are completely transmitted across markets. However, different factors such as trade policies can hamper the proper transmission of price signals between the markets. The magnitude, the speed and the direction of price transmission can be empirically examined by the use of cointegration techniques. The cointegrating relationship is interpreted as the long-run equilibrium between the prices (Rapsomanikis, 2011; Rezitis, 2019; Kopp et al., 2017).

Figure 3.3 depicts the monthly spot price for white sugar in the EU and the monthly world market price which are already shown in figure 3.2. The margin depicts the monthly price differential between the EU and the world market price

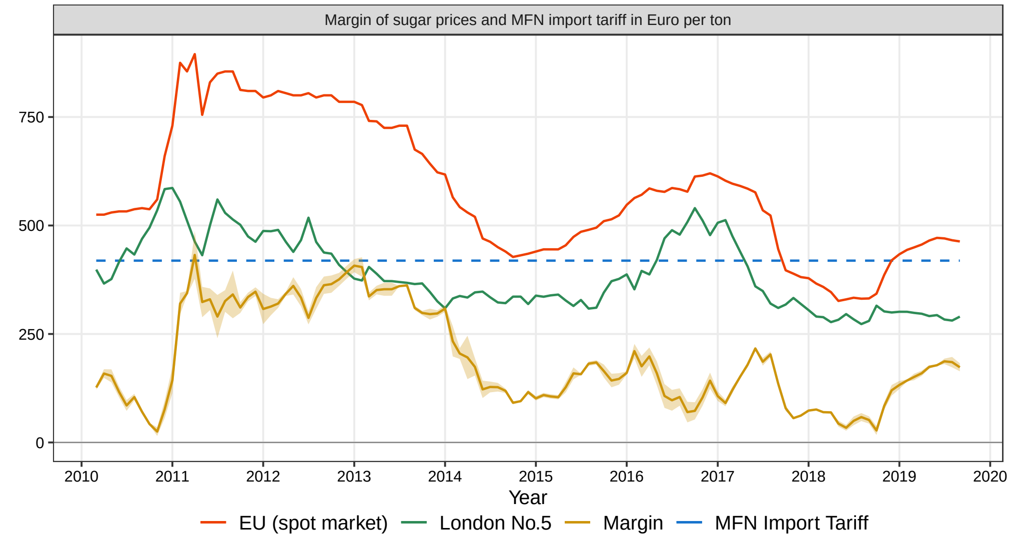

Figure 3.3: Price differential for non-preferential sugar imports
Source: Own production based on data described in section 3.3.

per tonne over time.[12] Importing sugar from non-preferential origins, under the full MFN import tariff of 419 Euro per tonne, is only profitable if the margin exceeds at least this tariff. Hence, it confirms that even in times of shortages, there was nearly no incentive given to import sugar from the non-preferential origins – at least from this static perspective with monthly averages. This highlights that the very high MFN import tariff prevented spatial arbitrage and presumably hampered price transmission between the world market and the EU as a consequence. Additionally, several factors might have led to an asymmetry in the transmission of price signals. Among these factors are the prevalence of supply contracts in the sugar market and concerns of market power in the sugar-producing sector (e.g. Aragrande et al., 2017; Areté, 2012).

The heterogeneity of sugar prices in the European countries and especially the highly fluctuating margin in Figure 3.3 indicates, that a linear price transmission approach with a constant margin is not suitable. Furthermore, with regard to the concentration in the sugar-producing sector, Meyer and Von Cramon-Taubadel (2004) conclude that market power can lead to asymmetry in price transmission. Since a linear price transmission model is expected to be unsuitable for the following analysis of price transmission, we estimated a non-linear autoregressive distributed lag (NARDL) model for the estimation. The NARDL model is a generalization of the autoregressive distributed lag approach (ARDL) proposed by Pesaran et al. (2001). In contrast to the commonly applied asymmetric error correction models, the NARDL model can be used to simultaneously detect asymmetry in the long-run as well as in the short-run of price transmission. Assuming we have two time series such as y_t and x_t ($t = 1, 2, ..., T$), following Shin et al. (2014), non-linearity in the ARDL framework is introduced by decomposing the

[12]Since the spot price is an average of two regions (Mediterranean and Western Europe), it is additionally given as a range representing the maximum and minimum margin in the corresponding month.

independent time series x_t into its positive (x_t^+) and negative (x_t^-) partial sums:

$$x_t = x_0 + x_t^+ + x_t^- \tag{3.1}$$

where x_t^+ and x_t^- are calculated as $\sum_{i=1}^{t} \Delta x_i^+$ and $\sum_{i=1}^{t} \Delta x_i^-$. This leads to the following representation of the asymmetric long-run (cointegrating) relationship between x and y:

$$y_t = \beta^+ x_t^+ + \beta^- x_t^- + u_t \tag{3.2}$$

The coefficients β^+ and β^- represent the asymmetric long-run coefficients corresponding to positive and negative changes in the independent variables, respectively (Shin et al., 2014). By associating a linear ARDL(p, q) model (Pesaran et al., 2001) with the asymmetric long-run relationship from equation 3.2, the following NARDL(p, q) model in error correction form can be obtained:[13]

$$\Delta y_t = \alpha_0 + \rho y_{t-1} + \theta^+ x_{t-1}^+ + \theta^- x_{t-1}^- + \sum_{i=1}^{p-1} \alpha_i \Delta y_{t-i} + \sum_{i=0}^{q-1} (\pi_i^+ \Delta x_{t-i}^+ \pi_i^- \Delta x_{t-i}^-) + \varepsilon_t \tag{3.3}$$

where Δ indicates first differences and p and q denote the lag order of the dependent variable and the independent variables in the distributed lag part, respectively (Shin et al., 2014; Rezitis, 2019). The parameters π reflect short-run effects. The corresponding long-run coefficients from equation 3.2 can be obtained by $\beta^+ = -\frac{\theta^+}{\rho}$ and $\beta^- = -\frac{\theta^-}{\rho}$. The coefficient ρ can be interpreted as the speed to which the dependent variable y_t corrects deviations from the long-run equilibrium.[14]

3.5 Results

First, we conduct different tests to determine the order of integration of the series. As pointed out by Philips (2018), the (N)ARDL model requires variables to be I(1) one or lower. Specifically, the dependent variable has to be I(1) whereas the independent variables can be either I(1) or I(0). We tested the variable for the order of integration using the Augmented Dickey Fuller (ADF) test (Dickey and Fuller, 1979) in which a unit root is present under the null hypothesis whereas Kwiatkowski et al. (1992b) suggest a test routine (KPSS) which considers stationarity under the null hypothesis. Additionally, we apply a test proposed by

[13] Since the NARDL model is a single equation model, there is a potential risk of endogeneity, i.e., simultaneous causality, which would lead to biased estimates of the coefficients. The Johansen method was therefore used to test the maximum number of cointegrating vectors, which leads to the assumption that there is only a single long-run relationship among the prices. Although the Johansen method has better small sample properties than other methods (Cramon-Taubadel, 1998), the results should be treated with caution due to the small sample size and the asymmetric nature of the relationship. For the case of more than one long-run relationship, alternative multi-equation models would be required, since in this case only the parameters of the long-run relationship can be estimated consistently and unbiased in a single equation (Banerjee et al., 1993).

[14] See Shin et al. (2014), Greenwood-Nimmo et al. (2013), Philips (2018), Rezitis (2019) for more details on (N)ARDL estimation procedure and asymmetric price transmission.

Zivot and Andrews (2002) (ZA) which is robust in the presence of potential structural breaks. Table 3.3 depicts the test statistics of the variables in consideration. Given these test statistics, we conclude that all variables are I(1) or lower. The ZA test indicates that the order of integration is robust to structural breaks.

Table 3.3: Results of ADF, KPSS and ZA unit-toot tests

Variable (in logs)	ADF	KPSS	ZA
EU (ex-work)			
Level	-0.683	1.470^{***}	-2.844
1st Diff	-2.925^{***}	0.369^{*}	-8.422^{***}
EU (spot market)			
Level	-1.040	1.338^{***}	-2.720
1st Diff	-4.471^{***}	0.147	-8.225^{***}
London			
Level	-1.079	1.072^{***}	-3.693
1st Diff	-8.021^{***}	0.090	-9.227^{***}
ACP			
Level	-0.343	0.637^{**}	-8.279^{***}
1st Diff	-9.664^{***}	0.089	-19.872^{***}

***, **, * denote significance at 1%, 5% and 10% respectively.

The NARDL model in its generals form as given in equation 3.3 has been augmented with the additional explanatory variables as given in table 2.1: LON_t, ACP_t and EU_t^{spot}. These represent the world market price, the ACP import price and the EU spot market price, respectively. In addition, a control variable D_t^{quota} was added to absorb the effect of the ending quota in MY 2017/18, taking the value 0 until September 2017 and 1 after the quota ended in October 2017. The dummy enters the equation i) in first differences, capturing immediate short-run effects as an impulse dummy and ii) in levels, capturing effects on price levels in the long-run. The model was estimated in several steps to obtain a parsimonious model. In the first step, the model was estimated with asymmetry in all variables - both in the long and short run relationship. Subsequently, a standard Wald test was applied to check for symmetry in the corresponding parameters (cf. Rezitis, 2019). Hence, for the NARDL(1, 1) the model can be rewritten as[15]

$$\begin{aligned}\Delta\text{EU}_t = \alpha_0 + \rho\text{EU}_{t-1} + \theta_0^+\text{LON}_{t-1}^+ + \theta_0^-\text{LON}_{t-1}^- + \theta_1\text{ACP}_{t-1} + \\ \theta_2\text{EU}_{t-1}^{spot} + \theta_3 D_{t-1}^{\text{quota}} + \varphi_0^+\Delta\text{LON}_t^+ + \varphi_0^-\Delta\text{LON}_t^- + \\ \varphi_1\Delta\text{ACP}_t + \varphi_2\Delta\text{EU}_t^{spot} + \tau_0\Delta D_t^{\text{quota}} + \tau_1 D_t^{\text{trend}} + \varepsilon_t\end{aligned} \tag{3.4}$$

After estimating model 3.4, a series of residual-based tests were performed. Most importantly, tests for autocorrelation in the residuals resulting in the lag length being adjusted accordingly to remove any signs of autocorrelation (Philips, 2018),

[15] For technical reasons, variable ΔLON is also split into positive and negative changes, although differences in the estimated coefficients φ_0^+ and φ_0^- are not statistically significant. A robustness check was performed.

Table 3.4: NARDL estimation with asymmetry imposed in long-run for London

Var.	Coeff.	S.E.
EU_{t-1}	-0.178^{***}	0.029
London^{+}_{t-1}	0.069^{***}	0.025
London^{-}_{t-1}	-0.056	0.037
ACP_{t-1}	0.064^{***}	0.022
$\text{EU}^{(spot)}_{t-1}$	0.150^{***}	0.019
Quota_{t-1}	-0.022^{*}	0.011
ΔEU_{t-7}	-0.201^{***}	0.074
ΔEU_{t-11}	-0.223^{***}	0.074
ΔLondon^{+}	0.010	0.062
ΔLondon^{-}	0.026	0.072
$\Delta\text{EU}^{(spot)}$	0.051	0.050
$\Delta\text{EU}^{(spot)}_{t-5}$	-0.161^{***}	0.045
ΔACP	0.050^{***}	0.014
ΔQuota	-0.112^{***}	0.019
Trend	-0.003^{**}	0.001
Constant	-0.255	0.156
χ^2_{SC}	14.318[0.281]	
R^2	0.727	
$\overline{R}^2$	0.679	
F_{PSS}	21.654^{***}	
t_{BDM}	-6.178^{***}	

***, **, * denote significance at 1%, 5% and 10% respectively. Based on Pesaran et al. (2001), the critical values (bounds) for the F_{PSS} (t_{BDM}) for $k = 2$ and for ***, ** and * are 7.52 (-4.53), 5.85 (-3.95) and 5.06 (-3.63), respectively. χ^2_{SC} denotes Breusch-Godfrey tests for serial correlation up to 12 lags. Figures in square parentheses are the associated p-values.

and a Breusch-Pagan test which can not rejected constant variance of the residuals. Furthermore, a CUSUM test on recursive residuals did not reveal any evidence of parameter instability (see Appendix, figure B.1). The results of the NARDL estimation are presented in table 3.4. The Breusch-Godfrey test for serial correlation confirms that residuals are free of autocorrelation for up to 12 lags (months). Based on the results from Table 3.4, a bounds test was conducted to test for the presence of an asymmetric (cointegrating) long-run relationship among the price series. Firstly, Shin et al. (2014) suggest the procedure proposed by Banerjee et al. (1998) using the t-statistic for the null hypothesis of $\rho = 0$ (t_{BDM}). Secondly, the authors follow Pesaran et al. (2001) and propose an F-test for the joint null hypothesis of $\rho = \theta_0^+ = \theta_0^- = \theta_1 = \theta_2 = 0$ (F_{PSS}). Both the t_{BDM} and F_{PSS} statistics reject the null hypothesis. Hence, we conclude that the prices are cointegrated.

The results displayed in Table 3.4 indicate that the officially reported EU price, which is based on prices reported by EU sugar factories, is significantly affected by

Table 3.5: Asymmetric long-run price transmission elasticities

Var.	Coeff.	S.E.
London^{+}	0.387^{***}	(0.144)
London^{-}	-0.316^{*}	(0.182)
ACP	0.362^{***}	(0.101)
EU (spot market)	0.842^{***}	(0.137)
Quota	-0.124^{**}	(0.053)

***, **, * denote significance at 1%, 5% and 10% respectively. The long-run coefficients are obtained by $\hat{\beta} = -\frac{\hat{\theta}}{\hat{\rho}}$. Standard errors were computed via delta method.

the ACP, the EU spot market price and the world market price. Table 3.5 reports the long-run price transmission elasticities for ACP, world market and the EU spot market as well as the effect of the ending quota in the long-run equilibrium. The latter indicates, that with the end of the quota the gap between the EU ex-work price and the other price series has decreased.

Regarding the world market price, the Wald test confirms that the ex-work price is asymmetrically affected by the world market price in the long-run. The coefficients shown in table 3.5 indicate, that an increase in the price for sugar on the world market (ceteris paribus) transmits to an increase in the EU sugar price reported by the factories in the long-run. Interestingly, a decline in the world market price for sugar, does not result in a decline of the EU price reported by the factories.[16] In the short-run, the EU price is not significantly affected by changes in the world market price.

Turning to the long-run price transmission elasticity of the ACP price, the EU price is symmetrically affected. Regarding short-run movements, the EU price is affected by changes in the ACP price but only weakly. Looking at the spot market price in the EU, the estimates suggest that the long-run price transmission elasticity is rather high and close to one. In the short-run, however, 5-month lagged changes in the spot market price slow down the adjustment of the EU ex-work price.

The speed of adjustment parameter indicates that the EU price corrects 17.8% of the deviations from the long-run equilibrium within a month. This means that it takes nearly four months to correct 50% of a shock to the long-run equilibrium. This is rather slow but is in line with our initial suspicion of little market integration, as several factors were identified that may have impeded the proper transmission of price signals between the markets.

Figure 3.4 illustrate the simulation of the dynamic adjustment in the estimated NARDL model. It depicts the standardized, cumulative effect of a shock in the independent variables on the EU (ex-work) price. The green line indicates the response to a positive change, whereas the red line indicates the response to a negative change, respectively. As the figures show, the reaction of the EU price

[16] In fact, the results indicate that a decline in the world market price leads to an increases of the EU price. However, the associated standard error is relatively large.

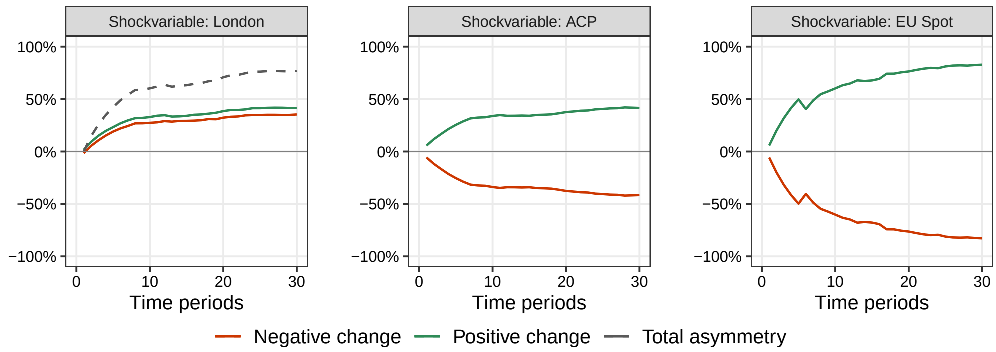

Figure 3.4: Cummulative (standardized) effect of shock in independent variables on EU price

is asymmetric for a shock in the world market price but symmetric for a shock in the ACP and the spot market price. Over time, a shock in the ACP price leads to a change in the EU ex-work price but at a smaller magnitude compared to a shock in the EU spot market price. When a new equilibrium is reached, the shock in the ACP price is transmitted by almost 50%, while a shock in the spot market price is transmitted by more than 80%. This is not surprising, since the long-run price transmission elasticities reported in table 3.5 differ substantially. Regarding a shock to the world market price, the figure illustrates the asymmetry in the response of the EU ex-work price and a transmission of the shock in the new equilibrium that is below 50% for a positive change.

3.6 Conclusion

The study has investigated price transmission among the EU ex-work price for white sugar which represents the officially reported price for white sugar in the EU on the on hand and the EU spot market, world market, and ACP price on the other hand. The analysis has been carried out using a NARDL model, which allows modeling and testing of asymmetry in the long-run and in the short-run relationship of the prices.

The asymmetry in the long-run relationship between EU and world market price leads to the conclusion that signals from the world market affect the EU market only in one direction. Together with the absence of statistically significant short-run interactions with the world market price, this is interpreted as an indication of the effective protection of the EU market from movements in the world market price by the European agricultural and market policies. Additionally, we interpret this as an indication of market power, exercised by the EU sugar industry to keep prices within the Europe at a higher level. Concerns of market power in the EU sugar market have already been pointed out in previous studies (e.g. Aragrande et al., 2017; Maitah et al., 2016; Areté, 2012; Tangermann, 2012) and the high concentration of EU sugar producers with limited competition was probably favored by the SMO (Aragrande et al., 2017; Maitah et al., 2016).

Since sugar imports from ACP countries are not subject to tariffs, the symmetric transmission of price signals is not surprising. At the same time, the magnitude of the effects is rather small. Sugar imports from ACP countries consist mostly of raw sugar, which first has to be refined and thus also finds its way to the EU (white) sugar market via European sugar factories - which in some cases even represent both, the importer and the exporter through shareholdings in foreign companies. Hence, if market power is exercised by the EU sugar producers, it is not surprising that price signals from the ACP countries are only passed on to a limited extent to the EU sugar users. Additionally, the amount of sugar that ACP countries export to the EU is also dependent on the price level on international markets and the price differential between EU and world market. Hence, if the world market price is comparatively low (high), imported quantities from ACP countries are increasing (decreasing). This could dampen the transmission of price signals.

In the short-run, movements in the EU ex-work price are mainly driven by contemporaneous[17] changes in the ACP price, lagged changes in spot market price and lagged changes in the EU ex-work price. It is notable, that all (statistically significant) coefficients have a negative sign. In combination with the parameters of the long-run relationship and the consideration of figure 3.2 - which indicates that the EU price tends to be too high compared to the world market - we interpret, that expiring supply contracts with higher prices, which are reflected in the ex-work price as well as past developments on the spot market seem to have a dampening effect on the development of EU ex-work price.

The literature on the causes of asymmetric price transmission is mostly referring to the case of (asymmetric) vertical price transmission rather than a spatial price transmission model (Meyer and Von Cramon-Taubadel, 2004). However, it is clear that the EU price appears to be decoupled to a large extent from world market movements, and that the long-run equilibrium is characterized by the presence of asymmetry. With respect to the effect of the SMO, two conclusions can be drawn from the literature and this study: European agricultural and trade policy (in particular the SMO) has i) significantly disrupted the integration of the domestic EU market with the world market and ii) stimulated a high degree of concentration in European sugar markets. Consistently, this has likely contributed substantially to price signals from the world market reaching European consumers and producers only to a limited extent and maintaining market price levels in the EU well above the world market. This has been at the expense of EU consumers, who pay a higher price for sugar and relevant products. It is likely that producers (ab)used their market power to reach a higher price level within the EU which further decoupled prices.

In conclusion the results indicate that movements of the world market price for sugar are not well reflected in the officially reported price for white sugar in the EU. We have identified several reasons for this. Besides the influence of the ACP price, which reflects the prices of duty-free raw sugar imports from ACP countries, the instruments of the European sugar market organization could also play a decisive role. In addition to the high tariff, which prevents imports from third countries even in periods of shortages, the quota had an effect on the EU ex-work price. Ultimately, additional research is required at this point, in which

[17]Due to the data structure, the term "contemporaneous" should not be emphasized to strongly here, as it refers to price movements within one month.

price behavior is analyzed using price transmission models in combination with models measuring market power in order to be able to filter out and interpret the effects of market power or market concentration to a greater extent. Another interesting aspect would be the distinction of price transmission processes with respect to the different trade regimes (net importer vs. net exporter) which could be determined by regime switching models.

4 Outlook: Policy Coherence for Development

From a more general perspective, this thesis has reviewed and analyzed effects of market interventions in the CAP. In addition to the direct effects of market interventions at the domestic level, and at the level of major exporters and the world market, indirect effects of domestic EU policies can also be expected. This can explicitly be highlighted as a shortcoming of the volatility analysis on the variable import levy in chapter 2, which does not account for effects on other importers of Argentinian corn (i.e., developing countries), but it also applies to a more general consideration of the CAP. We can summarize that the CAP has undergone an essential reform process, which has led to a liberalization of trade with agricultural products and market distortions of market interventions have been reduced to a large extent. Although free trade has proven to clearly enhance welfare for participating countries as a whole, trade liberalization does not exclusively lead to benefits for all market participants because gains can be unequally distributed within the countries (Lang and Mendes Tavares, 2018) – particularly in the short-run (Trefler, 2004). One could argue that this calls for compensation (Ahn and Duval, 2017; Asatryan et al., 2014), which is hardly found in developing countries (Boix, 2011).

To reveal trade-offs and identify developing and emerging countries that can be affected by EU policies, it is important to analyze the EU's agricultural trade with these countries. To this end, the concept of Policy Coherence for Development (PCD) is a normative framework that can serve as the legitimizing basis for a subsequent analysis. With the PCD, the EU committed to taking development objectives into account in all policies that have an impact on developing countries. It was first incorporated into EU law in the 1992 Treaty of Maastricht and most recently reaffirmed in the European Consensus on Development in 2017 (European Commission, 2021). Regarding the CAP, it requires the EU to review agricultural and trade related policies for their coherence with the objectives of development policy and, if necessary, to align them accordingly. Despite normative embedding of PCD, there is still a lack of institutional integration in the EU (Siitonen, 2016). Due to the strong interrelations between the EU and developing countries, and

This chapter has benefited from conceptual discussions with Yves Zinngrebe and Sebastian Lakner.

the lack of assessment indicators at the EU level, it is also difficult to measure any progress in the area of PCD that was made in the last years (Carbone and Keijzer, 2016). PCD of the EU can be examined with a view to the indirect effects in developing countries still arising from the CAP, related trade policies and the EU imports of agricultural commodities from developing countries. A first step to gain a better understanding of how the EU is linked to developing countries and how its policies can affect sustainable development could be to understand the linkages.

The EU's trade linkages with developing and transition countries with respect to agricultural products are complex. In terms of an assessment in the framework of the PCD concept, it is therefore difficult to directly derive the importance of the respective trade relationship i) for the EU and ii) for the exporting country based on mere trade volumes or values. However, due to the large number of developing and transition countries from which the EU imports agricultural products, it is necessary to assess the interrelations when evaluating PCD. For this purpose, we propose to use two indicators that allow us to determine the importance of imported agricultural products as well as the trading partners: relevance and leverage. Relevance can be used to assess the role of EU imports from individual countries and of specific products for the EU itself. We define relevance as the share of EU imports (in USD) from a specific developing country (or for a specific cropland-based product) in total EU imports of cropland products. Countries (products) consequently have high relevance if the imports from that country (product) represent a high share of total EU imports. In this sense, the respective country (product) is also of high relevance for possible strategies to strengthen PCD with the aim of improving the overall performance of the EU with regard to its development policy objectives. The leverage, in contrast, can assess the role of EU imports from a developing country perspective and can be interpreted as the share of production in developing and transition countries, that is exported to the EU - both at the product and country level. Hence, we define leverage as the share of EU imports (in USD) from the respective developing country or product in the cumulative value of production (in USD) across developing countries or products. We assume that the PCD strategies of the EU in countries (products) with a comparatively high leverage, in principle, have a greater potential to affect the development in these countries (products or value chains). In addition to the economic dimension, the relevance and leverage can also be calculated using environmentally related measures such as the factor content of trade (e.g. footprint measured by harvested area in ha) or induced deforestation (in ha).

For the economic dimension, we used data from FAOSTAT (2021) to derive an exemplary illustration of relevance and leverage - being aware that these data have certain limitations, in particular data gaps and inconsistencies especially for developing countries. Starting with the FAO trade matrix, which reports the annual quantities and monetary values of bilateral trade for each country pair, we first calculated EU imports and subtracted intra-EU trade.[18] To calculate the leverage for all developing and transition countries as classified by UNCTAD (2021), and

[18] We calculated the annual average of the years 2016 to 2019 since it represents the most recent data.

all cropland products[19] in the second step, we calculated the production value (in USD) at export prices that was derived from the same dataset. To this end, we first calculated the unit value of exports (quotient of export value and export volume) and multiplied this by the average production quantities reported by FAOSTAT (2021).

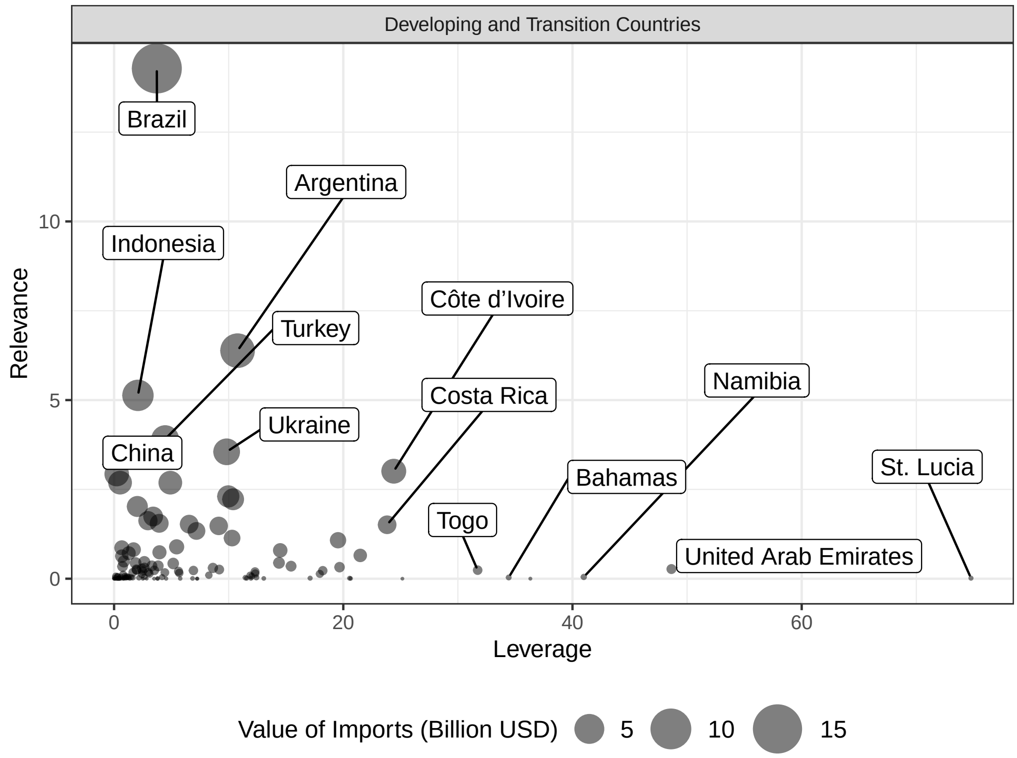

Figure 4.1: Relevance and leverage for developing and transition countries (in %)
Source: Own production.
Note: We have omitted outliers with a leverage greater than one (100%), since a leverage above one does not make sense (by construction). This applies to 5 countries (Antigua and Berbuda, Djibouti, Hong Kong, Maldives and Singapore) and is likely due to data issues. For reasons of clarity, most countries that are labeled are represented within the 95% quantile of the leverage and of the relevance. Development status of the countries is classified according to UNCTAD (2021).

The figures 4.1 and 4.2 illustrate that with the help of conceptualizing and measuring relevance and leverage, the structures of trade in agricultural products of the EU with developing countries can be examined in more detail. While the x-axis depicts the relevance and the y-axis depicts the leverage, the absolute value of imports (in USD) is illustrated by the size of the bubbles. On the country-level, Brazil (14.3%), Argentina (6.4%) and Indonesia (5.1%) have the highest value for relevance whereas their leverage is comparatively small. Brazil also represents the largest country in terms of the absolute value of imports. Countries with a small area for agricultural production are among the countries with the highest leverage but also with a small absolute value (small bubbles). Interestingly, Costa Rica and Côte d'Ivoir have comparatively high values in both dimensions. The value of imports of cropland products from Costa Rica consists mainly of pineapples (40.0%) and bananas (38.3%), whereas for Côte d'Ivoir it is mostly cocoa (73.8%).

[19]Imports of processed products (e.g. soybean oil) were recalculated to the primary product following Kastner et al. (2011) and Kastner et al. (2014)

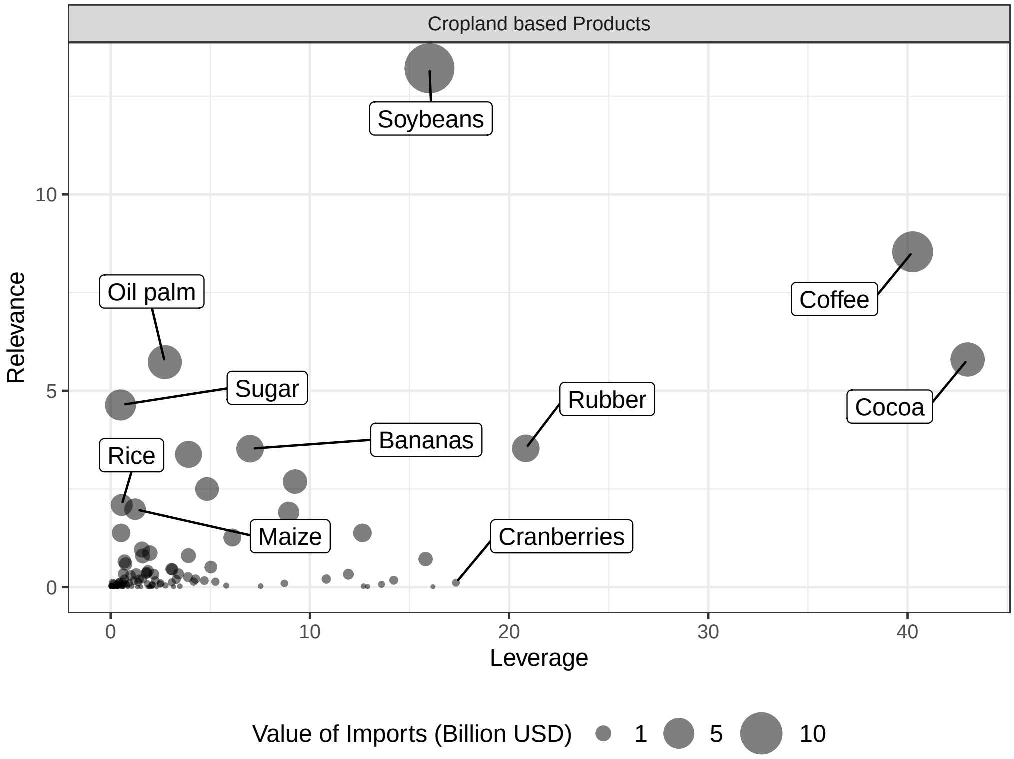

Figure 4.2: Relevance and leverage for cropland based products (in %)

Source: Own production.
Note: We have excluded all product categories that are marked as ”nes” (not elsewhere specified) in the original dataset from FAOSTAT (2021), since these product categories usually include multiple products and they play a minor role in international trade. However, the numbers are included in all calculations. For reasons of clarity, most products that are labeled are represented within the 95% quantile of the leverage and of the relevance.

On the product level, we identify soybeans (relevance 13.2% and leverage 16.0%), rubber (3.5% and 20.8%), coffee (8.5% and 40.3%) and cocoa (5.8% and 43.0%) to be important in both dimensions. Cocoa and coffee imports from developing and transition countries have a particularly high leverage and a comparatively high relevance, suggesting that a stronger PCD in the EU holds the potential for a large effect with regard to these products and value chains but also with regard to the overall performance of the EU.

A more in-depth analysis taking also other dimensions into account (e.g. environmental aspects such as deforestation and footprint) could provide further insights and reveal the effects and interrelations of EU policies with developing countries (e.g. bioenergy policy, trade policy, certification and standards). The aim of the first step of the analysis would be to understand the structures of agricultural trade with developing countries and the effects that arise in the exporting countries. This helps identify which countries and products could be important for a stronger coherence of agricultural and trade policies with the objectives of development policies. In a second step of the analysis, the results would have to be discussed in light of specific policies but also in light of existing private certifications and standards in order to reveal trade-offs and to derive further policy options to counteract them from a perspective of development policies.

5 General Conclusion

The CAP has undergone considerable changes in the past decades that have reduced its overall impact on international agricultural markets by reducing the distorting effect of interventions on markets, production and trade. In this thesis, we have, however, identified mechanisms that have the potential to distort trade and thus can negatively affect countries outside the EU. Following theoretical considerations from Martin and Anderson (2012) and Anderson (2012), which formulate that domestic price insulation is capable of exporting volatility, we first analyzed the EU's variable import levy for imports of corn. By applying a multivariate asymmetric volatility model, we find evidence that the variable import levy shifts corn price volatility from the EU to an exporting country, Argentina. Secondly, we have examined the EU sugar market, which continues to be subject to strong market interventions. In addition to a recently abolished production quota, the sugar market in the EU is characterized by an extremely high degree of protection and intervention as well as a complex system of preferential import regulations. We have therefore analyzed price formation in the European sugar market using an asymmetric cointegration model. We find that market interventions have led to a situation where the official EU price for white sugar reflects movements in the world market price only to a limited extent and reacts asymmetrically to changes in the long-run.

5.1 Limitations

There are some limitations to the research presented in this thesis that deserve attention. In the second chapter of the thesis, the effect of the variable import tariff of the EU on corn price volatility in the EU and in Argentina was examined. As mentioned in chapter 2.3, food price volatility is particularly threatening to market participants (i.e., poor households and producers) in developing countries. In the present analysis, although a volatility-increasing effect of the import tariff on the export price of corn in Argentina was found, at the same time no effects on other importers (i.e., developing countries) of Argentinian corn were examined. Even though a transmission of volatility to other trading partners is likely, the study does not provide an understanding of the extent to which a transmission of volatility may occur in these countries - both indirectly through trade of developing countries with Argentina and directly through trade of developing countries with the EU. Taking into account that among the ten largest importers of Argentinian corn, eight can be classified as developing countries (ITC, 2018), this aspect could be of additional importance.

The second part of this thesis has investigated price transmission on the EU sugar market. In particular, we looked at the integration of the world market price, the ACP import price, the EU spot market and the reported factory price for white sugar in the EU. From the (negative) asymmetric reaction of the EU price to changes in the world market price we concluded, among other things, that sugar producers exercise market power. This hypothesis is essentially based on the concentration in the European sugar market observed in previous studies and the nature of asymmetry. However, in order to formally prove and quantify the exertion of market power and price discrimination by sugar producers in the EU, an investigation considering a formal market power model would be necessary. Furthermore, although the empirical strategy of using a NARDL model allows for the joint modeling of asymmetry in the long-run dynamics as well as in the short-run dynamics of the model, it is a single equation model. Disadvantages and risks arising from the single equation approach have already been discussed in chapter 3.5. Alternatively, more flexible regime dependent models (such as Markov-switching VECM or smooth transition models) could be used to incorporate additional information. These models could provide additional insights to the price formation processes, especially in view of the complex trade regime of the EU which includes switches from net importer to net exporter and the various import channels.

5.2 Policy Implications

The findings of this thesis illustrate the importance of reducing market distorting support of domestic agriculture. It is in line with numerous studies that examined the effects of domestic agricultural support on other countries and a recent statement by a group of 20 WTO members, that call for a continued reduction of distorting domestic agricultural support (WTO, 2021). Although the Agreement on Agriculture (AoA) was an important milestone for the global reduction of harmful subsidies and agricultural trade barriers, almost 30 years later there are still considerable instruments in the CAP that are distortive to trade. Nevertheless, the implications derived from these findings are not limited to the CAP of the EU but should also be considered with regard to other countries that have implemented similar policies.

With regard to the variable import levies on the corn market, volatility-increasing effects outside the EU were observed. Thus, this instrument conflicts with international commitments to stabilize international trade and food prices (Brümmer et al., 2016c; G20, 2011) as well as with the fundamental objective of Article 4.2 of the AoA. Although the latter explicitly prohibits the use of variable import tariffs, the EU negotiated an exception in the Blair House Agreement. With a view to improving food price stability, the use of any domestic price insulation should be abolished without exemptions. This also applies to export restrictions, which have been used particularly during the food price crisis but in view of rising food prices in recent months (FAO, 2021) the likelihood of a revival of these restrictions is increasing. It is therefore important that policymakers recognize the global implications of domestic market interventions and take them into account before intervening in the domestic market, as long as they are not willing to ignore the negative international consequences. If the CAP aims to stabilize markets and farmers' incomes, the role of trade should be acknowledged: international markets can serve as a buffer to regional supply and demand shocks, thereby mitigating price responses. Only if trade can occur uninterrupted and price signals are fully transmitted between markets, trade can fulfill this function. Price and income risks for farmers should therefore not be addressed by politically fixed prices and trade restrictions but by mechanisms that support farmers in coping with volatility or provide non-distortive income support (Brümmer et al., 2016b; Tothova, 2011). However, the latter should be provided to farmers on an individual basis and not generally to every farmer.

The price formation analysis on the sugar market showed that the complex system of preferential trade rules, a very high MFN import tariff and the production quota have disturbed the price formation processes in the EU. The asymmetry also reveals that the insulation from the world market has consequences for the sugar price and market structure in the EU. The hampered price transmission on the sugar market means that price signals from the world market are only passed on to consumers in the EU to a limited extent. In the case of the sugar market, however, the above argument can be further elaborated. Even in situations where there is a serious shortage of sugar in the EU, imports from non-preferential countries are subject to a tariff rate, which normally prevents imports. Import demand must then be met by countries with preferential market access. If these countries (mainly ACP countries) cannot meet the demand, for example due to a high world market price level, additional import channels would be required. The EU Commission has demonstrated in the past that it is capable of releasing additional tariff quotas in such situations (Tangermann, 2012). However, these decisions, which remind more of a planned economy, usually take a comparatively long time. The result can be considerable price spikes and fluctuations and – as observed in the past – a price for sugar in the EU that was well above the world market price level which had to be paid by European consumers.

Finally, the aspect that the sugar market organization in the CAP has probably contributed to a high degree of concentration among sugar producers in the EU (Aragrande et al., 2017; Maitah et al., 2016), represents another important, but oftentimes overlooked aspect in debates on reducing market interventions. The abolition of the quota can be interpreted as a step towards the right direction. However, without opening the EU market to sugar imports from third countries, this could be exploited by large sugar producers and further increase concentration in the sugar market (Řezbová et al., 2015). To counteract this and at the same time allow price transmission, the MFN tariff should be substantially lowered to allow imports of sugar from non-preferred countries.

The research in this thesis revealed that there is an ongoing need to understand and evaluate the effects of domestic policies on other countries but also in the implementing country itself. It contributes to the understanding of domestic and external effects of policies related to agricultural production and trade in the EU. In order to take further steps towards free trade or at least to continue a reduction of trade barriers, it is important to identify obstacles and to continuously communicate their effects to policymakers.

A Appendix Chapter 2

Results from estimated VECM (Equation 2.7)

Table A.1: Results from estimated VECM as given in Equation (2.7)

	Δp_t^{EU}	Δp_t^{ARG}
ECT_{t-1}	-0.0057^{**}	0.0132^{***}
	(0.0029)	(0.0027)
Δp_{t-1}^{EU}	-0.1132^{***}	0.0494^{***}
	(0.0164)	(0.0153)
Δp_{t-1}^{ARG}	0.0933^{***}	0.0392^{**}
	(0.0174)	(0.0163)
Δp_{t-2}^{ARG}	0.0174	0.0398^{**}
	(0.0175)	(0.0163)
Δp_{t-6}^{ARG}	0.0327^{*}	-0.0231
	(0.0175)	(0.0163)
Δp_{t-7}^{ARG}	0.0494^{***}	-0.0033
	(0.0176)	(0.0165)
Δp_{t-9}^{ARG}	0.0068	-0.0276^{*}
	(0.0177)	(0.0166)
Δp_{t-10}^{EU}	-0.0314^{*}	0.001
	(0.0164)	(0.0153)
Δp_{t-11}^{EU}	0.0145	0.0364^{**}
	(0.0164)	(0.0153)
Δp_{t-12}^{EU}	0.1007^{***}	0.0381^{**}
	(0.0162)	(0.0152)
D^{FPC}	-0.0004	-0.0004
	(0.0008)	(0.0007)

***, **, * denote significance at the 1%, 5% and 10% levels, respectively. Standard errors in parentheses. Non-significant lags are not included.

CUSUM test on recursive residuals from ECM

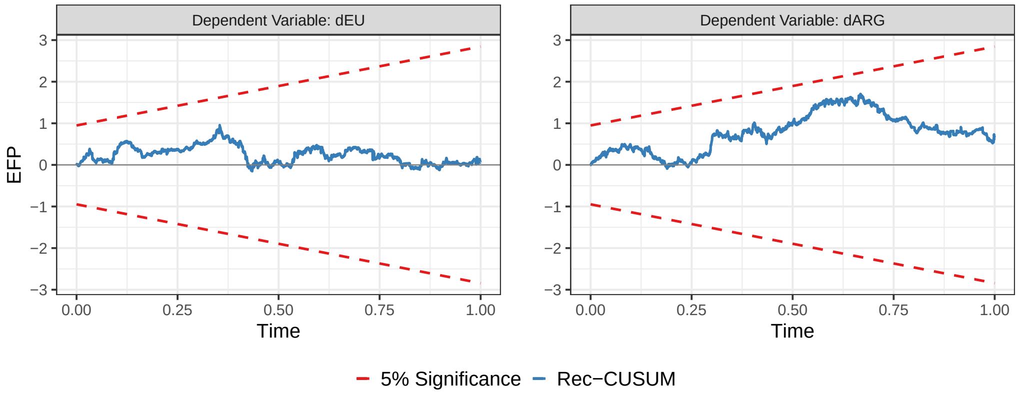

Figure A.1: CUSUM test on recursive residuals from equation (2.7)

B Appendix Chapter 3

CUSUM test on recursive residuals from NARDL

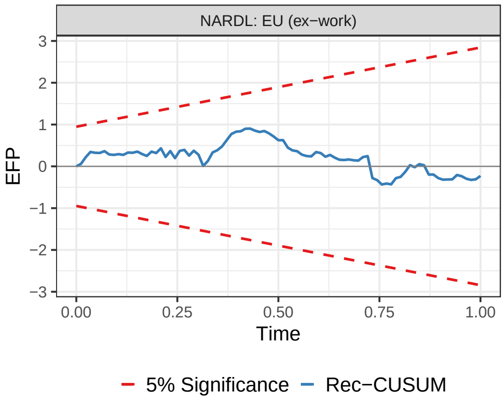

Figure B.1: CUSUM test on recursive residuals from model reported in table 3.4

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Erklärungen

Hiermit erkläre ich, Jurij Berger, dass

1. diese Arbeit weder in gleicher noch in ähnlicher Form bereits anderen Prüfungsbehörden vorgelegen hat.
2. ich mich an keiner anderen Hochschule um einen Doktorgrad beworben habe.

Göttingen, den 28.05.2021

(Jurij Berger)

Hiermit erkläre ich eidesstattlich, dass diese Dissertation selbstständig und ohne unerlaubte Hilfe angefertigt wurde.

Göttingen, den 28.05.2021

(Jurij Berger)