Vertical Price Transmission in Milk Supply Chain:

Market Changes and Asymmetric Dynamics

Abstract

The milk supply chain has been interested by great changes during the last two decades and, in particular, there has been a great trade liberalization and a conspicuous policy change due to the abolition of milk quotas. These market changes are likely to have had a large impact on the transmission of price along the supply chain. Our analysis aims at exploring how market changes have altered vertical price transmission, and, in particular, how asymmetries have changes over tims. We use an asymmetric error correction model to infer on short run and long-run adjustments and conclude on the potential role played by market changes.

Keywords: Asymmetries, Error Correction Model, Price transmission, Supply Chain

1. Introduction

The Italian dairy industry, especially the fluid milk sector, has been under the spotlight for the last ten years, with farmers leading numerous public demonstrations claiming an unfair value distribution along the chain and more often to be producing at a loss. Moreover, the abolishment of the quota regime enhanced their discontent, since they claim the (potential) increase in production will plunge the price, and competitors with largely lighter cost structures may enter the market.

On the other hand, the European Commission (EC) stated the abolishment of the quota regime is necessary for enhancing the farm-gate competitiveness and for a more market-driven dairy industry. Indeed, the European dairy sector witnessed several policy changes in the last ten years.

We explore the price transmission (PT) dynamics along the Italian fluid milk supply chain. Two time-series data of price indexes are employed, featuring the price paid to farmers and the price paid by consumers for fresh fluid milk, covering a period of 16 years. Non-structural models are applied, and hypotheses are drawn on the basis of the market structure of the investigated industry. The two price series and the econometrics method applied allow us to discover the degree of the PT, the speed at which a shock is pass-trough, the nature of transmission (i.e. cost-push, from producers to retailers, demand-pull, from retailers to manufacturers, or feedback-system, both the before mentioned) and whether transmission is symmetric or asymmetric. Moreover, policy changes are taken into consideration, and its impacts on PT dynamics is evaluated. Since non-structural time series models are applied, a thorough understanding of both the supply chain and the political events characterisng the time span analysed is needed. Therefore, we provided a description of International, European and internal measures deployed within the 2000-2016 period in Section 2, along with a brief literature review of the most recent works on PT in agrifood markets in Section 3. The applied methodology is then described in Section 4, the nature of the data collected together with results are presented in Section 5, and Section 6 concludes.

2. The Italian Dairy Sector and the EU Policy

The whole fresh fluid milk market is one of the most important agri-foods in Italy. The dairy industry is a major asset which is worth 15 billion euros, 11.5% of the food industry turnover, with more than two thousand dairy firms involved and a workforce of thirty thousand (Gonano and Mambriani, 2014). Moreover, Italy is the 5th EU-28 fluid (cow) milk producer, providing 7.4% of the total EU production (EUROSTAT, 2016).

However, Italy is a net importer of dairy produce, and as illustrated in Table 1, fluid milk is the most largely imported category.

Table 1 – Italian Dairy Trade Volumes (in milk equivalent), 2013

Product	Import	Export	Balance
Bulk Milk	2.190.826	24.924	- 2.165.902
- Packaged	*564.298*	*7.546*	- *556.752*
Cheeses	497.554	321.989	- 175.565
Yogurt and Fermented Milk	207.571	5.226	- 202.345
Other Milk Derivates	94.341	56.061	- 38.280
Milk Powder	79.526	5.253	- 74.273
Cream	78.625	16.682	- 61.943
Butter and Milk's Fats	56.500	9.563	- 46.937
Whey	54.787	441.284	386.497
Condensed Milk	1.465	330	- 1.135

Source: Soregaroli (2014).

This occurs because of the Italian dairy sector's production orientation, which is strongly devoted to the cheese production. According to the last figures, nearly 70% of the total raw milk is destined to cheese manifacturing, of which almost 50% will be labelled as PDO or PGI (Rapporto Latte 2016). Therefore, the dairy sector is of central importance when referring to the Italian agribusiness, and the recent milk producers' uprising all over the Italian territory unveiled an incresing discontent among agricultural producers, mainly towards the liberalization process the EU has decided to follow. They argue the latter has triggered a fierce and unfair competition with non-Italian dairy producers, whose cost structure is different and ligther, and to whom is granted a free-access to the national market(s), nowadays. If in one hand the Common Agricultural Policy is on the spot for its liberal policy, on the other hand on the internal side, the modern distribution is widely and heavily criticised for dumpening the consumer milk price, sullying the product's image, and exert market power on milk producers.

The following aims at providing a deeper understanding of Italian fresh milk market, investigating the relationship between industrial producer and consumer prices in the last 16 years.

2.1 EU and International Policy Measures: the Liberalization of the European Dairy Market

The General Agreement on Tariffs and Trade (GATT), served as an "[…] international organization for negotiating and administering the multilateral trade rules" up to 1994, later on formally taken over by the World Trade Organization (WTO). Its main task was that of "[…] strengthening and broadening the multilateral rules for trade in goods, and of reducing barriers to trade in goods". The so-called Uruguay Round within the GATT ended up with the Marrakesh Protocol, which eliminates or reduces tariff rates and non-tariff measures applicable to trade in goods (WTO, 1998). The Agreement on Agriculture came into force on 1 January 1995, aiming to a fair and market-oriented agricultural trading system via the establishment of general rules and commitments regarding the so-called three pillars: domestic support, market access, and export competition (i.e. export subsidies and other export-related measures) (WTO, 2003, 2017). This world-wide agreement, which undoubtedly aim at a more liberalized agricultural market (Mendonça, 2016; Swinbank, 2016), continued with the Doha Round in 2001[1], aimed at, once again, "[…] substantial improvements in market access; reductions of, with a view to phasing out, all forms of export subsidies; and substantial reductions in trade-distorting domestic support" (WTO, 2017). Despite the Doha Round is still in progress, yet in 2006 a first draft of agriculture text was circulating, containing formulas for cutting tariffs and subsidies. Later on, the Bali Package formulated in 2013 represented the "[…] first major agreement in trade negotiations […] since the WTO was formed", and the afterwards Nairobi Package in 2015 settled down the "[…] most important reform of international trade rules in agriculture" (WTO, 2017).

Of course, both the GATT's and WTO agreements impact the EU agriculture-related policies, which aimed at avoiding international trade distortions stemming from protectionist measures (i.e. abolishing export subsidies and, hence, limiting the intervention prices and stockpiling, lowering import tariff and introduce decoupled aid to farmers) (Bouamra-Mechemache et al., 2009; Gohin and Latruffe, 2006; Meijerink and Achterbosch, 2013). The McSharry Reform adopted in 1992 "[…] was partly intended, in addition to its domestic objectives, to facilitate the signing of the Agreement on Agriculture as part of the Uruguay Round. As a result the European Union has to a large extent complied with the commitments signed in Marrakesh" (Massot Marti, 2016). Indeed, it started the decoupling support process, continued (and extended) by the Agenda 2000, the Luxembourg Reform of 2003 and the Heath Check of 2008. The main two reasons for such a broad reform were to reduce the CAP's pressure on the EU budget but, mostly, the pressure exerted by trade partners within the Uruguay Round, which shaped the CAP reforms from 1992 up to 2008 (Cunha and Swinbank, 2011; OECD, 2011a; Swinbank, 2016). Indeed, all the reforms undertaken within the period 1992-2008 were oriented to markets

[1] The continuation of agricultural reform post-Uruguay Round was formally expressed in the Agriculture Agreement via the Article 20 (WTO, 2003, 2017).

liberalization (Tangermann and von Cramon-Taubadel, 2013), even though is with the 2003 reform when the milk market witnessed the fundamental policy shift towards a free market (Gohin and Latruffe, 2006). As stated by the European Court of Auditors (2009, p. 13) "[…] In accordance with the decisions contained in the Agenda 2000 action programme, the 2003 reform initiated the liberalisation of the milk sector by reducing price support and creating direct income support".

Therefore, the milk target price was abolished, the intervention price lowered, and national milk quotas increased by 1.5%, weakening the overall price support mechanism. Especially, the so-called Luxembourg Reform of 2003 set a 25% decrease in the butter intervention price over four years from 2004/2005 to 2007/2008 and a further 15% decrease for the SMP over a three-year period, from 2004/2005 to 2006/2007 (Bouamra-Mechemache et al., 2009). Consequently, the common market organization (CMO) for dairy products (Council Regulation (EC) No 1255/1999) was amended by the EC Regulation 1787/2003 and by the Single CMO (i.e. Council Regulation (EC) No 1234/2007) introduced in 2007. The latter set a new intervention price for butter and SMP of 221.75[2]€/100 Kg from the 2007/2008 campaign and 174.69€/100 Kg from the 2006/2007 marketing year, respectively[3] (See Figure 4). Furthermore, the threshold quantity above which the buying-in for butter has to be carried out by a tender procedure has been lowered by 10,000 thousand tons, i.e. 30,000 tons in 2007 (Matthews, 2013). Last but not least, is then when the official decision of dismnatling the quota system was taken. In addition, for the period June 2007-August 2011, export subsidies were set to zero due to high world market prices (except the period January-November 2009) (Meijerink and Achterbosch, 2013). Finally, the 2003 Reform introduced the Single Payment Scheme (SPS), by which farmers receive a decoupled single payment, making farmers more reactive to market price signals and coping with WTO's claims over EU distortive agricultural measures (Bureau and Witzke, 2010; Gohin and Latruffe, 2006)[4]. This could be introduced in each Member State (MS) from 2005 or 2006 (Anania and Pupo D'Andrea, 2015; OECD, 2011a). Regarding the milk sector, a compensation for price cuts was set to 35.5€/ton of milk quota from 2006 onward, and included in the SPS from 2007 (Gohin and Latruffe, 2006).

Indeed, one of the most important elements of the European milk-related policy was the quota system. Introduced in 1984[5] to regulate the structural surplus (i.e. curbing the milk production) the system of guaranteed price generated, and reducing the pressure of the dairy sector on the CAP's budget, they were dismantled the March 1st of 2015 (Giles, 2015; Tonini and Domínguez, 2009). The regime permitted to maintain a sort of price support for milk producers[6] and, thus, support for agricultural incomes, which generetaed a positive spread between the European and World milk prices over the thirty-years period in which the regime has been

[2] This is the corresponding 90% of the reference price, set at 246.39€/100 Kg.
[3] The threshold price for SMP was lowered to 169.8 €/100 Kg since September, 2008.
[4] As pointed in Gohin and Latruffe (2006), coupled direct payments were blue box measures under the WTO's, and moving to a more decoupled aid's framework means green box measures.
[5] See the two Regulations 856/84 and 857/84
[6] The so-called quota-rent: the amount of rent generated from a restriction on supply (Tonini and Domínguez, 2009).

functioning. Is in the 2000s when some of the main dairy producers and exporters started exerting pressure for the abolishment of the quota system (e.g. United Kingdom, Italy, Denmark, Sweden), since it was limiting production and, hence, reducing the volume they were able to export to emerging markets. Indeed, world prices were at their highs and growing, a natural consequence of increasing demand. Eventually, is with the implementation of the Luxembourg Reform (2003) first, and the Health Check (2008)[7] afterwards when the EU eventually decided the dismantling of the quota system by March 1st, 2015, being the 2014/2015 the last quota-milk campaign (Anania and Pupo D'Andrea, 2015). However, a 'soft-landing' phasing-out measure was adopted in the 2008 reform, aimed at preventing the dramatic drop in milk price due to a potential increase in production (Donnellan et al., 2015). Therefore, quota-regimes were increased from the 2008/2009 campaign by 2% and 1% from the 2009/2010 campaign for five consecutive years, except for Italy for which the cumulative 5% increase was frontloaded on the beginning of the 2009/2010 campaign[8].

The removal of EU quota regime aimed at fully integrate European markets into the world dairy market, a process that started already in 2007, as a result of relaxing some protectionist measures (i.e. intervention prices for butter and SMP).

Figure 1 and Figure 2 illustrate the EU monetary expense for agriculture and for the milk sector, respectively, showing a major change occurring in 2007. Looking at the general CAP expenses (Figure 1), export refunds decreased substantially in 2007, together with coupled direct aids, whereas decoupled aids increased tremendously as a consequence of the introduction of the SPS (OECD, 2015a). Moreover, the weight of the CAP on the EU GDP reduced substantially, from 70% in the 80s to around 40% in the last period (OECD, 2011a). Likewise, Figure 2 provides some useful insights relative to the dairy sector only. The Total Support Estimate (TSE) is an OECD indicator that combines all kind of agriculture-related public monetary expenses9. This decreased from 2.63% of GDP in the 1986-88 period to 0.84% in 2007-09, that is below the OECD average (OECD, 2011a). Moreover, is it clear form the graphical representation how from 2007 the MPS witnessed a profound change, accounting for 96% of the total policy expense for the period 1986-2006, whereas, afterwards, its incidence turned negative and near zero. The increased share of PBO on the TSE from 2007 reflects, once again,

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[7] The European Commission released in November 2007 the document "Communication from the Commission to the European Parliament and the Council. Preparing for the Health Check of the CAP Reform

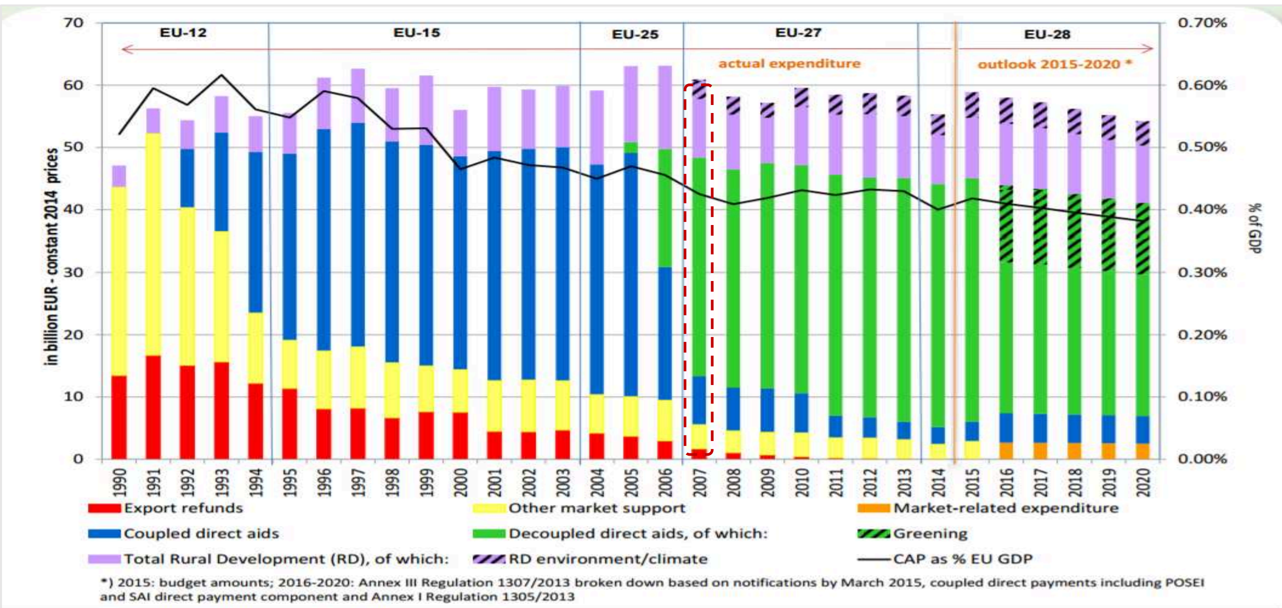
[8] See the Report from The Commission to The European Parliament and The Council: Evolution of the market situation and the consequent conditions for smoothly phasing-out the milk quota system - second "soft landing" report (COM(2012) 741 final).

[9] In details, those are: the MPS "[…] transfers from consumers and taxpayers to agricultural producers arising from policy measures that create a gap between domestic market prices and border prices of a specific agricultural commodity, measured at the farm gate level" (OECD, 2016b, p. 30), PSE (Producer Support Estimate, transfers to agricultural producers individually, which is a main element constituting the MPS category), the GSSE (General Services Support Estimate, policy expenses that do not going directly to farmers but have agriculture as the main beneficiary), and the CSE (Consumer Support Estimate, budgetary support to consumers net of market price elements that are already accounted in the PSE) (OECD, 2016b).

the introduction of the SPS, limiting the distortive effect of EU policy on the world market[10]. Furthermore, the share of the PSE over the gross farm milk receipts witnessed a relevant decrease in 2007, reducing almost to zero and maintaining a very low impact afterwards. Indeed, all these indicators hint that the EU agricultural policy moved to a far less-distorting policy framework, according to a liberalization course of agricultural markets throughout the EU that started in 1992 with the McSharry Reform (OECD, 2011a, 2011b, 2015a, 2016a).

Apart from all the reported policy changes, the year 2007 has been also characterised for some changes on the fundamentals on the international market. First and foremost, as broadly documented and investigated (see among others Abbott, 2009; Bukeviciute et al., 2009; FAO and OECD, 2011; LEI, 2010; OECD and FAO, various years from 2008 to 2016), the 2007-08 period has been characterised by a relevant surge in commodity prices, with consequences on the farms' cost structure (i.e. the increase in feed prices, which account for roughly 20% of milk production cost, caused an increase of milk production costs for about 25% in 2013 with respect to 2007) (European Commission, 2016). On the dairy side, world demand increased mostly due to a major demand in non-OECD countries (DG-AGRI, 2016; LEI, 2010), and New Zealand, one of the major milk producers, experienced a significant drought, reducing the world supply. This price turmoil has eventually enhanced the tighter legacy of the EU dairy markets with the rest of the world. Indeed, as EDA (2015), DG-AGRI (2016), and COPA-COGECA (2007) report, an increase in volatility has been observed since 2007 concerning the European dairy sector.

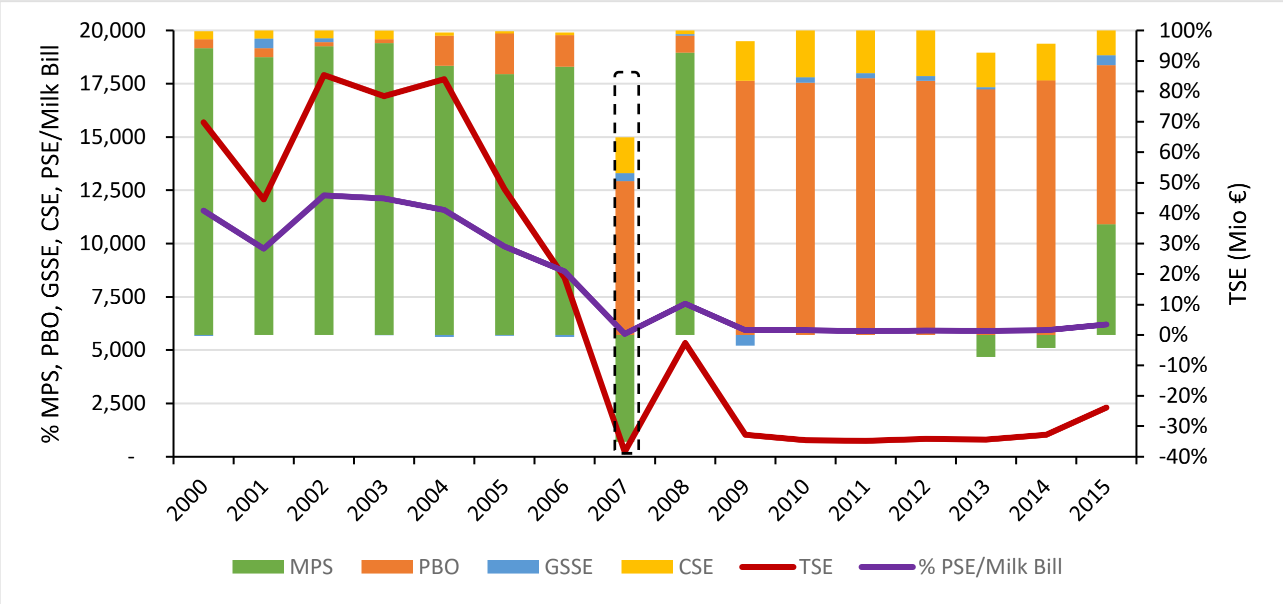
Figure 1 – CAP Expenses, 1990-2020



Source: European Commission (2015).

[10] After 2007, the dairy premium the producers received as a compensation for the cutting in intervention prices have been integrated in the SPS (Meijerink and Achterbosch, 2013).

Figure 2 – Total Support Estimates (TSE) for Milk in the EU and its Composition, 1986-2015



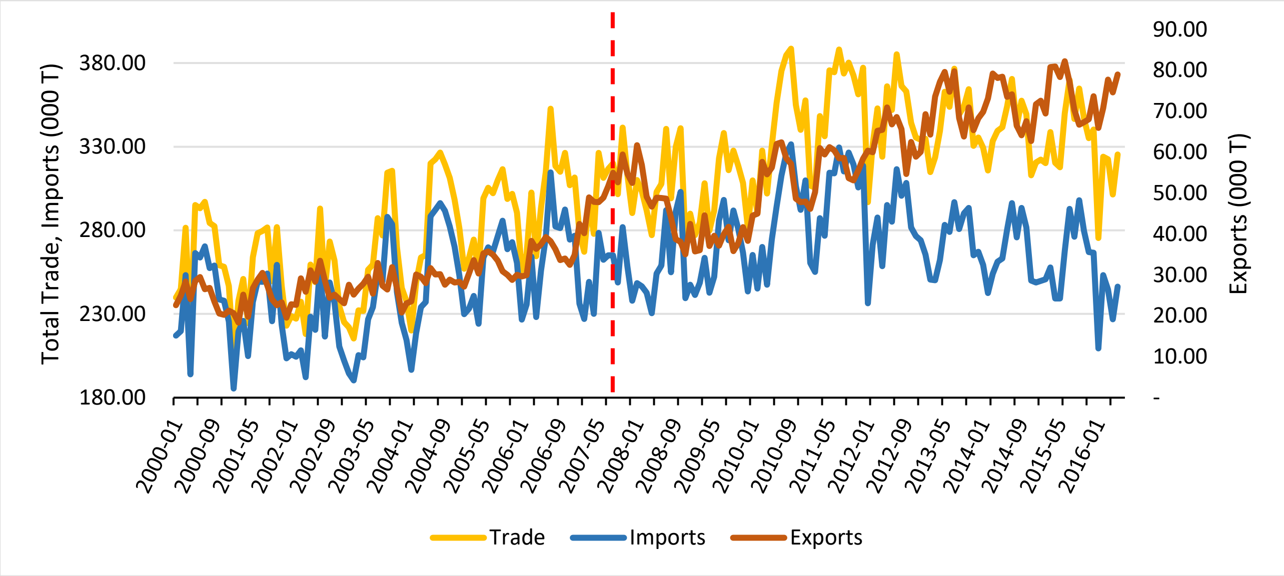
Source: OECD (2017).

2.2 *The Italian Dairy Sector: Facts and Figures*

Figure 3 illustrates the imports' and exports trends for the five macro-categories of dairy products. While imports are quite stable through time (one may spot a slight positive trend for cheese and yogurt and a light decrease for milk and cream), exports entail a more complex course. Indeed, the price surge in 2007 together with an increasing demand for protein in emerging markets (i.e. China and India mostly) may explain the massive increase in milk and cream and whey exports (+95% and +97% respectively, according to ISTAT). Yogurt and other fermented products rose 49 % the volume exported, while for the two cheese and butter categories the growth in exports was slightly positive (6% and 13% respectively). If one look at the overall traded volumes, the upsurge of milk (and all commodity) prices in 2007 seem to be a watershed for Italian trade. However, the change in exports is ten times bigger than that of imports, which maintain the same erratic course with a very tenuous positive course.

Table 2 illustrates the average trade flows for the two selected periods, confirming the structural change occurred for the Italian trade flow; indeed, exports doubled the traded volume, while imports slightly increase. Overall, trade increased by more than one-fifth with respect to the first period analyzed.

Figure 3 – Italian Trade Volumes, 2000-2016



Source: Authors’ elaboration on ISTAT

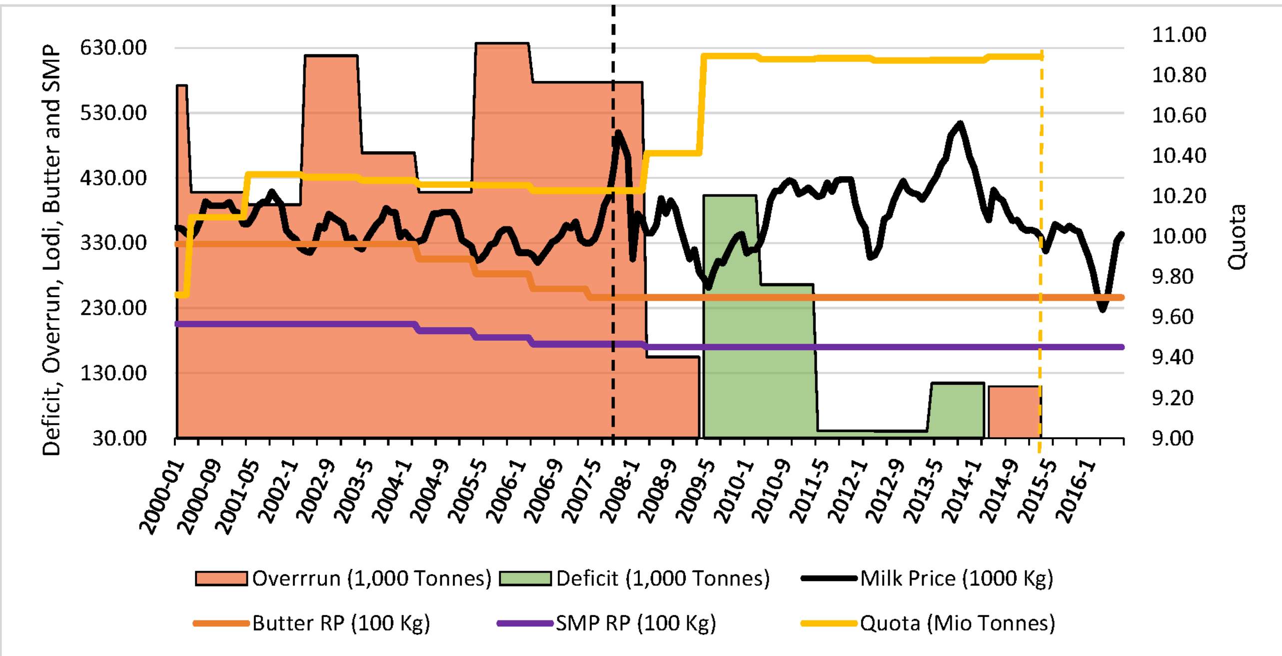
Table 2 – Average Trade Flows in Italy, 2000-2016 (000 Tonnes)

	Period	Iilk and Milk Cream	’ogurt and Other	Whey	Butter	Cheese	Total
Exports	2000-2006	15.5	3.8	102.0	13.3	206.1	68.1
	2007-2016	53.5	5.6	348.3	11.1	299.9	143.7
	% Change	245.9%	46.6%	241.6%	-16.2%	45.5%	**110.9%**
Imports	2000-2006	2,305.86	131.16	53.41	50.89	380.27	584.32
	2007-2016	2,367.50	213.72	121.03	60.81	481.17	648.84
	% Change	2.7%	62.9%	126.6%	19.5%	26.5%	**11.0%**
Total Trade Volume	2000-2006	1,160.66	67.49	77.69	32.09	293.17	3,262.20
	2007-2016	1,210.49	109.66	234.68	35.98	390.52	3,962.64
	% Change	4.3%	62.5%	202.1%	12.1%	33.2%	**21.5%**

Source: Authors’ own calculations on ISTAT

Figure 4 illustrates the Italian farm-gate price and the central European policy interventions in the dairy sector. The yellow line shows the amount of milk quota assigned to Italy (the hatched line define the end of the quota regime) while red (green) bars refer to overruns (deficit) on the quota assigned. It is evident how, particularly from the 2008/2009 Campaign, the surpluses reduce dramatically, in reason of a higher quota thresholds. Indeed, for four consecutive campaigns (i.e. from 2009/2010 to the 2013/2014 marketing year), Italy milk deliveries were under the assigned quota. The two purple and orange lines represent the two reference prices (RP) for SMP and butter, respectively. Italy is the 7th butter largest producer in the EU, while is not a significant SMP producer.

Figure 4 – Italian Spot Milk Price and EU Policy, 2000-2016



Source: Authors' personal elaboration on MMO (Personal Communication), MMO (Press Release, Various Years within 1999-2016) and the Chambers of Commerce of Lodi.

Nevertheless, as the COPA-COGECA (2007), EDA (2015), Mela (2012), and Pieri and Rama (2016) argue, those interventions led to a more volatile market, as confirmed by Figure 5 and Table 3. The Italian milk price, since 2007, witnessed an increased volatility, at both producer and consumer levels. While the consumer price experienced an increase in volatility of about 28%, the producer price has seen an increase of 83%. Moreover, looking at the spot milk price in Figure 4, it is evident how from 2007 there is a switch in the price behavior. The seasonality that clearly characterized the period 1991-2007 disappeared and an unpredictable price course, with many spikes and valleys, sprout up.

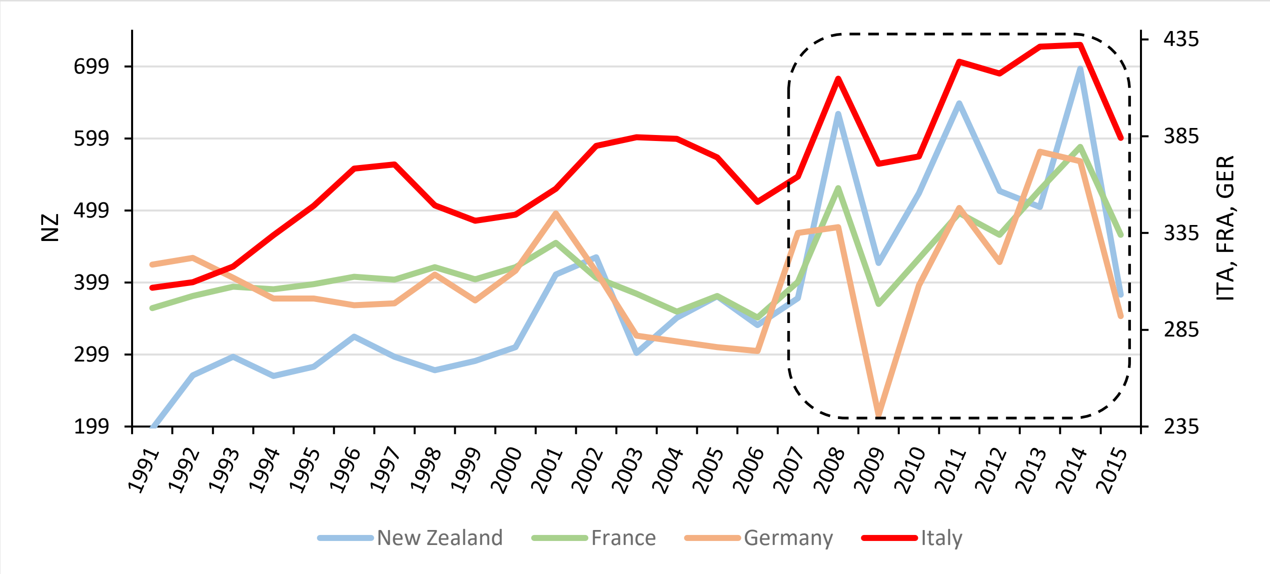
Table 3 – Estimated Volatility[11], January 2001 – July 2007 and August 2007 – June 2016

CPI	
2001:01-2007:07	0.331662
2007:08-2016:08	0.424264
PPI	
2001:01-2007:07	0.374166
2007:08-2016:08	0.685565

Source: Authors' own calculation

[11] Volatility has been calculated as: $\sigma_t = \sqrt{\frac{1}{m}\sum_{i=1}^{m} r_{t-i}^2}$, where $r_t = 100 * (P_t - P_{t-1})/P_{t-1}$, m is the number of observations and the mean of returns $\bar{r}$ is assumed to be 0.

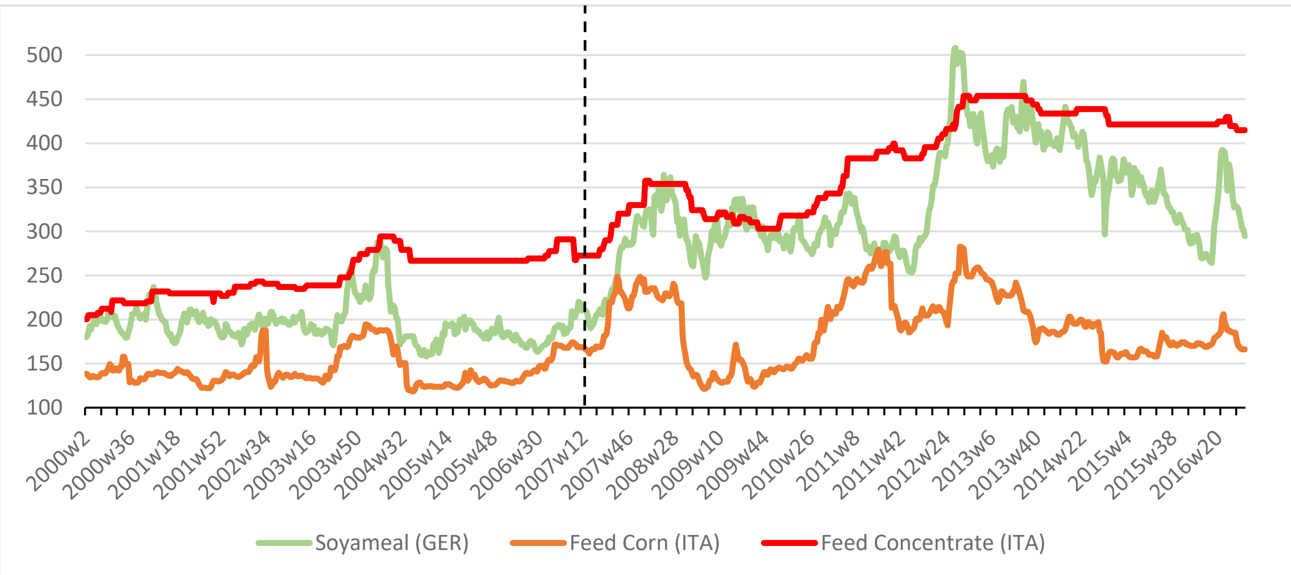
Figure 5 – Spot Prices in Standard Local Currency per Ton for selected markets, 1991-2015



Source: FAOSTAT (2016).

Worth of mention is also the upsurge of feed prices in 2007, mainly due to scarce cereals yields and a growing demand for crops. Figure 6 shows the jump in concentrate feed for bovines in 2007, pulled by both the increase in soy meal and corn prices. Since feed expense represents about 20% of total milk production cost (European Commission, 2016), its increase may cause an increase in the milk price, given the new cost structure farmers have to face. However, given the market power retailers can exert over producers, this may lead to the shrinkage of farmers' margin rather than an increase in the milk consumer price.

Figure 6 – Italian Feed and Main Feed Ingredients Prices, 2000-2016



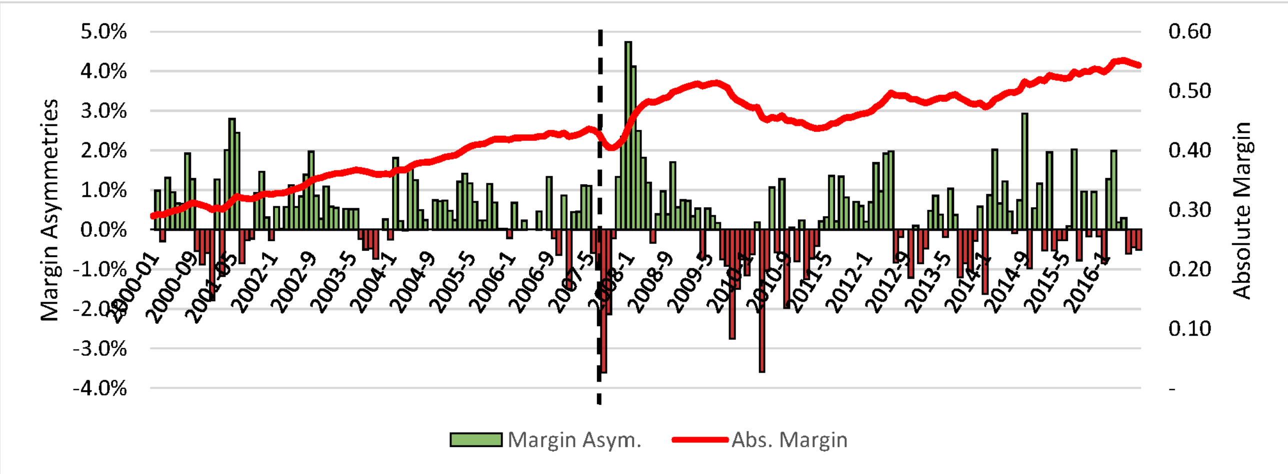
Source: Authors' elaboration on PublicLedger (Soyameal), AGER Bologna (Feed Corn) and the Chamber of Commerce of Forlì (Italy, Feed Concentrate)

Besides the events occurred at the European level, year 2007 also witnessed some significant national changes which may have an impact on milk prices. With the modern distribution (i.e., Hypermarkets, Supermarkets, Discounts) accruing for the lion share of households' purchases, Pieri (2008, 2009) detailed how the Private Label (PL hereafter), that is the product branded by the distributor, were increasingly gaining market share. Given their lower price by definition (due to the very negligible promotion and marketing costs), their growth may, partly, justifies the low volatility increase consumer price experienced when compared to the producer one. Another relevant event is the enlargement of the purchasing group "Centrale Italiana", which in 2006 accrued for 22% of market share after the entry of the retailer "Il Gigante". The group was dismantled in late 2014 by the Italian Anti-Trust Authority.

2.3 The Italian Milk Margin

Figure 7 illustrates the percentage change in marketing margins through time. The red (green) bars are displayed whenever the margin is decreasing (increasing) on the previous month. An increase in the margins occur whenever there is an increase (decrease) in the consumer (producer) price, whereas a decrease describes the opposite situation. Given the hatched line representing the structural break, it is evident how the period preceding the change featured general lower margins, despite it increased quickly. This is also evident from Table 4: the average change in margin for the first period is two times that of the second one. The maximum and minimum values are rather higher in the second period, probably due to a much higher volatility in both upstream and downstream prices. However, in absolute terms the average margin increased in the post-break, being 0.49€/l against 0.37€/l of the pre-break period.

Figure 7 – Italian Milk Margin Trend



Source: Authors' own elaboration

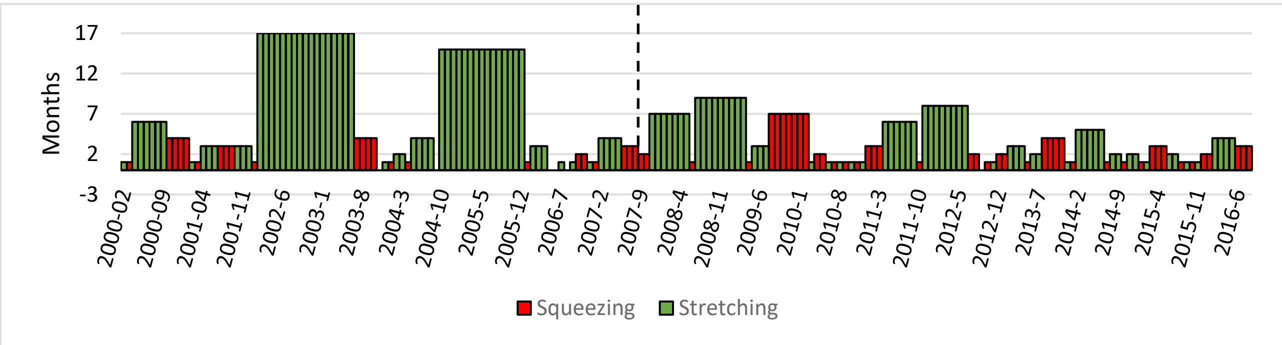
Table 4 –Margin's Trend, January 2000 – July 2007 and August 2007 – June 2016

Jan 2000-Jul 2007		Aug 2007-Jun 2016	
Average	0.4%	Average	0.2%
Max	2.8%	Max	4.7%
Min	- 1.8%	Min	- 3.6%

Source: Authors' own elaboration

Another important fact regarding the margins trend is their persistence in terms of time. Figure 8, together with Table 5, show a much more equilibrated margin dynamics in the second period, with the average persistence for positive changes almost two times smaller than the one characterizing the first period. Moreover, the number of negative margin changes also increased.

Figure 8 – Persistence of Positive (Stretching) and Negative (Squeezing) Margin Changes



Source: Authors own elaboration

Table 5 – Statistics of Positive and Negative Changes in Margin

	. Negative Margin Changes	l. Positive Margin Changes	; Negative n the total	istribution f Negative Changes	% Positive n the total	istribution f Positive Changes	Average NEG ersistence (months)	Average POS ersistence (months)
Pre Break	23	63	25.3%	34.3%	69.2%	50.0%	1.83	5.41
Post Break	44	63	40.7%	65.7%	58.3%	50.0%	1.97	3.16
Total	67	126	33.7%	-	63.3%	-	1.90	4.21

Source: Authors own elaboration

3. Literature Review

Being prices the instrument by which information is conveyed to all stages of the supply chain, economists are heavily interested in how price shocks are transmitted within (vertical price transmission – VPT) and between (horizontal price transmission – HPT) markets. Gardner' seminal paper on PT (1975) explicates the relevant theory, clarifying '[…] the mechanisms and their implications in an area that has been characterized by its fair share of misunderstanding and overreach' (Lloyd, 2016, p. 1). Since then, a vast literature on price transmission (PT) has been developed and as Kouyaté and von Cramon-Taubadel (2016) pointed out, are 492 the studies embodying this kind of analysis. Focussing on Asymmetric-VPT (AVPT), its importance is related to the capacity of giving a measure of the behavior of economic agents and of its functioning (Ben-Kaabia and Gil, 2007; Lloyd, 2016; Serra and Goodwin, 2003). In recent years, PT analysis witnessed a wide development of new econometric modeling techniques that allows for testing the presence of asymmetries in the PT process (APT). Therefore, new technics together with structural changes occurring in the food industries (i.e. mergers and acquisitions and policy changes), enhanced the interest of economists on founding asymmetric price dynamics. Asymmetries generate a disruption in welfare distribution within the considered supply chain since depending on the sign of the price changes (i.e. positive or negative), the magnitude and the speed of adjustment to the equilibrium may differ (European Commission, 2009; OECD, 2015b). In his inspiring study Peltzman (2000) demonstrated that prices rise faster than they fall (i.e. the rockets and feathers phenomenon), spawning APT-related research. Indeed, he found that asymmetries are the rule rather than the exception, highlighting an existing gap in economic theory. More recently, Bakucs et al. (2014) also found APTs in more than 50% of investigated agricultural markets. However, despite a substantial number of works investigate asymmetries, drawing conclusions that should motivate such (inefficient) market behavior and suggest general policy intervention is yet a troublesome task (Vavra and Goodwin, 2005). Nevertheless, Meyer and von Cramon-Taubadel (2004) detailed a thorough description of what may cause an asymmetric price adjustment. Market power is probably the most quoted one (Bailey and Brorsen, 1989; Lloyd et al., 2006; Madau et al., 2016; McCorriston et al., 2001; Sckokai et al., 2013; Sexton, 2013; Shrinivas and Gómez, 2016; Simioni et al., 2013; Soregaroli et al., 2011; Verreth et al., 2015), although not always asymmetries match with high concentrated markets (Acosta and Valdés, 2014; Bakucs et al., 2014; Bettendorf and Verboven, 2000; Peltzman, 2000; Sckokai et al., 2013; Serra and Goodwin, 2003). Ward (1982) was the first scholar linking VAPT with the level of product perishability, concluding that retailers respond more to decreasing wholesale prices than increasing ones. These findings may suggest that retailers are adverse to increase prices for the perishable product since this could lead to sales reduction and increase spoilage. On the other hand, Heien (1980) argues that prices of perishable products are more dynamic, though changing prices is less of a problem. Peltzman (2000) found weaker evidence of asymmetries for perishable products and, alike, Serra and Goodwin (2003) found APT in long shelf-life dairy products while symmetric PT in high-perishable milk products. Kim and Ward (2013) observe that PT in fruit and vegetable commodities is negative asymmetric, and decreases in the wholesale prices are passed through more quickly than increases. Santeramo (2015), in his study on the tomato and cauliflower sectors in Europe, supports both Kim's and Ward (2013) and Ward (1982) conclusions since wholesalers price decreases have a larger impact on retail than price increments. Finally, Santeramo and von Cramon-Taubadel (2016) analyze different products from the fruit and vegetable category and conclude APT is found in 17 out of 40 cases, of which 16 products were classified as “low-perishable,” supporting the hypothesis of a more symmetric PT in high perishable products.

Moreover, there is a vast number of studies investigating how a change in government policies could affect price transmission dynamics. Kinnucan and Forker (1987) studied how government support to producer prices (e.g. floor prices) could cause APT in the US dairy sector. Santeramo and Cioffi (2012) and Cioffi et al. (2011) studied the effects of the EPS (i.e. entry price scheme) in the fruit and vegetable sector in the EU, concluding the stabilization effect on domestic prices is rather limited. Lee and Gómez (2013) estimated how the end of the coffee export quota system (EQS) affects PT between international and retail prices in France, Germany, and the US. They found that retail became more responsive to changes on the international side in the post-EQS period, despite short-run asymmetries and a decrease in the speed of adjustment to the equilibrium. Cacchiarelli et al. (2016) investigated how the mid-term reform of the CAP in 2005 affected the PT process within the wheat-pasta chain. If the farm-wholesaler relationship became symmetric in the post-reform, the opposite occurs in wholesaler-retailer relation, where there is a significant asymmetric long-run behavior from retailers. Han et al. (2016) compared PT behaviors in US cattle markets pre- and post-EPA (i.e. Energy Policy Act), which increased the production of corn ethanol, finding a lower integration and a slower transmission between the investigated markets in the post-EPA period. Esposti and Listorti (2013) determined whether and how temporary trade-policy measure applied to mitigate price bubbles (i.e. the suspension of the European import duties on cereals) do have an impact on PT process in the Italian and North American markets, in particular for cereals. When effective, such policy measure mitigated the impact of the price bubbles. Brümmer et al. (2009) analyzed the PT between wheat and wheat flour in Ukraine during a period of significant policy intervention, and they found a strong coincidence between regimes of high uncertainty and policy interventions, concluding these may amplified instability. Ihle et al. (2012) explored simultaneous impacts of policy reforms and animal health crisis on HPT among four main European markets, showing these significantly impacted PT process in the investigated markets.

Further causes for APTs were explored, such as substitutability between agricultural and other marketing inputs (Bettendorf and Verboven, 2000; McCorriston et al., 1998), adjustment and transportation costs (Azzam, 1999; Chavas and Mehta, 2004; Santeramo, 2015), asymmetric information (Bailey and Brorsen, 1989) and inventory costs (Reagan and Weitzman, 1982).

4. Methodology

The first specification for modeling asymmetric price transmission was designed by Wolffram (1971) and later modified by Houck (1977) and Ward (1982), where the response of consumer (retail) price P_c to a shock in processor price $P_p$was estimated via the model:

$$\Delta P_{c,t} = \gamma_0 + \sum_{j=1}^{m}(\gamma_j^{+}\mathrm{D}_t^{+}\Delta P_{p,t-j+1}) + \sum_{j=1}^{n}(\gamma_j^{-}\mathrm{D}_t^{-}\Delta P_{p,t-j+1}) + \mu_t \qquad (1)$$

where $\Delta P = P_t - P_{t-1}$, D_t^{+} and D_t^{-} are dummy variables for positive ($P_{p,t} > P_{p,t-1}$) and negative ($P_{p,t} < P_{p,t-1}$) values, respectively, γ_0 is the constant term and μ_t are error terms. In this context, the hypothesis of symmetric price transmission can be tested against asymmetric adjustment ($\mathrm{H}_0: \gamma^{+} = \gamma^{-}$; $\mathrm{H}_a: \gamma^{+} \neq \gamma^{-}$). However, the model expressed in (1) is not consistent with cointegration (Engle and Granger, 1987) and it neglects the time series properties of the data, such as autocorrelation and unit-root (von Cramon-Taubadel, 1998; von Cramon-Taubadel and Loy, 1996). In order to overcome such limitations and drawbacks, Granger and Lee (1989) first introduced the Asymmetric Error Correction Model (AECM), segmenting the Error Correction Term (ECT) into positive and negative values. This asymmetric model was later applied to agricultural markets firstly by von Cramon-Taubadel and Loy (1996) in their study on wheat, and later generalized by the seminal paper of von Cramon-Taubadel (1998) investigating price transmission dynamics in the German pork market:

$$\Delta P_c = \alpha_0 + \beta_0 \Delta P_{p,t} + a_1^+ ECT_{t-1}^+ + a_2^- ECT_{t-1}^- + \sum_{i=1}^{k-1} \Gamma_i \, \Delta P_{c,t-i} + \sum_{i=1}^{k-1} \psi_i \, \Delta P_{p,t-i} + \varepsilon_t \qquad (2)$$

where ECT_{t-1}=$ECT_{t-1}^+ + ECT_{t-1}^-$, i.e. it is split into its positive and negative values, and an F-test can be used testing the null of symmetry ($a_1^+ = a_2^-$).

Recently, Santeramo and von Cramon-Taubadel (2016), Alam et al. (2016), Acosta et al. (2014), Gómez et al. (2010) and Capps and Sherwell (2007) also employed the (Vector)AECM for studying APTs within and between different agricultural markets.

According to Lee and Gómez (2013), aiming at investigating asymmetric price dynamics in the short-run, we split lagged differenced prices into their positive and negative values, such that:

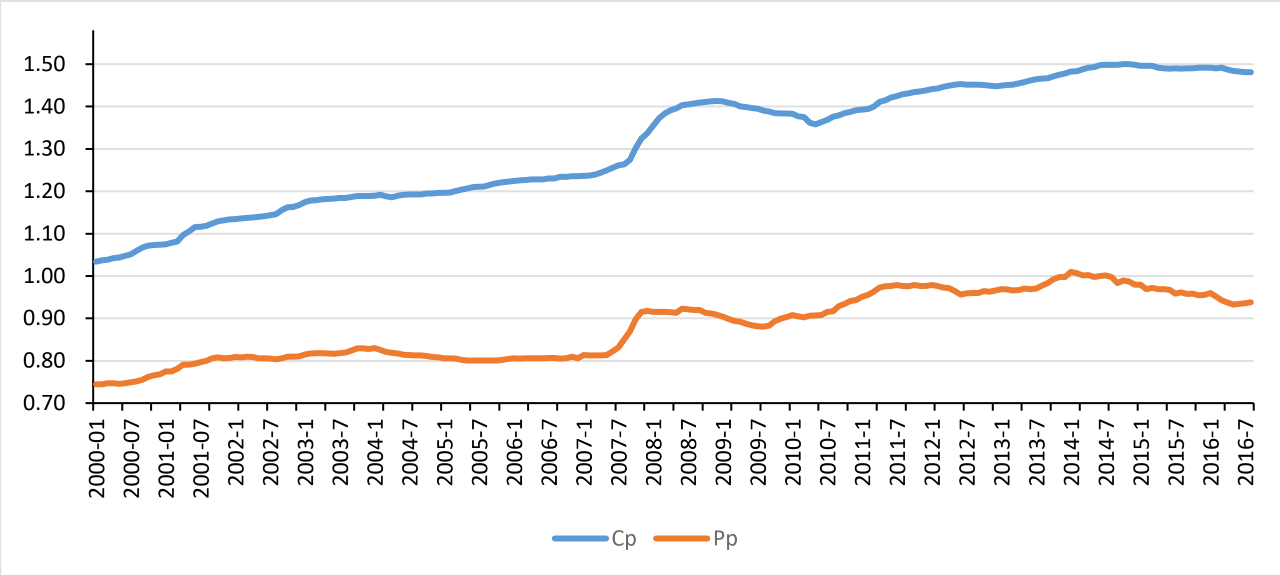
$$\Delta P_c = \alpha_0 + \alpha_1 ECT_{t-1}^+ + \alpha_2 ECT_{t-1}^- + \sum_{i=1}^{k-1} \Gamma_i \, \Delta Pc_{t-i} + \sum_{i=1}^{k-1} \psi_1 \, \Delta^+ Pp_{t-i} + \sum_{i=1}^{k-1} \psi_2 \, \Delta^- Pp_{t-i} + \mu_t \quad (3)$$

Again, one can use an F-test for testing short-run asymmetries ($\psi_1 = \psi_2$). Finally, the Italian dairy market has (potentially) witnessed some structural changes, gave the new policy regime through years and market turbulence in the recent past. Accounting for such breaks along the time series data is of great importance then, since structural break may entail different methodological approaches and, primarily, change the economic interpretation of final results. Therefore, we hinged on the Zivot-Andrews (1992) test for structural breaks and, whenever we found a break (T_1)does occur, we employed the Johansen, Mosconi, and Nielsen (2000) cointegration test. Indeed, the latter allows for up to two structural breaks into the cointegration relation, i.e. broken linear trend levels.

5. Data and Results

We used monthly price data at two different levels of the milk supply chain: the price paid by retailers to the industrial milk processor (Pp) and the price applied by the same retailers to the consumer market (Cp). Using two price indexes provided by the ISTAT and indexed by the year 2010 we built two price series in levels according to the Pp and Cp a food retailer provided us for the year 2010. The time span covered began in January 2000 to end in August 2016, accounting for 200 observations (see Figure 9). Aimed at mitigating the fluctuations and increasing the likelihood of stationarity after first differencing, we transformed our series into their logarithms. Moreover, this allows for interpreting results in percentage change terms, with the long-run coefficient β representing the price transmission elasticity (Ben-Kaabia and Gil, 2007; Hamilton, 1994).

Figure 9 – Producer and Consumer Prices of Fresh Fluid Milk on the Italian Market, 2000-2016



Source: Authors own elaboration.

As a first step, unit-root tests were applied to our data. A constant was included since it accounts for the current margin between the two price series over time. Diverse unit-root tests were employed, as the literature suggests, to firmly conclude if the series contain a unit-root or not. The GLS-ADF test (Elliott et al., 1996) and the KPSS test (Kwiatkowski et al., 1992) have been additionally employed to the PP test (Phillips and Perron, 1988) to overcome the low power and size distortions bore by canonical tests such as the ADF and the PP tests (DeJong et al., 1992; Ng and Perron, 2001; Schwert, 1989). As Table 6 shows, all tests lead to the conclusion the two series are I(1) differenced stationary processes[12].

The following step would be testing for cointegration between the two price series as a linear combination of the two I(1) series may results in an I(0). However, from graphical inspection and from the events in the economic calendar we describede in previous sections, one might suspect that some structural change occurred around the mid-2007. Hence, the Zivot-Andrews test (1992) for detecting structural breaks was applied, spotting a change in August 2007 (see Table 7 for further details).

Table 6 – Unit-Root Tests for CPI and PPI

			CPI				
Unit-Root Test	**Lags**	**Tau-Stat.**	**1% C.V.**	**5% C.V.**	**10% C.V.**	**IC**	**Results**
DF-GLS (w/Trend)*	4	-1.859	-3.46	-2.911	-2.625	Ng-Perron	I(1)
	1	-1.125	-3.46	-2.936	-2.647	SBIC, MAIC	
PP*	4	-2.411	-3.477	-2.883	-2.573	Newey-West	I(1)
PP (w/Trend)*	4	-1.178	-4.007	-3.437	-3.137	Newey-West	
KPSS (w/Trend)	4	0.47	0.217	0.148	0.12		I(1)
KPSS	4	3.94	0.739	0.462	0.348		

[12] The same battery of unit-root test was applied to both series differenced one time, leading to the result they are stationary.

			PPI				
DF-GLS (w/Trend)*	11	-2.116	-3.46	-2.837	-2.557	Ng-Perron, MAIC	I(1)
	2	-2.162	-3.46	-2.928	-2.64	SBIC	
PP (no Trend)*	4	-1.691	-3.477	-2.883	-2.573	Newey-West	I(1)
PP*	4	-1.248	-4.007	-3.437	-3.137	Newey-West	
KPSS (w/ Trend)	4	0.264	0.217	0.148	0.12		I(1)
KPSS	4	3.727	0.739	0.462	0.348		
***Maximum lag-length selection set to 12**							

Source: Authors' own calculations

Table 7 - The Zivot-Andrew Test for Structural Break

		CPI		
lags	break	t-stat	10%	Results
1	2007m9	-3.819	-4.58	I(1)
		PPI		
lags	break	t-stat	10%	Results
2	2007m6	-4.167	-4.58	I(1)

Source: Authors' own calculations

Accordingly, cointegration test has to account for the presence of such break, and therefore the standard Johansen test would not be appropriate. The Johansen, Mosconi, and Nielsen (2000) methodology has been used (see the specification in (4)). A constant has been restricted to the cointegrating relationship and results are detailed in Table 8 below.

Table 8 – Johansen Trace Test for Cointegration

Rank	Trace	Frac95	P-Value
0	27.832	26.406	0.033
1	8.224	12.836	0.266
The number of lags to include was selected accordingly to the SBIC, and it was set to 1			

Source: Authors personal calculations

By normalizing on consumer price, we obtain $Cp = 0.206Pp + 0.149D_t + 3.576$, where D_t is the dummy variable for structural break with $\mathrm{t} = 2007{:}08$; meaning that only 20.6% of a one unit shock in the producer price is transmitted to the consumers. This clearly appoints to an imperfect price transmission, since the relationship between the two prices is not $\beta(1,-1)$. Regarding the adjustment coefficients, we carried out the weak-exogeneity test in order to statistically prove which price is weakly-exogenous (i.e. does not adjust to the long-run disequilibria). Producer price is weakly-exogenous, confirming the results of previous studies that cost-push mechanism leads the dynamic of PT in agricultural markets (Abdulai, 2002; Ben-Kaabia and Gil, 2007; von Cramon-Taubadel, 1998; Santeramo and von Cramon-Taubadel, 2016)[13]. Moreover, in order

[13] For the Cp and Pp results of weak-exogeneity test were 10.609 and 3.453, respectively, before a 5% C.V. of 3.841. Therefore, we accept the null of $\alpha_i = 0; i = Cp, Pp$ in the producer price case only.

to reinforce the exogeneity assumption, Granger-Causality test was investigated, leading to the exogeneity of producer price (see Table 9).

Table 9 - Granger Causality Wald Test for a VAR(2)

Equation	Excluded	χ^2	d.f.	p-value
$\Delta \boldsymbol{Cp}$	ΔPp	18.285	2	0
$\Delta \boldsymbol{Pp}$	ΔCp	2.108	2	0.348

Note the null hypothesis has to be read as: for each equation, we test if the excluded variable does not Granger cause the independent. A p-value greater than 0.05 (i.e. 5%) means we cannot reject the null and, hence, the variable set as independent is exogenous

Source: Authors own calculations

Before the modeling of APT, one more step is needed, that is the calculation of the Error Correction Term; from the linear cointegrating regression, $ECT_t = Cp - \alpha_0 - Pp - D_{2007:08} = \mathrm{Cp} - \alpha_0(-0.004) - \mathrm{Pp}(0.994) - D_{2007:08}(0.040)$. Given the exogeneity of the Pp[14], we set Cp as the independent variable for estimating the (A)ECM.

First, we estimated an ECM to understand if the two prices eventually adjust in the long-run. Results are presented in Table 10 below, and they confirm there exists a long-run equilibrium between producer and consumer prices (the lagged error correction term in the third row is significantly different from 0).

Table 10 – Estimates from the ECM(1)

ΔCPI	Coef.	Std. Err.	t-Stat	P>t
$\Delta \boldsymbol{PPI_{t-1}}$	0.115771	0.034235	3.38	0.001
$\boldsymbol{ECT_{t-1}}$	-0.01554	0.006114	-2.54	0.012
$\Delta \boldsymbol{CPI_{t-1}}$	0.560485	0.057423	9.76	0
$\boldsymbol{\alpha_0}$	0.000651	0.00019	3.44	0.001

Source: Authors own calculation

To deepen the understanding of asymmetric price dynamics in the short-run only, we specified an asymmetric short-run model (ASRM) such as: $\Delta P_c = \alpha_0 + \sum_{i=1}^{k-1} \Gamma_i \, \Delta Pc_{t-i} + \sum_{i=1}^{k-1} \psi_i \, \Delta^+ Pp_{t-i} + \sum_{i=1}^{k-1} \psi_i \, \Delta^- Pp_{t-i} + \mu_t$, whose estimates are presented in Table 11.

Table 11 – Estimates from the ASRM(1)

ΔCPI	Coef.	Std. Err.	t	P>t
$\Delta^+ \boldsymbol{PPI_{t-1}}$	0.142415	0.044843	3.18	0.002
$\Delta^- \boldsymbol{PPI_{t-1}}$	0.108102	0.07538	1.43	0.153
$\Delta \boldsymbol{CPI_{t-1}}$	0.599437	0.056387	10.63	0
$\boldsymbol{\alpha_0}$	0.000505	0.000239	2.12	0.036

Source: Authors own calculation

[14] The estimation of the marginal model suggested in von Cramon-Taubadel (1998) for ensuring the exogeneity is detailed in the Appendix I.

Only positive changes in the producer price are significant, and therefore only when producer price increases (i.e. margins are squeezed) the consumer price response is significant. This dynamic seems quite in line with the existing literature claiming prices behave like “feathers” when margins stretch and “rockets” when they squeeze. However, estimating an AECM will provide a deeper understanding of asymmetric price dynamics. We estimate the model expressed in (2), although we excluded the contemporaneous effect of the ΔPp_t, since retail prices in agricultural markets take time to respond to shock, such as $\Delta P_c = \alpha_0 + a_1^+ ECT_{t-1}^+ + a_2^- ECT_{t-1}^- + \sum_{i=1}^{k-1} \Gamma_i \Delta P_{c,t-i} + \sum_{i=1}^{k-1} \psi_i \Delta P_{p,t-i} + \varepsilon_t$.

Table 12 – Estimates from the AECM(1)

ΔCPI	Coef.	Std. Err.	t	P>t
ΔCPI_{t-1}	0.539381	0.057903	9.32	0
ECT_{t-1}^+	0.003487	0.011152	0.31	0.755
ECT_{t-1}^-	-0.04197	0.014346	-2.93	0.004
ΔPPI_{t-1}	0.105854	0.034311	3.09	0.002
α_0	0.000124	0.000321	0.39	0.7
F-test	H_0	**F-stat**	**p-value**	
F(1,194)	$H_0 = ECT_{t-1}^+ + ECT_{t-1}^- = 0$	9.23	0.002	

Source: Authors’ own calculation

Only when $P_p > P_c$ (i.e. negative ECT) the system adjusts to the steady-state (i.e. Positive Asymmetries). This result is consistent with the ASRM, in which only positive changes in the producer price are significant to the consumer price. An F-test was carried out in order to check if there exists asymmetry in the price transmission process and the statistic resulted to be smaller than the C.V. at 1% (see the last row in Table 12), hence we rejected the null of symmetric adjustment. To deepen the understanding of asymmetric price dynamics, an asymmetric short-run model (AECM-SR) as in (3) was estimated, and results are reported in Table 13.

Table 13 – Estimates from AECM-SR(1)

ΔCPI	Coef.	Std. Err.	t	P>t
ΔCPI_{t-1}	0.534472	0.058588	9.12	0
ECT_{t-1}^+	0.003394	0.011172	0.3	0.762
ECT_{t-1}^-	-0.04242	0.01439	-2.95	0.004
ΔPPI_{t-1}^+	0.12241	0.044271	2.77	0.006
ΔPPI_{t-1}^-	0.066435	0.074801	0.89	0.376
α_0	0.000036	0.000353	0.1	0.919
F-test	H_0	**F-stat**	**p-value**	
F(1,194)	$ECT_{t-1}^+ + ECT_{t-1}^- = 0$	9.41	0.0025	
F(1,194)	$\Delta^+ Pp_{t-1} - \Delta^- Pp_{t-1} = 0$	5.74	0.0175	

Source: Authors’ own calculation

Only positive changes in the producer price are significant, and therefore only when producer price increases (i.e. margins are squeezed) the consumer price response is significant. This dynamic seems quite in line with the existing literature, claiming prices behave like “feathers” when margins stretch and “rockets” when they squeeze. This is confirmed by the behavior of the ECT. Both F-tests (see the last two rows of Table 13) confirm the existence of both long and short-run asymmetries.

However, we might introduce the structural break we found in the initial steps of our analysis. Therefore, we introduced a break in the ECTs in the AECM-SR, such that

$$\Delta P_c = \alpha_0 + \alpha_1 ECT_{t-1}^{+} + \alpha_2 ECT_{t-1}^{-} + \sum_{i=1}^{k-1} \Gamma_i \, \Delta Pc_{t-i} + \sum_{i=1}^{k-1} \psi_1 \, \Delta^{+} Pp_{t-i} + \sum_{i=1}^{k-1} \psi_2 \, \Delta^{-} Pp_{t-i} + \alpha_3(ECT_{t-1}^{+} * D_t) + \alpha_4(ECT_{t-1}^{-} * D_t) + \mu_t$$

Where D_t takes the value 1 when $t > T, T = August\ 2007.$

Table 14 – Estimates from the AECM-SR(1) with a structural break in the ECT

ΔCPI	Coef.	Std. Err.	t	P>t
$\boldsymbol{\Delta CPI_{t-1}}$	0.494913	0.060311	8.21	0
$\boldsymbol{ECT_{t-1}^{+}}$	0.015428	0.012174	1.27	0.207
$\boldsymbol{ECT_{t-1}^{-}}$	-0.03901	0.01485	-2.63	0.009
$\boldsymbol{ECT_{D,t-1}^{+}}$	-0.03723	0.017131	-2.17	0.031
$\boldsymbol{ECT_{D,t-1}^{-}}$	-0.01784	0.017358	-1.03	0.305
$\boldsymbol{\Delta PPI_{t-1}^{+}}$	0.125666	0.045739	2.75	0.007
$\boldsymbol{\Delta PPI_{t-1}^{-}}$	0.005552	0.080136	0.07	0.945
$\boldsymbol{\alpha_0}$	1.68E-05	0.000351	0.05	0.962
F-test	$\boldsymbol{H_0}$	**F-stat**	**p-value**	
F(1,190)	$ECT_{D,t-1}^{+} + ECT_{D,t-1}^{-} = 0$	5.17	0.024	
F(1,190)	$ECT_{D,t-1}^{+} - ECT_{t-1}^{-} = 0$	0.01	0.94	

Source: Authors' own calculation

Estimates (see Table 14) confirmed previous models results, even though after the structural break the term $ECT_{D,t-1}^{+}$ turns significatively different from zero, meaning that when margins are stretched, consumer price re-adjusts to the equilibrium also. In order to understand if there still exists some asymmetries in price dynamics, the F-Test (see the last row of Table 14) has been used, resulting in accepting the null of equality. Therefore, in the post-break period the price transmission turned (more) efficient.

Following Ben-Kaabia et al. (2005) and Santeramo (2015), we estimated the half-lives for each model specification, that is the periods required for the system to achieve ε% adjustment to their new equilibrium after an exogenous shock occurred. They are expressed at the same time series frequency of the data one has used. For an ECM specification, they are expressed as $\mathrm{H} = \frac{\ln(1-\varepsilon)}{\ln(1+\rho)}$, where ε is the factor of adjustment and ρ is the speed of adjustment of the ECT, i.e. the associated coefficient (α_j), and H is the number of months the system implies to reach the equilibrium again.

Table 15 – Half-lives for each model specification

Model	Coefficient	% ε	ρ	H
AECM	ECT_{t-1}^{-}	0.5	-0.04197	16.166
		0.75		32.333

		0.9		53.703
		0.99		107.41
AECM-SR	ECT^{-}_{t-1}	0.5	-0.04242	15.991
		0.75		31.982
		0.9		53.121
		0.99		106.24
AECM-SR (w/ structural break)	ECT^{-}_{t-1}	0.5	-0.03901	17.42
		0.75		34.839
		0.9		57.867
		0.99		115.73
	$ECT^{+}_{D,t-1}$	0.5	-0.03723	18.269
		0.75		36.538
		0.9		60.689
		0.99		121.38

Source: Authors' own calculations

Looking at the 50% adjustment, there is a slight decrease in the speed of adjustment in the post-break, of roughly 1.5 months, regarding the squeezed-margin scenario. However, the two speeds in the post-break period are quite the same, despite a slightly quicker adjustment when margin are squeezed.

6. Conclusions

The paper explores the VPT process within the Italian dairy industry, a major agrifood sector which has been on the spot in recent years as a consequence of the liberalization policy put in place by the European Commission. Indeed, the authors try to assess the impacts of such policies on the price transmission dynamics along the fluid milk supply chain. Diverse AECM specifications have been estimated in order to understand if asymmetries characterize the PT process in the investigated market. Moreover, a structural break was detected in the mid-2007, corresponding to an increase in volatility for most agricultural commodities, together with an increase in trade in the dairy sector in Italy. Moreover, since the 2008/2009 marketing campaign, the quota regime has started a progressive increase until March 2015, and a decrease in the intervention price for butter has been set in June 2007. Consequently, the employed modeling techniques have taken such structural change into account.

Firstly, we assessed the existence of APTs in the Italian dairy industry through a standard AECM. We found a pass-through transmission, that is going from producer to retailing only. Positive asymmetries were found, i.e. only when producer (retailer) price increases (decrease) there is a significant adjustment back to the equilibrium. Therefore, only when margins are squeezed the system responds to shocks. We then introduce asymmetries in the short-run parameters, and consistently with the AECM results, only the lagged positive change in the producer prices were significant.

The statistical test for structural break detected a change in August 2007. The new measures the European Commission put in place led to a more integrated European dairy markets into the world markets, increasing volatility and boosting trade. Indeed, we found that volatility increased in the second period, although consumer prices do not witness a massive increase as producer prices do. The trade volume also increased, in general, and in particular with regard to the exports. The more liberalization the sector experienced has eventually influenced the PT process. In the post-break period, also when marketing margins are stretched the system corrects the disequilibrium. However, the coefficients for the ECT, for the whole and post-break periods, are not statistically different, leading to a symmetric PT along the chain, since the speed of adjustment to positive and negative shocks is of the same magnitude. The explanation for this behavior may be found in Ward (1982), where he figured out that for perishable products one might expect negative asymmetries since retailers may face spoilage if sales reduce. Moreover, when perishable products are concerned, one might expect less asymmetric adjustments (Peltzman, 2000; Santeramo and von Cramon-Taubadel, 2016; Serra and Goodwin, 2003). However, this do not explain why in the pre-break scenario this was not happening. In one hand, an increase in volatility may entail more efficient, hence symmetric, price dynamics (Ganneval, 2016). On the other hand, a heavier governmental intervention may led to asymmetric dynamics as found by Serra and Goodwin (2003). The increase in the trade volumes may also change the slopes of supply and demand, hence different elasticities (i.e. curves shall be more elastic). We also have to consider the change in consumer preferences, since the consumption of cow fluid milk has been decreasing in the latest years, what could affect the cross-price elasticities with fresh milk substitutes (e.g. vegetable milk, organic milk, enriched milk, UHT milk). This may affect retailers' behaviour, whom may fear spoilage and, hence, be more market-oriented. Furthermore, consumer search costs shrank in the last years, due to an easier and quicker access to information: this enhances the importance of a strategy looking at the market trends, since competitors may easily catch more customers with a more efficient price strategy.

When we compare the different half-lives, we see a quite slow-adjusting sector: correcting the 50% of the shock may take up to 17 months if we consider the entire period, while this time spans more (i.e. 18 months) when we consider just the post-break regime. So apparently, the more liberalized market increased (or do not have any impact) on the speed of adjustment along the supply chain. On the other hand, since a liberalization means the entry of new competitors, one could argue the retail prices now depend not only on the national-produced milk but also on other international suppliers. This may be true when considering high-processed products (e.g. industrial mozzarella or UHT milk, where the freshness of the raw material is not of concern), but for a fresh product such as the fresh fluid milk with a few days-shelf-life, this hypothesis may be weak. Hence, even in a more volatile scenario, the speed of adjustment didn't change or, if it does, it increased. The latter scenario may be consistent with the widely spread retailer's behavior of exerting their market power: in the case of negative asymmetries, the re-adjustment takes more time that it does in regard to positive asymmetries. Consequently, retailers can maintain higher margins for longer periods.

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APPENDIX I

Marginal Model for Testing Exogeneity for the Pp:

$$\Delta P_p = \alpha_0 + \sum_{i=1}^{k-1} \Gamma_i \, \Delta P_{c,t-i} + \sum_{i=1}^{k-1} \psi_i \, \Delta P_{p,t-i} + v_t$$

the $\hat{v}_{t-1}$ were estimated and plugged into the ECR

$$\Delta P_c = \alpha_0 + \alpha_1 \left(P_{c,t-1} - \beta_0 - \beta_1 P_{p,t-1}\right) + \sum_{i=1}^{k-1} \Gamma_i \, \Delta P_{c,t-i} + \gamma_1 \Delta P_p + \sum_{i=1}^{k-1} \psi_i \, \Delta P_{p,t-i} + \delta_1 \hat{v}_{t-1} + \mu_t$$

as well as into the AECR

$$\Delta P_c = \alpha_0 + a_1^+ ECT_{t-1}^+ + a_2^- ECT_{t-1}^- + \sum_{i=1}^{k-1} \Gamma_i \, \Delta P_{c,t-i} + \gamma_1 \Delta P_p + \sum_{i=1}^{k-1} \psi_i \, \Delta P_{p,t-i} + \delta_1 \hat{v}_{t-1} + \varepsilon_t$$

The residuals from the marginal model result in being non-significant in both cases, and, hence, prevents the rejection of the null hypothesis of weak-exogeneity to short-run parameters.

Marginal Model Estimates

ΔP_p	Coef.	Std. Err.	t	P>t
Γ_i*	.1503525	.1123403	1.34	0.182
ψ_i*	.4932108	.0686206	7.19	0.000
α_0	.0003261	.0003793	0.86	0.391

*SIC indicates one lag has to be included

Weak-Exogeneity Test in the ECR

ΔP_c	Coef.	Std. Err.	t	P>t
ψ_i	.156332	.0715323	2.19	0.030
γ_1	.1379021	.0338763	4.07	0.000
α_1	-.0142241	.0060028	-2.37	0.019
Γ_i	.4956704	.058995	8.40	0.000
δ_1	-.1326526	.0705737	-1.88	0.062
α_0	.0005659	.0001831	3.09	0.002

Weak-Exogeneity Test in the ECR

ΔP_c	Coef.	Std. Err.	t	P>t
Γ_i	.4840481	.0591374	8.19	0.000
a_1^+	.0005263	.0106896	0.05	0.961
a_2^-	-.035664	.0142017	-2.51	0.013
ψ_i	.1372335	.0721223	1.90	0.059
γ_1	.1349431	.0337673	4.00	0.000
δ_1	-.1178216	.0708121	-1.66	0.098
α_0	.0001553	.0003067	0.51	0.613

Aimed at testing also the weak-exogeneity of Pp regarding the long-run parameters, we tested for the statistical significance of the $ECT_{t-1}, ECT_{t-1}^{+}, ECT_{t-1}^{-}$ into the marginal model, such as:

$$\Delta P_p = \alpha_0 + \sum_{i=1}^{k-1} \Gamma_i \, \Delta P_{c,t-i} + \sum_{i=1}^{k-1} \psi_i \, \Delta P_{p,t-i} + \alpha_1\left(P_{c,t-1} - \beta_0 - \beta_1 P_{p,t-1}\right) + v_t$$

and:

$$\Delta P_p = \alpha_0 + \sum_{i=1}^{k-1} \Gamma_i \, \Delta P_{c,t-i} + \sum_{i=1}^{k-1} \psi_i \, \Delta P_{p,t-i} + a_1^{+} ECT_{t-1}^{+} + a_2^{-} ECT_{t-1}^{-} + v_t$$

Estimates from the Marginal Model with the ECT

ΔP_p	Coef.	Std. Err.	t	P>t
ψ_i	.4980574	.0700114	7.11	0.000
α_1	.0046224	.0125035	0.37	0.712
Γ_i	.1626874	.1174296	1.39	0.168
α_0	.000298	.0003877	0.77	0.443

Estimates from the Marginal Model with the ECT split into positive and negative values

ΔP_p	Coef.	Std. Err.	t	P>t
ψ_i	.4870199	.0706924	6.89	0.000
a_1^{+}	.0257962	.0229768	1.12	0.263
a_2^{-}	-.0247918	.0295569	-0.84	0.403
Γ_i	.1391981	.1193005	1.17	0.245
α_0	-.0002894	.0006605	-0.44	0.662

All the ECT added in the two models resulted being non-significant. Thus, we cannot reject the null hypothesis of Pp weak-exogeneity from long-run parameters.

The Johansen, Mosconi, and Nielsen (2000) cointegration test we applied is as follows:

$$\Delta P_t = \alpha\left(\beta' P_{t-1} + \delta_1 (t-1) D_{1.t} + \delta_2 (t-1) D_{2,t}\right) + \sum_{i=1}^{k-1} \Gamma_i \Delta P_{t-i} + \sum_{i=1}^{k} \theta_i D_{1,t-i} + \varepsilon_t \qquad (4)$$

Where ΔP_t is the vector of our price series; $D_{1.t}$ is a dummy variables which takes the value 1 whenever $t > T_1$ and zero otherwise; $D_{2,t} = 1 - D_{1,t}$; Γ_i and θ_i are matrices of short-run parameters; δ_1, δ_2 are parameter vectors referred to the intercepts of the two regimes (Ben-Kaabia et al., 2005).

Further estimated models:

ECM with structural break

ΔCPI	Coef.	Std. Err.	t	P>t
ΔPPI_{t-1}	0.101784	0.034703	2.93	0.004
ECT_{t-1}	-0.00824	0.007097	-1.16	0.247
$ECT_{t-1} * D_t$	-0.02387	0.012031	-1.98	0.049
ΔCPI_{t-1}	0.535444	0.058373	9.17	0

$\boldsymbol{\alpha_0}$	0.000708	0.00019	3.72	0

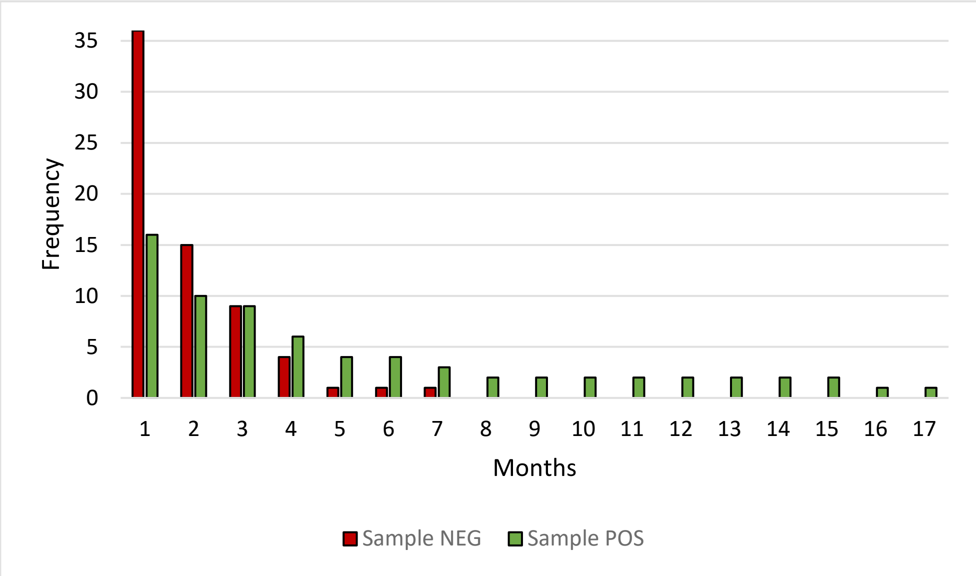
AECM-SR with Structural Break

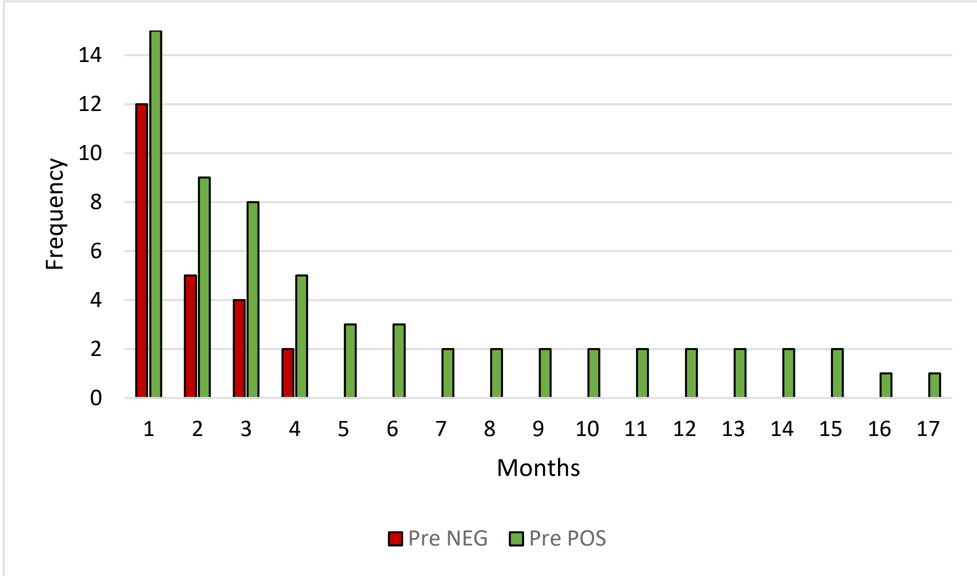
$$\Delta P_c = \alpha_0 + \alpha_1 ECT^{+}_{t-1} + \alpha_2 ECT^{-}_{t-1} + \sum_{i=1}^{k-1} \Gamma_i \, \Delta Pc_{t-i} + \sum_{i=1}^{k-1} \psi_1 \, \Delta^{+} Pp_{t-i} + \sum_{i=1}^{k-1} \psi_2 \, \Delta^{-} Pp_{t-i} + \alpha_3 (ECT^{+}_{t-1} * D_t) + \alpha_4 (ECT^{-}_{t-1} * D_t) + \left(\sum_{i=1}^{k-1} \psi_3 \, \Delta^{+} Pp_{t-i} * D_t\right) + \left(\sum_{i=1}^{k-1} \psi_4 \, \Delta^{-} Pp_{t-i} * D_t\right) + \mu_t$$

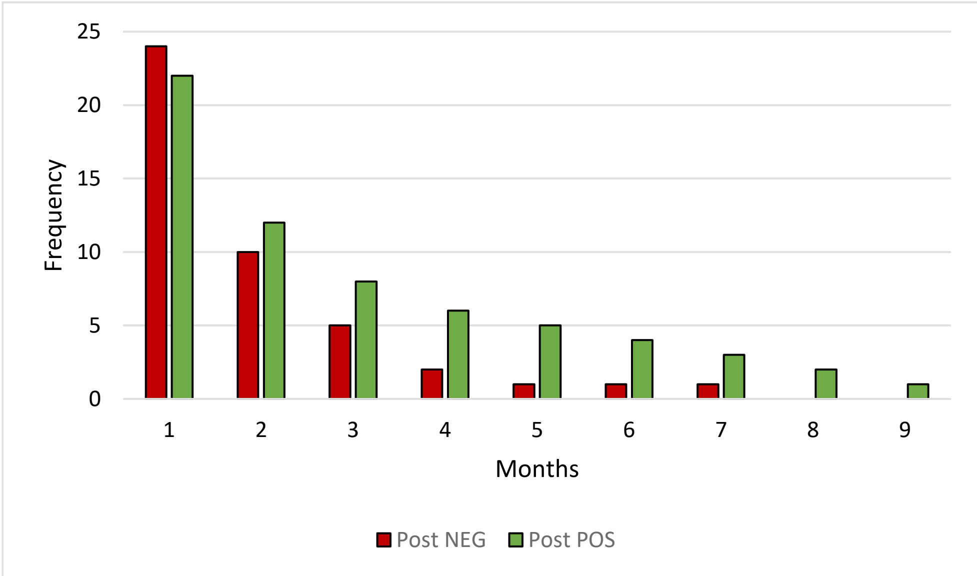
AECM-SR with Structural Break

Variables	**AECM(1) SR w/ break**			
$\boldsymbol{\Delta P_c}$	**Coef.**	**Std. Err.**	**t**	**P>t**
$\boldsymbol{\Delta Pc_{t-1}}$	0.499308	0.060253	8.29	0
$\boldsymbol{\alpha_1}$	0.021159	0.012575	1.68	0.094
$\boldsymbol{\alpha_2}$	-0.05197	0.016392	-3.17	0.002
$\boldsymbol{\alpha_3}$	-0.04514	0.018687	-2.42	0.017
$\boldsymbol{\alpha_4}$	0.004593	0.021354	0.22	0.83
$\boldsymbol{\psi_1}$	-0.02315	0.092607	-0.25	0.803
$\boldsymbol{\psi_2}$	0.057473	0.188374	0.31	0.761
$\boldsymbol{\psi_3}$	0.188201	0.101823	1.85	0.066
$\boldsymbol{\psi_4}$	-0.06064	0.199094	-0.3	0.761
$\boldsymbol{\alpha_0}$	2.35E-05	0.000355	0.07	0.947

Persistence of Positive and Negative Changes







Margin's Box-Plots