| Paper Title	Vertical price transmission (VPT) in the UK liquid milk (LM) supply chain.

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Abstract	*200 words max*

The aim of this paper is to analyse the price transmission (PT) process between producers and retailers, in the UK liquid milk (LM) sector and to explore possible asymmetries within this mechanism. This was pursued using monthly, producer and retail price time series data, for the period 01/2000-01/2023. The methodology employed consisted of the nonlinear-Granger causality test proposed by Diks and Panchenko (2006) to examine price causality followed by the Nonlinear Autoregressive Distributed Lag model (NARDL) proposed by Shin et al. (2014) to explore the long and short-run relations, accounting for asymmetries. Findings revealed a unidirectional relationship, with shocks being transmitted from the retail to producer prices. In addition, asymmetries have been confirmed in terms of magnitude and speed with positive shocks in the retail prices being transmitted with greater intensity and magnitude to the farmgate level compared to negative ones. The magnitude of adjustment is larger for positive shocks with the equilibrium correction being achieved after nearly 40 months. Thus, results established the leading role of retailers in the supply chain whereas the study highlights the need for policy intervention, such as price floors, to protect the welfare of producers and encourage growth within the sector.

Keywords	UK liquid milk market, price transmission, market efficiency
JEL Code	Q11, C22 see: www.aeaweb.org/jel/guide/jel.php?class=Q)

Introduction	*100 – 250 words*

In 2023, the United Kingdom (UK) produces 15 million metric tons of cow milk, ranking among the world's top producers (Statista, 2023). UK is also the 10th largest exporter of milk worldwide for 2020, primarily exporting value-added dairy products to Europe and North America (AHDB, 2021a; 2021b). Since the early 1990s, UK dairy industry restructuring followed interventions by national and European policymakers to boost milk demand and regulate LM supply. Despite government efforts to redistribute market power, price dispersions remain a contentious issue for UK dairy farmers, causing many producers to be forced out of the market. Moreover, the UK food retail market can be described as concentrated, as four companies hold 56% of the total market share, including Tesco (23.1%), Sainsbury's (12.8%), ASDA (11.5%) and WM Morrison (8.6%) (IBISWorld, 2021a). The concentrated number of retailers have high bargaining power over milk producers, often resulting in low prices for commodity products like milk. Understanding price transmission mechanisms among supply chain actors (vertical price transmission) is vital due to its impact on consumer and producer income and welfare, influencing the milk market's economic sustainability. Evidence supports that the limited number of processors in the milk processing market, product perishability, market power, government intervention, market structure and more led to retail price increases being transmitted faster than decreases (price asymmetry) to farmgate prices. This leads to benefits being distributed unequally across the supply chain actors. Thus, the present study assesses
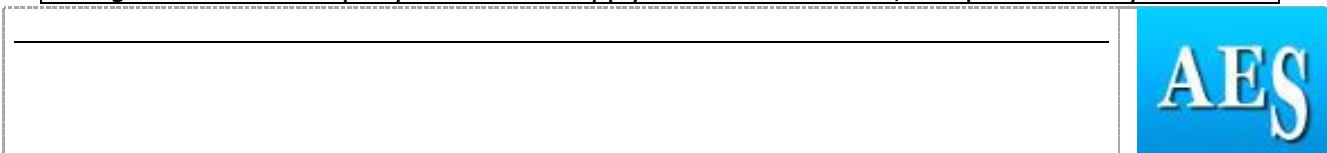
the extent of price dependence between UK producer and retail LM price pairs in the long and short-run and explores the pattern of price transmission.

Methodology	*100 – 250 words*

For this study, monthly, secondary, time-series price data were obtained spanning the period 01/2000-01/2023. Data refer to farmgate LM prices (pf), expressed as pence per litre (ppl) and representing the average prices paid to producers were derived from the Agriculture and Horticulture Development Board (AHDB) database. Regarding retail LM prices (pr), these were obtained from the Office for National Statistics (ONS) database, reflecting average monthly prices paid by consumers, expressed as pence per pint (ppp). To ensure consistency, retail LM prices were converted into ppl (1 pint = 0.568 litres) and all data were expressed as natural logarithms (lpf and lpr respectively) during the analysis. Initially, the unit root tests of Lee and Strazicich (2004) test including one break and the Lee and Strazicich (2003) unit root test including two breaks are applied to examine the order of integration of the price series. Then, the nonlinear-Granger causality test proposed by Diks and Panchenko (2006) is employed to examine price causality and thus to determine the level of the supply chain that a price shock initiates and evokes a response to the other level – central market. This is pursued on VEC filtered residuals derived through the process of Johansen cointegration test followed by the conduction of a VECM model, whereas diagnostic tests have been applied on the residuals to ensure they are free from serial correlation. On a second stage, the Nonlinear Autoregressive Distributed Lag model (NARDL) proposed by Shin et al. (2014) is applied to examine the long-run relation as well as to consider asymmetries in the long and short-run in a combined system.

Results	*100 – 250 words*

Results from Lee and Strazicich (2004;2003) unit root tests suggest that both price series are integrated of order one, I(1). Findings from Diks and Panchenko (2006) causality test show a unidirectional relation with retail prices granger causing farmgate prices at 5% level of significance. As such, a shock originates in retail prices and evokes response to farmgate prices. Using the NARDL model, results rejected the null hypothesis of no cointegration since the F_{PSS} and t_{BDM} statistics exceeded the upper critical bounds (1%). In addition, results from the Wald tests suggested that the null hypotheses of long and short symmetries can be rejected at 1% level of significance, providing evidence of asymmetries in magnitude and speed in the PT mechanism. Long run elasticities suggested that increase by 1% in retail prices leads to an increase by 0.76% in farmgate prices whereas decrease by 1% in retail prices leads to a decrease by 0.064% in farmgate prices. Thus, positive shocks in the retail prices are transmitted to the farmgate level with greater intensity compared to negative ones. The dynamic multipliers suggested that in the short run, farmgate prices respond quicker to price increases than decreases in retail prices. The magnitude of adjustment is larger for positive shocks with the equilibrium correction being achieved after nearly 40 months. The behaviour of dynamic multipliers is consistent with both short- and long-run asymmetry.

Discussion and Conclusion	*100 – 250 words*

This research showed that the UK LM market is partially integrated due to a confirmed long run relation, however, price changes are not fully or quickly transmitted between the actors. Higher levels of integration are translated as full transmission, and with greater speed, regarding price shocks (Rezitis and Rokopanos,2019). Price shocks are generated and transmitted from the retailer to the producer suggesting a univariate price shock direction due to retailers having greater power and because of the degree of high market concentration confirming the findings of Stubley et al. (2018). Moreover, evidence of asymmetry has been provided, both in the short and long-run, given the disparity in market power, and, the declining trend of dairy holdings in the UK. These results align with the findings of Kinnucan

and Forker (1987) who concluded that the pattern of PT between producer-retail LM prices in U.S was asymmetric and manipulated by price floors set by the government. In addition, similar findings have been confirmed for price behaviour in the EU milk supply chain (Loy et al,2014;Antonioli and Santera,2021). Last, the suggested low speed of adjustment may be explained by the lack of market integration between farmgate-retail milk prices, suggesting the need for efficient policies to be implemented (Goetz and Cramon-Taubadel, 2008) that counter anti-competitive behaviour by retailers. The Grocery Code Adjudicator could enforce a code of practice for larger retailers. To empower producers and stimulate growth, measures like price floors could enhance income stability and support producer welfare.