An investigation into the price transmission between producers and retailers within the UK milk market

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AN INVESTIGATION INTO THE PRICE TRANSMISSION BETWEEN PRODUCERS AND RETAILERS WITHIN THE UK MILK MARKET

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Abstract

The main aim of this article is to investigate the price transmission of milk between the producers and the retailers within the UK to understand the influence of large retailers on the market. In recent times smaller dairy farms have been forced to close down because they believe that prices are not being conveyed from retailers to producers. The research interlinks well-established econometric tests, which are frequently used within vertical price transmission research to gain an understanding of the transmission from producer to retailer. These are unit root tests, cointegration tests and causality test. The main findings were that there is a unidirectional transmission of milk prices in the UK between producers and retailers. The Granger causality test shows that causality runs from the retailer to the producer and but not from the producer to the retailer. There was a significant break in 1994, which is when the MMB disbanded and has provided a new research gap. The direction of causality means that when producers are losing out to large retailers. The ECM results indicate that the prices are slow in recovering to a new equilibrium after a shock has occurred. Research specifically on the UK milk market is limited and therefore this research is a basis for future studies, which will help policy makers when moving forward post brexit.

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Key Words

Price transmission; retailer; producer; milk.

INTRODUCTION

This research is going to investigate the vertical price transmission of milk between producer prices and the retailer prices within the UK. Price transmission is the process, which measures the relationship of prices between two markets. The two types of price transmission are horizontal and vertical. Horizontal price transmission explores the relationship of prices across different markets for example across two countries. This provides a good comparison between two similar markets, which is useful for benchmarking. Vertical price transmission measures the relationship upstream and downstream within the specified market. It is used to assess where value is added within supply chains and particularly within agriculture to establish the relationship between producers and big retailers. Both horizontal and vertical price transmissions have been used effectively in econometrics to investigate the relationship of prices during fascinating and challenging financial times. Agricultural products are notoriously volatile in price and therefore econometric techniques are frequently used to investigate the relationships of prices.

On average UK dairy farms are increasing in size and productivity is rising causing smaller dairy producers to struggle to cope with decreasing prices paid from retailers and increasing production costs on farm. The result of this is that many smaller producers have had to resign from milk production. The anger from producers is being directed at large retailers who hold massive bargaining power when it comes to negotiating prices. In order to protect the UK dairy industry in the future it is necessary to understand where the issues are.

This dissertation will conduct a literature review, which will analyse current research in order to gain an understanding of what methods previous studies have used and what they have already found. This will establish a gap in the current literature where more research needs to be undertaken and expose which methods are successful and which methods have limitations. The methodology will then outline the details of how the research is going to be completed. From the literature review it should be possible to get a good interpretation of what econometric approaches will be useful and applicable. The methodology will outline what type of data is required and how it will be collected, what theories will be applied and what statistical tests will be used. Once the research has been undertaken the results will be displayed. Relevant comments will support the results and where applicable explanations will be provided for the findings. Lastly the research will be concluded, binding together the whole research proposal and listing any comparisons with previous research, any weaknesses and any strong findings. This will establish any areas for further research.

LITERATURE REVIEW

The Application of Price Transmission

Agricultural markets are one of the most common areas of study for price transmission as a result Meyer and Cramon- Taubadel (2004) investigated how effective asymmetric price transmission actually is. They used a number of methods to examine possible causes of asymmetric price transmission and they investigated the empirical tests used to determine results. They found that research struggled to combine both the theoretical and methodological aspects of asymmetric price transmission. It was established that in particular the agricultural studies, which account for large proportions of this work, failed to link theory and methods together. As a result researchers in other fields of economics often overlooked these studies. They suggest that more emphasis needs to be put on the quality of the data, the relevance of the results in relation to the external economy and explanations behind the results. This led to modern research using techniques that could prove the validity and reliability of the data.

Price transmission has been studied extensively and Conforti (2004) researched claims that there were as many as six factors affecting price transmission models. These were Transport and Transaction costs, Market Power, Increasing Returns to Scale in Production, Product Homogeneity and Differentiation, Exchange Rates and Border and Domestic policies. It was believed that these factors contribute to the behaviour of a vertical or horizontal price transmission model. These factors are important to understand, as they will have an influence on the results of future studies (Conforti, 2014). The research looked to provide support and point out weaknesses of price transmission within agriculture. The research was based on a range of countries all of which have a strong basic food commodity trade improving the significance of the studies results. Due to the scale of the investigation it is difficult to generalise the results however a geographical regularity was discovered providing evidence that the price transmission model is accurate. It was also found that transmission within a domestic market is more integrated than transmission between domestic and border prices. When analysing data for a given product it is more reliable to use figures from producers, retailers and wholesalers within a domestic market instead of incorporating world prices. The last finding was that price transmission arose for products that are regulated by public intervention, for example policies. Many of the potential pitfalls highlighted in this study would not affect data, which is contained within one country.

The six factors Conforti (2014) identified as price transmission influencers are reciprocated in other studies. An et al (2016) found that boarder and domestic policies were key components to the volatility of wheat and flour market prices in Ukraine. In addition to this Assefa et al (2014) explained how market power affected the asymmetry of Dutch potato prices between retailers and farmers. Farm price decreases were not fully transmitted to the retailer price however farm price increases where almost perfectly

transmitted to the retail price. The limited markets available for producers to sell their potatoes explained this. With few retailers, due to their colossal size, there isn't any alternative competition for producers to market their potatoes to. Parsley (2003) inspected the influence exchange rates have on both vertical and horizontal price transmission. The exchange rate pass-through was compared within world prices and within domestic prices. The results demonstrated that individual domestic markets are more responsive to currency rate changes, which isn't reciprocated at world price levels. This was expected as previous research from Goldberg and Knetter (1996) had mirrored these results, however this was on a larger scale and therefore more reliable. Research in to exchange rates and in particular the pass-through is imperative for policy makers within countries as decisions being made will affect the domestic market structure (Baldwin, 1988). This will therefore have an impact on the price of goods and influence the price transmission between producers and retailers. These findings are significant as it confirms that the six influencers Conforti (2014) found, hold true for a large number of markets and therefore need considering when analysing milk prices.

Previous Empirical Results

The nature of examining price transmission means that using secondary data is the most effective data to use (Lloyd, 2017). Slagboom et al (2016) conducted online surveys to collect primary data to explore the organic dairy industries production in comparison to conventional farmers. Using online surveys meant a large amount of surveys could be conducted however participants may not be motivated to answer appropriately and therefore the validity and reliability of the data is questionable. The study is limited because of the methods Slagboom et al (2016) used in collecting data. Similarly to this Tuckett (2012) used an interview technique to gather market information on financial markets. When using quantitative tests in research it has often been argued that this method of collecting data is unsuitable (Gray, 2013). However Tuckett (2012) found that interviews could be an effective tool for backing up finical data and give explanatory narrative to quantitative data. It has to be noted that this was based solely on one interview, which shows significant fragilities within the research. When conducting this research it will be possible to give qualitative explanations for the data by reading extensively around the topic. Having access to huge amounts of qualitative data online will give sufficient explanations to back up any findings.

  McLaren (2015) researched world markets and their effect on local agricultural markets asymmetry in price transmission. The consequences in local markets of a poorer price transmission could mean farmers going below the poverty line (Mosley and Suleiman, 2007). Mclaren (2015) found that where there was a bigger presence of large intermediaries, big powerful organisations like Cargill, then the asymmetry is stronger. Local agricultural markets can be harmed, particularly in poorer countries by a high degree of asymmetric price transmission when large intermediaries are present. This is

also the case in recent years for UK milk producers who have seen their payments decrease to levels below the cost of production (AHDB. 2017).

Investigating the relationship between the producer and retailer has become more interesting recently as it is claimed that retailers have obtained too much buying power (Acosta and Valdés, 2014). They suggest that a lack of communication between the milk sector and government organisations has lead to insufficient policies being used within dairy markets around the world. In view of this, econometric analysis has developed so that the relationships of the price between producers and retailers can be easily studied (Hassouneh et al., 2012). As a result it is possible to understand what causes the price fluctuations. Hassouneh et al's (2012) explored techniques where co-integration and whether unit roots did or did not exist. Unit roots signify whether data is stationary, which means it is reliable and valid for testing. Co-integration examines whether the data has a long run relationship. The methods they used to test for unit roots were the ADF test (Dickey and Fuller, 1979) and the PP test (Perron, 1997). They concluded that if the data had unit roots then it was applicable to test for co-integration. If unit roots are not present then instead use the vector error correction model for co-integration, with stationary data. Hassouneh et al (2012) tested co-integration using Johansen's (1988) approach. It was concluded that if there was co-integration and therefore there was a long run relationship between the two sets of pricing, then further in-depth analysis could be applied. This includes Threshold Vector Error Correction Model and the Smooth Transition Vector Error Correction Model (Hassouneh et al., 2012). If co-integration did not exist then it should be tested using prices in first difference. Weldesenbet (2013) used this methed to test the asymmetric price transmission of liquid milk in Slovakia. There were worries over the productivity of the milk market price transmissions as the country saw a divergence of prices. Johansen's (1988) co-integration test and Granger's (1969) causality test was used. It was proved that the wholesalers and producers prices were co-integrated, as were the retailers and producers prices. The direction of causality is from the producers to the retailers and to the wholesalers, which means that if the producer price changes it effects the retailer price and the wholesaler price and therefore it was concluded that the Slovakian milk market is asymmetric. The methods used were similar to the findings of Hassouneh et al (2012) and the asymmetric results coincide with a volatile milk price seen in Slovakia.

Vertical and Horizontal Price Transmission

The steps used by Hassouneh et al (2012) and Weldesenbet (2013) are used in much of the contemporary research on price transmission. Bakucs et al (2012) used the same steps, Unit Root test, Co-integration and Causality test to examine the price transmission in the milk sector. The thing that separated this study was that it was one of the first journals to consider the price transmission across two countries, being Poland and Hungary. After confirming cointegration exists they found that in Poland the causality runs from the retailer to the producer however in Hungary it runs from the

producer to the retailer. In Poland the retailer price affects the producer's price whereas in Hungary, like Slovakia, the producer's price affects the retailer's price. This was explained by the high power of the dairy producers in Hungary, which does not exist in Poland. What it so effective about the methods used to analyse horizontal price transmission is that it can be applied to any country and any commodity and it is comparable, like in this instance, across two countries. By comparing two countries the study is not limited in the understanding of the speed and size of price adjustments as there is a direct comparison. The differences that arose between the countries gave evidence, which actually explained the speed and nature of price transmission. With a growing uncertainty around milk producers in Europe it is necessary to compare and contrast with similar countries in order to try and gain an understanding of the problems. Most theories suggest that the producer struggles are a result of increases in price from the retailers, which are not being transmitted down steam in the supply chain. In addition Bakucs et al (2012) also conducted the tests with structural breaks, which gives further confidence in the results that where obtained as it shows any shocks and spikes in the prices were considered.

Asche et al (2007) used both vertical and horizontal techniques when examining market integration and price transmission of salmon. The usual unit root testing and cointegration tests were applied but the producer prices were from the UK and Norway and the retailer prices were from France. Having multiple countries provided the horizontal aspect of analysing price transmission. The benefits of this are that there is a direct comparison of the two producing countries and therefore the trade disputes that have arisen can be answered for and settled. The results show a high level of integration and price transmission in both UK and Norwegian Salmon. There was no competition between the two countries at producer level however having a high level of price transmission means that any restrictions or advantages across the whole Norwegian supply chain will benefit or harm the UK supply chain at the corresponding level. Therefore the effects of salmon companies in Norway becoming more international could put pressure on the price of the UK producers. While an obvious advantage is that Asche et al (2007) had access to data from 3 countries and 2 complete supply chains the data was only for a six year period. This is a relatively short-medium term period and therefore the data may not be valid in the long run. In addition the French retailer prices could not be separated for Norwegian producers or UK producers leading to more potential inaccuracies. While the horizontal and vertical approaches combined have yielded more functional results, the data restrictions appear to have a large influence on how reliable and creditable the research actually is.

There is very little research about the price transition patterns of milk for the UK. Considering the recent hard times of UK milk producers it is surprising that this it has not been more thoroughly investigated. Franks and Hauser's (2012) research collected data using an online survey of UK milk producers, which it could be argued would give an imbalanced view. In addition using an on-line survey to gather data may be unreliable as only those who have a really biased viewpoint will take the time to answer it. The

need for the research was because the UK's MMB was disbanded in 1994, which left a void between milk producers and milk retailers. Franks and Hauser (2012) recognised this gap and explored two titles in relation to milk prices; "marginal value in the least remunerative use" or whether "the market had put in place some other mechanism for raising the price upwards" following the MMB collapse. They found that a better transparency of prices would result in better prices for the producer. The producers achieving the best price were the ones selling direct to processors rather than selling to one of three main farmer owned cooperatives. Conclusions found that since the break up of the MMB there could have been more done to protect the prices producers were paid for their milk. While Franks and Hauser (2012) raise some interesting points, there methods mean that only milk producers have taken part in the research. For future research it would be important to get a balanced perspective by using data from both the producers and the retailers. Despite this pitfall, there is an obvious need to look in more depth at the price being paid to producers and whether it reflects the price retailers are receiving.

The only current similar research to the price transmission of milk in the UK is for other products. Sanjuán, and Dawson (2003) examined price transmission between the retailer and producer for the prices of beef, lamb and pork. The purpose of this research was to investigate the affect the BSE crisis, which occurred in 1996, had on the meat industry. The methods used to examine the price transmission were the most common, unit root test, co-integration tests and causality tests. This is the same method, which Hassouneh et al (2012) discovered to be reliable when examining price transmission. By focusing on the UK Sanjuán and Dawson (2003) could investigate three different products. This differs to Franks and Hauser (2012) who compared across countries rather across different products. Both are successful and useful for looking at the explanation behind price transmission rather than just the theory. Sanjuán and Dawson (2003) found that the BSE crisis did not have any significant affect on the lamb or pork market. However there was a structural break in producer and retail prices of beef in 1996 in which the price transmission from producer to retailers was poor increasing the retailer's margin and benefitting them as a result. This is as expected, and is consistent with research that finds powerful retailers and intermediaries taking advantage of smaller producers (Dairy Co, 2011). Although Sanjuán and Dawson (2003) were using different products, there are many aspects of the methodology, which can be used to examine the price transmission of milk in the UK, particularly the use of structural breaks that may occur. By incorporating a break date in to the econometric tests Sanjuán and Dawson (2003) were able to judge whether this period of time (in 1996) had a big affect on the relationship between retailer and producer prices. A weakness of this study is that they could have gone further and examined the ECM, which would allow them to see the speed of recovery back to the equilibrium after the shock had occurred.

The Common Agricultural Policy

In 2003 there was a reform to the European CAP which changed how subsidies were distributed to dairy producers within the UK (Lelyon et al., 2008). This undoubtedly would have implications for the dairy sector as production costs are always increasing and therefore less subsidies would have a massive implication on producers. Zrakić et al (2015) investigated the implications of the 2003 CAP reform on the Croatian dairy industry. By using a simulation model and inputting policy, macroeconomic variables and producers pricing it is possible to forecast the future of the dairy industry. The results found that by 2025 productivity would increase by 25% and the dairy industry in Croatia would be in a more favorable position than before the 2003 reform (Zrakić et al., 2015). It was also suggested that in order to obtain the full benefits of the reform then dairy farmers would have to utilise funds from both the pillar 1 and pillar 2 CAP's. A limitation of using a simulation model like this is that the researchers are only predicting what is going to happen and they cannot allow for any external variables, which could have an effect on the dairy industry, for example Brexit. The data inputted in to the model is based on projections and therefore may be inaccurate and unreliable. Another general limitation of the CAP research is that there are very little studies on the 2003 reform in relation to the milk industry particularly for the UK, thus providing a gap for research.

Dairy Retailers

Within the UK 40% of raw milk sales are from four main supermarkets, which demonstrates the oligopolistic market (Dairy Co, 2011). A small number of large companies absorb a majority of national milk production. Dairy Co (2011) found that bargaining power, which works in relation to the size of firms, was one of the overriding benefits supermarkets could impose on producers. The main goal for the retailers is to satisfy the consumers, it means they do not proritise with producers (Dairy Co, 2011). The market failure of retailers not transmitting prices downstream to producers in some countries has lead to increased poverty and lower food security (Schroeder and Hayenga, 1987). Retailers offer contracts to producers however Dairy Co (2011) identified weaknesses within these contacts. These include no price certainty, long notice periods and no details on future negotiations. All these factors weaken the position of the producer and it is claimed that milk contracts are simply a "licence to supply" (Dairy Co, 2011).

Dairy Producers

British dairy farms have been struggling recently and their major concern is that retailers are not paying them a fair price. Farmers have been forced to close their businesses down or even go as far as pouring milk away because they are loosing so much money. Steffen and Spiller (2013) looked in to the efficiency of dairy producers and factors that could be hindering their performance. It was believed that if milk producers were not efficient then

they would struggle to make appropriate returns. The results found that one of the main factors contributing to lack of efficiency of dairy farmers was their willingness to adapt techniques and unite together to achieve a targeted milk quota for the future. Steffen and Spiller (2013) believed that increased efficiency throughout the supply chain there would enable dairy producers to be more profitable, even with reduced prices. This suggests that the producer is at fault for recent hard times in the milk industry. de Fátima Oliveira et al (2014) originally opposed this view and believed the price paid to producers had a bigger influence on the milk industry than other factors such as efficiency. This was the reasoning behind their research in to the price transmission of milk within the Portuguese market. They found that when the price of the retailer changes the price paid to the producer did not. This suggests that in Portugal it is not the price that is causing hardship on farms and therefore theory that efficiency is to blame for poor milk price return that Steffen and Spiller (2013) proposed, seems feasible. Bor et al (2014) conducted research in a similar manor to de Fátima Oliveira et al (2014) but for Turkey instead of Portugal. The conclusions contrasted as Bor et al (2014) found that large retailers in Turkey act quickly when the input prices of milk increase but they are slower to react when the inputs decrease. This implies that in Turkey large retailers hold all the power shown by the asymmetric price transmission. It also means the retailers control the producer prices and consumer prices, which is the opposite to the Portuguese milk market.

The differences between price transmissions across countries are expected because of the individual markets within the country. Bakucs et al (2014) found that policies, governance, laws, economies and power all bare an effect on a countries agricultural markets. This means that the differences across countries, even though evaluating the same product, are normal. Due to these differences occurring horizontally across countries much research starts by looking vertically initially.

The Gap

The need to look at the long run relationship of the price of milk between the producer and the consumer is more necessary in the UK due to the issues facing many dairy farmers. The 2003 CAP reform changed how subsidies were distributed to milk producers and there is little research in to the effects of this reform on the price of milk. In addition to this the UK has voted to leave the EU so now is an important time for the domestic milk market as the UK will be creating it's own agricultural policies. If British dairy farmers continue to lose out on price then it could have huge consequences on the whole milk industry. Dairy producers are going out of business and they are blaming it on powerful monopoly retailers for driving prices down and therefore it is necessary to assess how true these claims are.

A lack of studies within the UK milk market means there is a need to create foundations which will be useful for policy makers, retailers and producers when moving forwards. In addition, there is significantly more research conducted on the milk markets within foreign countries, which gives them a

competitive advantage over the UK. The varied and mixed results found from other countries in previous literature means there is a big gap for research within the UK.

Research indicates there was a change in the milk market in 1994 when the MMB disbanded. There is a need to see if this is highlighted as a structural break and if it had any benefits to either party. Other studies researching the price transmission of milk have not considered breaks, which further confirms the need for the research to be conducted. The collection and availability of 'big data' means an appropriate data range is available which has been a limitation of previous studies.

METHODOLOGY

Research Title

The Price Transmission between producers and retailers within the UK milk market.

Research Objectives
1. Establish whether a long run relationship exists between producer and retailer milk prices.
2. Investigate the direction of causality between producer and retailer milk prices.
3. Investigate the effects of structural breaks within producer and retailer milk prices.

Data

Qualitative data is descriptive data, which can be collected via interviews, surveys or by using secondary data. The data is valuable for giving insight and explanation when conducting research. Many previous studies have successfully used qualitative data to provide great depth and reasoning to endorse their analysis. However qualitative data is not suitable for the econometric tests being used when analysising the price transmission of milk. Limitations of qualitative data are that it is hard to interpret and it is not easy to gather data over a large time scale (Silverman, 2011). These limitations rule out using qualitative data in this research.

This research will benefit from using quantitative data, as this is suitable for the econometric tests, which will be used to examine vertical price transmission. Using quantitative data will mean objective results will be obtained. This will give a definitive answer to the research question proposed. In addition it will be possible to acquire a large range of data, which will be important for this research. Quantitative data however, does not give the level of insight and detail which qualitative data does, which is a limitation (Silverman, 2011).

Primary data is collected first hand, which has the advantage of being tailored and personalised to exactly what is required. Collecting primary data is time consuming, which is a limitation of this research. Primary data is often expensive to collect and usually the results have to be manipulated to make the data usable, which can be time intensive. If the data is collected first hand then the researcher can be sure it is trustworthy or can add variables when collecting the data to make it adhere to features of the methodology. It is difficult to obtain a significant amount of observations in order to collect a suitable amount of data (Saunders, 2011). It will not be possible to collect a large range of time series data and because it is already available primary data is not suitable for this research.

The benefits of conducting the analysis with secondary data are that it is easy to obtain a large amount of reliable prices for both the consumer and producer (Saunders, 2011). In addition to this with the time constraints of this research, using secondary is the only viable way to gather the range of data required. The data needed is readily available and is to be sourced from the Office for National Statistics, (2016) which is a trusted and accurate resource for secondary data. The milk prices will be collected for a range of 18 years, which is a sufficient length of time to be able to analyse the long run relationship.

Time series data is discrete-time data, which will be used to give monthly increments from 1988 to 2016. The advantages of using time series data is that it allows a comparison of two variables at predetermined time intervals and therefore it is possible to see any correlations (Adams *et al.*, 2014). An alternative would be panel data, which is data, which spans space as well as time. An advantage of panel data is that by combining two dimensions the data has more variation and more degrees of freedom (Saunders, 2011). However for this specific research panel data is harder to obtain and because the only variable we require are the retailer prices and the producer prices, time series data will be used.

Testing for Non-stationary data

The first step will be to check the data is stationary, which proves whether data is reliable and valid. This will be done by checking the data has unit roots, for both of the variables. The tests for this are the PP (1997) unit root test and the ADF (1979) unit root test. The tests will help establish if there is a trend in the data or whether there are any extreme values. The reason for using two tests is so that we can be absolutely sure the data is valid and reliable. Previous studies have used only one of these tests, which can raise questions over the quality of their data. DeJong *et al* (1992) argued that the PP test had less power in practice than the ADF test; therefore it is necessary to conduct both. Nonstationary variables mean that there could be statistical issues, like spurious regression or non-sense regression, when analysing a time-series (Cuthbertson and Nitzsche, 2005). This would mean that further statistical interpretation may seem in unity with theory, however the results are not valid and not reliable (Greene, 2012). For this reason it is

vital to firstly prove stationarity. Stationary time series' can be described as having a constant mean, constant variance and constant autocovariances for each given lag (Brooks, 2014). Using Eviews econometrics software it is possible to conduct both the PP test and ADF tests for both the retailer prices and the producer prices to gain instant results (Griffiths *et al.,* 2012). Firstly the data will be tested in level on Eviews, if the variables are nonstationary then the data will be tested for the first difference (Griffiths *et al.,* 2012). In addition it will be important to run the unit root test with breaks, which are shocks within the data. This will confirm that the data is stationary even with the shocks included, which enhances the reliability. It will only be possible to move on to the cointegration tests once it is proved the data is stationary (Maddala and Lahiri, 2009).

Bai-Perron

Bai and Perron (2003) investigated structural change models for a range of different elements including the techniques used to select the quantity of breaks, the consistency of break dates and the tests involved in identifying structural changes. The Bai-Perron test can find multiple structural breaks using a bivariate analysis of a relationship. This will give an indication of whether there are structural breaks that occur as a result of the relationship between retailer and producer prices (Bai and Perron, 2003). It will also give up to 5 separate breaks, while other additional tests concerning breaks in the relationships can only show up to two breaks. This is a benefit when using such a large time series of data.

Co-integration

When it is proved that the variables are stationary then the second test will be to check if the two variables have a long run relationship. The initial analysis of cointegration is to investigate whether it actually exists within the data. The test to examine this is called Johansen (1988) and it tests for long run relationships regardless of breaks or shocks, which may occur within the data (Greene, 2012).

Johansen (1988) test starts with the VAR model:

$$Y_t = \mu + A_1 Y_{t-1} + A_2 Y_{t-2} + \cdots + A_p Y_{t-p} + \varepsilon_t \qquad (1)$$

In equation (1) Y_t simultaneously represents both the variables which are integrated in order I(1), producer prices and retailer prices.

The VECM is then created:

$$\Delta Y_t = \mu + \Gamma_1 \Delta Y_{t-1} + \Gamma_2 \Delta Y_{t-2} + \cdots + \Gamma_{p-1} \Delta Y_{t-p+1} - \Pi Y_{t-1} + \varepsilon_t, \quad (2)$$

where:

$\Gamma_i = -I + A_1 + A_2 + \cdots + A_i$ is the matrix for each differenced lag.

For $i = 1, 2, \dots, k - 1$ and $\Pi = I - A_1 + A_2 + \cdots + A_k$

Johansen (1988) uses two key statistics for testing for cointegration, the trace statistic and the maximum eigenvalue statistic. The likelihood ratio tests used to acquire the statistics are:

$$Trace\ Statistic = -T \sum_{i=r+1}^{p=2} \ln(1 - \hat{\lambda}) \qquad (3)$$
$$Maximum\ Eigenvalue\ Statistic = -Tln(1 - \hat{\lambda}_{r+1}) \qquad (4)$$

For equation (3) the null hypothesis tested is that there are at most r cointegrating vectors present. This means the number of cointegrating vectors is ≤ r, when r equal to 0 or equal to 1. For both values of r the null hypothesis is examined against the general alternative hypothesis.

For equation (4) the null hypothesis of r = 0 is tested against the alternative hypothesis of r = 1, then the null hypothesis of r = 1 is tested against the alternative hypothesis of r = 2.

If Johansens (1988) test shows one cointegrating vector it means there is a long run relationship between the retailer prices and the producer prices and that one mutual trend is causing the comovement of the two price variables (Chang *et al.*, 2004). The Johansen test can then be conducted with breaks, which ensures that spikes or shocks within the data are not affecting the cointegration.

Engle-Granger Cointegration

Engle-Granger (1987) is one of the most widely used and reputable cointegration tests (Maddala and Lahiri, 2009). Engle and Granger (1987) stated that after proving both variables (retailer prices and producer prices) are stationary in first levels I(1) we can estimate the cointegration regression by OLS.

$$y_t = C + \alpha x_t + e_t \qquad (5)$$

After identifying the residuals seen in equation (5), the second step is to examine them through a unit root test. This is done by using the PP (2003) test, and if the residuals are stationary then it can be concluded that there is a long run relationship between retailer prices and producer prices.

Error Correction Model

Cointegration indicates the presence of an ECM. This model establishes how long it takes for the variables to return to a new equilibrium after a shock has occurred (Maddala and Lahiri, 2009). This is used to understand the

speed of recovery, which will provide further understanding about the relationship between the two variables. Additionally, it will enable suggestions to be made on how to improve future policies.

Granger Causality

Once the long run relationship is established it is necessary to check the relationship in the short run (up to 5 years), as it may not yield the same results as the long run relationship. The Granger, (1969) causality test will examine the short run relationship and test if there is:

- Unidirectional causality - the price of the producer affects the price of the consumer.
- Unidirectional causality - the price of the consumer affects the price of the producer.
- Bilateral causality - both the price of the producer and the price of the consumer affect each other.
- Independence – no relationship between the price of the producer and the price of the retailer.

This will establish the direction of causality, which is necessary in this research to understand which variable, retailer or producer price, is having an effect on the other. Grasping this causality will enhance the ability to make future suggestions on the milk market.
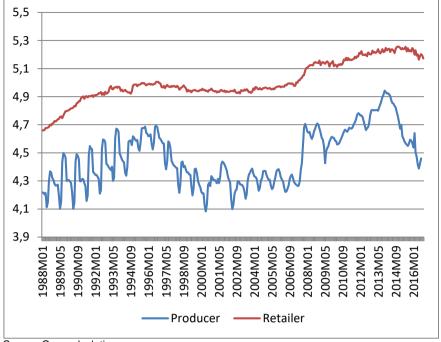
Momentum Threshold Autoregressive

Enders and Granger (1998) and Enders and Siklos (2001) developed the M-TAR model, which tests for asymmetries. The MTAR model is given by equation (6).

$$\Delta\mu_t = I_t p_1 \Delta\mu_{t-1} + (1 - I_t)p_2 \Delta\mu_{t-1} + \sum_{j=1}^{p-1} \gamma i \Delta\mu_{t-j} + \varepsilon_t \qquad (6)$$

p_1 and p_2 are the coefficients which signify the different speeds of adjustment when there is a divergence from the long run relationship (equilibrium). We test for the null hypothesis of no cointegration by using the equation p1=p2=0 in an F-test. The critical values come from Enders and Siklos, (2001). If a cointegration relationship exists then we apply an F-test to p1= p2 with the null hypothesis of symmetry to determine whether asymmetries exist.

Empirical Data

Figure 1: Natural Logarithms of the Producer and Retailer Prices, UK milk, 1988 – 2016

Source: Own calculations.

From observing Figure 1 it is expected that a long run relationship exists between producers prices (LPRI) and retailers (LRPI). It is evident that a correlation exists between the two variables however it is unknown whether there is any causality.

It is also possible to see shifts and spikes within figure 1. A notable detail for the producer price is the seasonal price changes for, which follow a similar pattern each year, whereas the retailer prices remain more stable. A significant looking period for the retailer includes early 2008 where prices increase dramatically. This may be explained by the low levels of milk supply during this time causing retailer prices to increase (Dairy Co. 2009). A noteworthy time frame for the producer prices emerges from 2014-2016, where prices show the biggest decrease. These factors and dates will be considered within the results.

EMPIRICAL RESULTS AND DISCUSSION

Unit Root Tests

Table 1: Unit Root Test Augmented Dickey-Fuller

Price Variable	t -statistic (levels)	P-Value (levels)	t – statistic (1st differences)	P – Value (1st difference)

Producer	-2.03	0.09	-2.97**	0.04
Retailer	-2.66	0.08	-25.23***	0.00

Test Critical Values:
***1% = -3.45
**5% = -2.87
*10% = -2.57

Source: Own calculations.

Table 2: Unit Root Test Phillips Perron

Price Variable	t - statistic (levels)	P- Value (levels)	t – statistic (1st differences)	P – Value (1st difference)
Producer	-2.71	0.07	-14.91***	0.00
Retailer	-2.49	0.12	-24.85***	0.00

Test Critical Values:
***1% = -3.45
**5% = -2.87
*10% = -2.57

Source: Own calculations.

The ADF and PP test for stationarity is applied to the retailer and producer price variables to determine the order of integration. The test results displayed in table 1 and table 2 suggest that both variables are non-stationary processes during levels for both the ADF and PP tests, as the t-statistics are greater than the 5% test critical values and the p-values are greater than 0.05. However, from table 1 and 2 it is evident that when converted to 1st difference they become stationary processes. The variables now can be labeled as integrated processes of order one, I(1). This means co-integration tests can now be applied to the variables.

The unit root tests in tables 1 and 2 have shown that the variables without breaks are I(1). Breaks will show shocks in the retailer and producer prices. If breaks are not included the unit root tests may produce misleading results so now it is necessary to perform the same tests, but taking in to consideration structural breaks.

Table 3: Unit Root Augmented Dickey-Fuller With Breaks

Price Variable	Break Date	t – statistic (1st difference)
Producer	1994	-4.67**

Retailer	1994	-26.27***

Test Critical Values: ***1% = -4.95
**5% = -4.44
*10% = -4.19
Source: Own calculations.

Table 3 displays the results for unit root test with breaks which found both price variables are I(1) including a break in 1994 for both the retailer and producers prices. Since the ADF t – statistic of -4.67 for the producer is less than the critical value of -4.44 at a 5% level of significance, with a probability of 0.027 we can deduce that the producer prices are stationary on the 1st difference and therefore can be described as I(1). As the t – statistic of -26.27 for the retailer is less than the critical value of -4.95 at a 1% level of significance it can be concluded that the retailer prices are stationary on the first difference and are also I(1).

The break in 1994 may coincide with the disbanding of the MMB, which was mentioned previously. This was the only link between the producers and the retailers and once it was gone there was no formal link between them. This allowed large monopolies (retailers) to take advantage of there position and put pressure downstream on to the producers (Brigstoke, 2004). Finding this break confirms the 1994 disbanding of the MMB may have caused a shock in the prices of both the retailer and the producer.

Bai-Perron Test

The previous test performed with breaks was univariate, meaning that it expressed shocks individually without the influence of the other variable.

Table 4: Bau-Perron Test Results

Variable	Break Date Estimate
Pr = Re	1992, 1998, 2003, 2008 and 2012.

Source: Own calculations.

The test results presented in table 4 indicates 5 structural breaks for the relationship between retailer and producer prices (bivariate). The breaks in 1992 and 2003 may be explained by the CAP reforms. However the 2003 CAP reform did not have the adverse affect initially feared and milk prices did not increase as was anticipated (Burrell, 2004). In 2008 as previously discussed, there was a shortage in supply of milk causing prices to increase (Dairy Co, 2009).

Co-integration

Next the Johansen cointegration approach[1] is applied without structural breaks to test for a long run relationship between the two variables. Since there are two variables, one relationship should exist between them in the long run.

Table 5: Johansen Cointegration Without Breaks

Hypothesized No. of CE(s)	Trace Statistic	0.05 Critical Value	Probability
None	27.96**	20.26	0.004
At most 1	8.28	9.16	0.073

Note: ** indicates rejection of the null hypothesis at the 5% level of significance.
Source: Own calculations.

The null hypothesis of the test states that there is no relationship between the examined variables, therefore no cointegration (H0: No relationship). The alternative hypothesis shows the existence of a relationship, thus it confirms the fact that cointegration exists (H1 : There is a relationship). This is indicated by the number of CE's within the first column.

The Trace statistic 27.96 is greater than the critical value 20.26, with a probability below 0.05 so the null hypothesis H0 is rejected. Therefore the alternative hypothesis H1 is accepted and at least one cointegration vector exists.

The next pair of hypotheses state that the null hypotheses is at most 1 cointegrating vector appears between the examined variables (H0: One relationship), while the alternative is that there are more than one cointegrating equations (H1 : More than one relationship). Since the trace statistic 8.28 is less than the critical value 9.16 and the probability 0.073 is above 0.05, we reject the alternative hypothesis and accept the null. Thus, there is a cointegration between producer and retailer prices and one cointegrating vector between them as expected.

The break dates obtained from Bai-Perron test were not significant and did not have a great influence on the relationship between the two variables. Since the only significant break date found for both variables is 1994 it is now included endogenously in Johansen's cointegration approach to test if it alters the results of cointegration.

Table 6: Johansen Cointegration test with Breaks

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[1] All the equations satisfy all the statistical assumptions required for the Johanshen approach and we can apply cointegration analysis. We deployed the diagnostic tests for heteroskedasticity, normality and autocorrelation in all the equations.

Hypothesized No. of CE(s)	Trace Statistic	0.05 Critical Value	Probability
None	29.35**	24.28	0.011
At most 1	12.05	12.32	0.055
At most 2	0.63	4.13	0.487

Note: ** indicates rejection of the null hypothesis at the 5% level of significance.
Source: Own calculations.

The null hypothesis of this test again states that there is no relationship between the examined variables, therefore no cointegration (H_0: No relationship). The alternative hypothesis shows the existence of a relationship, thus it confirms the fact that cointegration exists (H_1 : There is a relationship). From table 6, the trace statistic 29.35 is greater than the critical value 24.28, with a probability below 0.05 so the null hypothesis H_0 is rejected. Therefore the alternative hypothesis H_1 is accepted and at least one cointegration vector exists, similarly to when the test was conducted without breaks. The next pair of hypotheses state the null hypothesis is that at most one cointegrating vector appears between the examined variables (H_0: One relationship), while the alternative is that there are more than one cointegrating equations (H_1 : More than one relationships). Looking at table 6, the trace statistic 12.02 is less than the critical value 12.32 with a probability above 0.05 and therefore we reject the alternative and accept the null hypothesis. So, one cointegrating vector-equation exists. From performing Johansen's cointegration test including breaks we can conclude that cointegration exists between the examined variables and the break date did not affect the results.

Next the Engle-Grangle test for cointegration is performed which is a robust test that investigates if a long run relationship exists between two variables. It is a two-step process which involves firstly performing an ordinary least square, including the detected break in 1994, and then we examine the residuals in terms of stationarity. Residuals have to be integrated of order zero, which means stationary in levels. Thus, residuals will move around the mean and will not affect the reliability of our results, depicting a stable pattern. Since the residuals obtained are integrated of order zero, cointegration can be supported.

Table 7: Engle-Granger cointegration (First step)

Variable	Coefficient	t - statistic	Probability
LRPI MILK	1.32	21.65	0.00
D1994	-0.13	-6.68	0.00

| Constant | -2.02 | -6.85 | 0.00 |

Table 7 shows that the retailer prices and the break date included of 1994 are significant since the p–value is less than 0.05 and t–statistic is greater than |1.7|.

Results derived from table 7 express the linear equation depicted below (8), which represent the long run relation between producer-retailer milk prices.

$$y_t = C + \alpha x_t + e_t \qquad\qquad (7)$$

$$LnProducer = -2.02 + 1.32 * LnRetailer - 0.13D1994 \qquad (8)$$
$$(21.65) \qquad\qquad (-6.68)$$

This means that if the retailer price increases by 1 unit then it would be expected that the producer price would increase by 1.32 units. This explains the most recent increases in producer prices, which have come as a result of pressure on the retailers from the public (Horne, 2017). A coefficient of 1.32, which is greater than 1 means an imperfect market structure exists. This denotes that there is oligopsony power on the demand side (milk retailers) (Lajdová and Bielik, 2013). This demonstrates that milk retailers have greater power than milk producers.

Also, the 1994 break seems to affect in a negative way on the producer prices, leading to a decrease by 0.13 units or 0.13%. As previously discussed this may be attributed to the disbanding of the MMB, which is known to have caused price instability in a negative manor.

The second step of the Engle–Granger procedure is to examine the residuals through a unit root test.

Table 8: Phillips Perron unit root estimates

Residuals	t – statistic	Probability
U	-19.49***	0.00

Test Critical Values:
***1% = -3.45
**5% = -2.87
*10% = -2.57

Table 8 shows results from the Phillips- Perron unit root test and indicates that the residuals are stationary in levels and thus integrated of order zero I(0).

From the Johanson and Engle-Granger tests above, we can conclude that there is a long run relationship between the retailer and producer prices. This is supported by the literature from the rest of Europe where it is presented that long run relationships exist between retailer and producer milk prices in many countries. This also means that the six factors Conforti (2014) identified, as affecters of price transmission are likely to also have an influence on the UK milk price transmission.

Error Correction Model

Since cointegration exists in the long run the next step is to investigate how quickly the prices return to a steady state and thus to the new equilibrium when a shock occurs in the independent variable - retailer price.

Table 9: Error Correction Term Estimates

Dependent variable	ECT	t – statistic
Producer prices	-0.099	-4.12

Source: Own calculations.

The ECT has to be negative since it shows the return to the long run relationship, and also has to be statistically significant. Table 9 shows that when the producer price is the dependent the ECT is negative (-0.099) and is significant because -4.12 it is greater than |1.7|. This shows that if a shock happens to the retailer price and both prices move apart from the long run relationship they return to a new equilibrium at a rate of (-0.099) 10% per month. This means it would take up to 10 months to fully recover back to a new equilibrium. This slow recovery may be explained by the dominance of large retailers, in which four are responsible for 40% of the milk sales, and the lack of power of the producers (Dairy Co, 2011). These slow recovery results are consistent with the findings of Acosta and Valdés, (2014). There explanation for low price transmission was attributed to market power concentration, the presence of perishable goods and different levels of price elasticity at different market levels (Acosta and Valdés, 2014). This confirms the view of many small UK producers who have been blaming retailers for their demise. Furthermore these results are consistent with Serra and Goodwin, (2002) who found that milk producer prices appear more elastic to shocks which explains why it takes a long time for prices to reach a new equilibrium.

Granger Causality

The Granger causality test enables us to examine whether there is a short run relationship in the examined variables as well as the direction of this causality.

Table 10: Granger causality test estimates

Null Hypothesis	Critical Value – F stat	F – Statistic
LRPI does not Granger cause LPRI	3.00	2.28
LPRI does not Granger cause LRPI		3.16

Source: Own calculations.

The first case has a null hypothesis that LRPI does not Granger cause LPRI (H_0: The retailer price does not effect the producer price) and an alternative hypothesis suggesting that LRPI does Granger cause LPRI (H_1 : The retailer price does effect the producer price). Table 10 shows the F – Statistic and the critical value. Since the F – Statistic (2.28) is less than the critical value (3.00) we reject the null hypothesis and accept the alternative. Therefore there is a short run relationship from the LRPI to LPRI and the retailer price does effect the producer price.

In the second case the null hypothesis suggests that LPRI does not Granger cause LRPI (H_0: The producer price does not effect the retailer price) and the alternative hypothesis states that LPRI does Granger cause LRPI (H_1 : The producer price does effect the retailer price). Since the F – Statistic (3.16) is greater than the critical value (3.00) we accept the null hypothesis and reject the alternative hypothesis. Thus a short run relationship with direction from the producer to the retailer does not exist and therefore the producer price does not affect the retailer price. This was also supported by the results from the ECM but on a long run basis. The results obtained from the ECM showed no influence from the producer to the retailer, thus a long run relationship does not exist in this direction.

Asymmetry Analysis

The M-TAR test is used to identify whether asymmetry exists.

Table 11: Momentum-Threshold Autoregressive estimates

Dep./ Indep. Variable	T	p_1	p_2	$p_1=p_2=0$	$p_1=p_2$	K
PRODUCER/ RETAILER	0.00	**-**0.031 (0.036)	-0.047 (0.041)	0.817	0.1204	10

RETAILER/ PRODUCER	0.00	-0.004	-0.046	0.988	0.9726	10
		(0.033)	(0.033)			

Source: Own calculations.

T represents the threshold value,
K represents the lag length, SE are in parenthesis,
$\rho 1= \rho 2= 0$ is the null hypothesis of no co-integration, the critical values are obtained from Enders and Siklos (2001) p.172
$\rho 1= \rho 2$ is the null hypothesis of symmetry, critical value for 5%: PR/RET: 3.00, RET/PR: 2.67.

Table 11 represents MTAR estimates with a threshold equal to zero. Thus, p1 indicates values above the threshold – positive and p2 shows prices below the threshold-negative.

For the relation of the producer/retailer, we have a p1 value where -0.031 is the coefficient and in brackets (0.036) is the standard error. p1 has to be negative and statistically significant. Coefficient/ standard error= t-statistic, so the t-stat for p1 is -0.031/0.036=0.861 which is less than |1.7| and hence, not significant. The t-stat for p2 is -0.047/0.041=-1.146 which is less than |1.7| meaning it is not significant.

The p1=p2=0 represents the result for cointegration under the asymmetry. From table 11 we get an F-statistic of 0.817 for the F-joint (appendix 1). The null hypothesis is no cointegration (H_0: There is no cointegration under asymmetry) and the alternative that there is a cointegration (H_1 : There is cointegration under asymmetry). We compare the 0.817 with the critical value provided in the results table 5.837 (see appendix 1). If the F-stat is greater than the critical value, we reject the null and accept the alternative. Here, 0.817 is less than 5.837 so we accept the null hypothesis and reject the alternative hypothesis, H_0: There is no cointegration under asymmetry.

The p1=p2 column in table 11 represents the result for asymmetry, labelled as F-equals in appendix 1. The null hypothesis is symmetry (H_0: Symmetry exists) and the alternative is asymmetry (H_1 : Asymmetry exists). Again, we compare the F-stat 0.120 with the critical value 3.00. If the F-stat exceeds the critical value, there is asymmetry. So, we reject the null and accept the alternative. Here, the F-stat 0.12 is less than the critical value 3.00 and therefore we accept the null and reject the alternative meaning there is symmetry.

For the retailer/producer we use the same method and find the same result meaning there is symmetry. These results are consistent with findings of Serra and Goodwin, (2002). However, it contrasts with the findings of Kinnucan and Forker (1987) who found the presence of asymmetric vertical price transmission in the United States milk market.

Since we found that asymmetry does not exist, it means that positive and negative shocks are transmitted in the long run from the retailer to the producer with the same intensity. As we found the same for both pairs it also means that the magnitude is the same and they have the same effect

whether an increase or a decrease in the prices occurs. This shows also the dependence of the two stakeholders and the fact that shocks are fully transmitted between them in the point that there is no difference to the impact caused no matter if the shock is positive (increase in milk price) or negative (decrease in milk price). Therefore, returning to the Engle-Granger model, if the retailer prices decrease by 1 unit then it would be anticipated that the producer price would fall by 1.32 units. This backs up previous literature, which found that large retailers were driving down milk prices between 2014 and 2016 causing producer prices to fall (Dairy Co, 2011).

CONCLUSION

The results of the analysis show a long run cointegration relationship exists between the producer prices and the retailer prices. When the significant break is included, the same long run cointegration relationship exists. This means that both variables progress in association with one another. Furthermore the causality runs from the retailer to the producer. This means that when retailer prices change it effects the producer prices. However when the producer prices change, it does not transmit to the retailer prices. With producer costs increasing and them not receiving a fair price transmission, which reflects retailer prices, we can conclude that this is why many dairy producers are struggling to within the UK.

The UK milk market's price transmission results are similar to the results Bakucs et al, (2012) found within Poland's milk market, which we considered previously. In Poland the direction of causality was from retailer to producer, which was explained by the power of the producers. These results are parallel to the UK results and many other studies that have been considered, which further confirm our findings, that retailers in the UK are causing price issues for producers.

The results from the ECM suggest it takes at least 10 months for the price variables to converge to a new equilibrium. From this it is possible to conclude that the prices the producers or retailers receive is very slow at reacting when there is a spike in the price. This confirms the view that retailer prices have not been transmitting downstream and giving producers a fair price. It also confirms that the prices within the whole milk market are dictated by the oligopolistic retailers. We can conclude retailers are more concerned about offering low prices to consumers than they are about paying a fair price to producers.

Policy Implications

As previously discussed Steffen and Spiller (2013) found there was a lack of efficiency within dairy producers. From this study we can conclude that a lack of power and trust may be causing producers to be reluctant to invest money in to their operations. This lack of investment may be causing the inefficiencies that Steffen and Spiller, (2013) identified within their research. A policy implication that could solve this is to grant producers a guaranteed

price when negotiating a milk contract, which currently doesn't exist (Dairy Co, 2011). The consequences of this would enable producers to invest and plan for the future knowing what their expected levels of income will be, thus reducing their risk.

Future policies need to protect producers to ensure they receive a fair share of the price transmission. This could be the catalyst for arguing that the MMB or a similar organisation needs to be reintroduced. In the light of the results, policy makers should concentrate their attention on actions that are aimed at decreasing the levels of price transmission from retailers to producers and increasing the levels of price transmission from producers to retailers within the milk market.

Limitations

There are limitations of this study including my lack of experience prior to the research being conducted. The reason this was a limitation is because more valuable time had to be spent understanding the topic and econometric techniques. Overall this did not have much of an affect on the results of the study. The availability of data during the short space of time given to conduct this research means that there is a reliance on the Office for National Statistics for providing reliable statistics. This is a limitation as it is impossible to be sure the data is correct. However because it is a trustworthy source it is unlikely to have had an affect on the results.

Future Research

There are grounds for further research based on this study. Firstly it would be interesting to compare the vertical price transmission results of the UK with other similar European countries such as France, Spain and Germany who also may be effected by Brexit. Secondly this study could provoke an interest in comparing the UK milk prices horizontally with other similar EU countries. For example comparing producer prices and retailer prices independently across boarders.

This research also provides a motive to compare the price asymmetry of milk against other products and for the asymmetry of other products to be considered individually. The desired effect of this would be to use successful policies from other markets to help milk producers and reduce the power of milk retailers.

This project provides the foundations to now consider pairwise analysis for each stage of the dairy supply chain, including wholesalers, producers, retailers and consumers. This would give a better understanding of exactly where prices aren't being transmitted within the milk supply chain.

Once the UK has left the EU and set its own policies future research could be conducted to look at how the new policies set will affect the transmission of milk prices between the producer and retailer.

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APPENDIX

Appendix 1: Momentum-Threshold Autoregressive Results

Endogenous variables: LPRI_MILK LRPI_MILK

Exogenous variable(s): D1994

Method: Threshold (tau is defined by user)

Lags (determined by data): 10

Date: 04/17/17   Time: 08:45

Sample (adjusted): 1988M12 2016M08

Included observations: 333 after adjustments

Variable	Coefficient	Std. Error
Above Threshold	-0.031363	0.036999
Below Threshold	-0.047905	0.041652
Differenced Residuals(t-1)	0.068873	0.059264
Differenced Residuals(t-2)	-0.252162	0.057668
Differenced Residuals(t-3)	-0.169276	0.056511
Differenced Residuals(t-4)	-0.230380	0.056422
Differenced Residuals(t-5)	-0.132503	0.057111
Differenced Residuals(t-6)	-0.148896	0.057505
Differenced Residuals(t-7)	-0.140517	0.056517
Differenced Residuals(t-8)	-0.286592	0.056056
Differenced Residuals(t-9)	-0.152428	0.054702
Differenced Residuals(t-10)	-0.301796	0.055146

Threshold value (tau):	0.000000	
F-equal:	0.120415	(3.000130)*
T-max value:	-0.847666	(-2.086908)*
F-joint (Phi):	0.817149	(5.837907)*

Simulated critical values for 5% significance level.

Number of simulations: 1000

Elapsed simulation time: 0 hours 0 minutes 7 seconds.

Endogenous variables: LRPI_MILK LPRI_MILK

Exogenous variable(s): D1994

Method: Threshold (tau is defined by user)

Lags (determined by data): 10

Date: 04/17/17   Time: 08:47

Sample (adjusted): 1988M12 2016M08

Included observations: 333 after adjustments

Variable	Coefficient	Std. Error
Above Threshold	-0.004077	0.033532
Below Threshold	-0.046666	0.033308
Differenced Residuals(t-1)	-0.024302	0.058066
Differenced Residuals(t-2)	-0.182190	0.056429
Differenced Residuals(t-3)	-0.218485	0.055454
Differenced Residuals(t-4)	-0.171510	0.056018
Differenced Residuals(t-5)	-0.147449	0.056250

Differenced Residuals(t-6)	-0.129185	0.056582
Differenced Residuals(t-7)	-0.139628	0.056597
Differenced Residuals(t-8)	-0.243472	0.055462
Differenced Residuals(t-9)	-0.164181	0.055214
Differenced Residuals(t-10)	-0.255339	0.056004

Threshold value (tau):	0.000000	
F-equal:	0.972585	(2.676458)*
T-max value:	-0.121588	(-2.163273)*
F-joint (Phi):	0.987639	(6.038325)*

*Simulated critical values for 5% significance level.

 Number of simulations: 1000

 Elapsed simulation time: 0 hours 0 minutes 7 seconds.

Source: Own calculations.