Price pass-through in UK fertiliser markets

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Abstract

Fertiliser prices have received considerable attention recently owing to elevated volatility, high prices, and supply disruptions arising from shocks to factor markets. In the UK, the domestic production environment for nitrogen fertiliser has undergone structural change at the same time. This work uses nonlinear autoregressive distributed lag (NARDL) techniques to examine the dynamics of price transmission from international bulk fertiliser prices to UK prices. Analysis fails to find evidence for long run asymmetry, but does identify evidence of short run-asymmetry in transmission of shocks from bulk prices to domestic prices.

Keywords Fertiliser; Pass-through; NARDL

JEL code Q11; Q17

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Introduction

Nitrogen fertiliser is a key input for both crop and livestock agriculture. The United Kingdom is a net importer of fertiliser, and has recently undergone structural change in the nitrogen fertiliser sector, with a substantial reduction in domestic production capacity. High prices and volatility both globally and in the UK since 2021 have drawn attention to fertiliser markets in a way not seen since the 2007/08 price shocks.

Domestic prices appear to be determined by import parity, with UK prices following events in international markets. Despite this, UK fertiliser markets remain relatively little studied, their prominence in some farm accounts notwithstanding.

This paper examines the nature, speed and symmetry of price and exchange rate pass-through to UK nitrogen fertiliser prices, and tests for the existence of asymmetries in price transmission.

Literature

This section outlines some of the general themes seen in the fertiliser price literature; it is not an exhaustive review, rather an indicative one.

Most UK-focused fertiliser literature concerns estimation of the demand function for fertiliser (e.g., Burrell 1989), or looking at fertiliser as part of a broader study of farm cost and profit functions.

Some pass-through studies look at the relationship between fertiliser cost shocks and farm or retail prices (e.g., Olagunju, Feng, and Patton 2021) or upstream input cost shocks and fertiliser prices (e.g., Bushnell and Humber 2017).

Hu and Brorsen (2017) examine spatial price transmission between markets within the contiguous United States, using VECM models to assess speed of correction. This is close to what this paper sets out to examine, but examines product markets at a similar point in the supply chain.

Relatively few studies could be found that examine pass-through from bulk fertiliser markets to domestic fertiliser markets. Alemu (2017) uses Momentum Consistent Threshold Autoregressive model and error correction models to examine international to domestic price transmission in South Africa. Bor and Dagistan (2024) use a nonlinear autoregressive distributed lag (NARDL) model to examine price transmission from international to domestic Turkish prices of urea and diammonium phosphate prices. It is this latter methodology adopted for this study.

There is value in better understanding the way in which UK farm input prices respond to shocks in international bulk markets, both in understanding the speed and addressing the question of symmetry. Better understanding can farmers better set their expectations about how international market events will affect their operations.

Data

UK fertiliser price indices were taken from Defra's (2025) Agricultural Price Indices dataset. Specifically, this paper uses the indices for straight nitrogenous fertiliser.

International bulk fertiliser prices were taken from the World Bank's (2025) commodities price 'Pink Sheet'. The bulk urea price was used as a proxy for global nitrogen prices. The urea price is an imperfect proxy in the case of the UK, where ammonium nitrate fertiliser is by far the most commonly applied, but the two prices are themselves closely linked due to their closely related production processes and status as substitutes.

The exchange rate (with the USD as quote currency, GBP as the base) and US PPI were taken from FRED – the St. Louis Federal Reserve Economic Data database (Board of Governors of the Federal Reserve System (US) 2025; U.S. Bureau of Labor Statistics 2025)

The paper uses monthly data from January 2001 to November 2024, transformed by taking their natural logarithm.

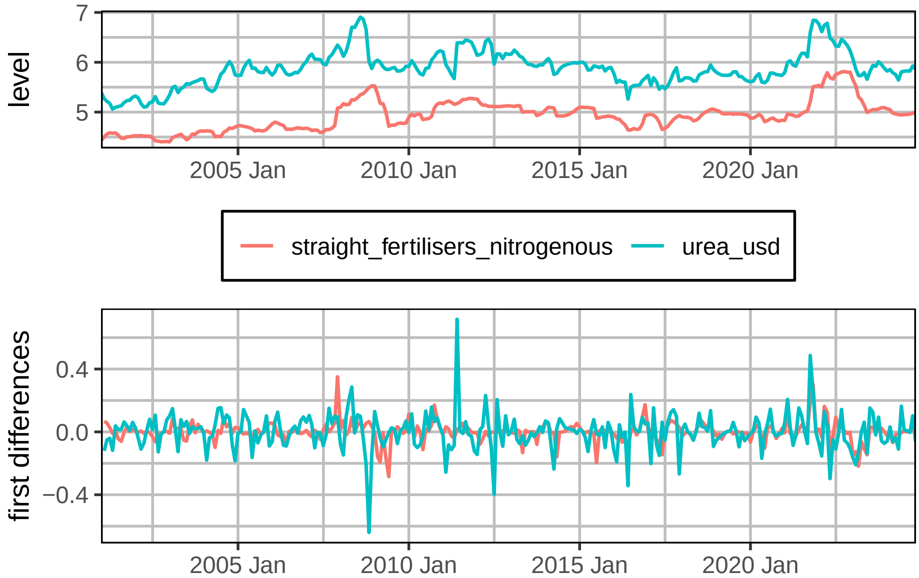

Figure 1: Log nitrogen fertiliser prices, Jan 2001 - November 2024

Software

The paper was composed using the Quarto publishing system, with a reproducible pipeline enabled by `targets` (Allaire et al. 2024; Landau 2021).

Data manipulation and analysis was undertaken in the R programming language using `readODS`, `tidyverse`, `tsibble`, and `tsbox` (Schutten et al. 2025; Wickham et al. 2019; Wang, Cook, and Hyndman 2020; Sax 2021). Data and model reporting was aided by `gt`, `broom` and `ggpubr` (Iannone et al. 2025; Robinson, Hayes, and Couch 2024; Kassambara 2023).

Model estimation and parameter manipulation was conducted with the `ARDL` package (Natsiopoulos and Tzeremes 2023).

Pre and post-estimation testing was undertaken using the `tseries`, `lmtest` and `car` and `urca` packages (Trapletti and Hornik 2024; Zeileis and Hothorn 2002; Fox and Weisberg 2019; Pfaff 2008).

Methods

Price transmission studies often employ autoregressive distributed lag (ARDL) or multi-equation vector autoregressive models (or their respective error-correction representations when cointegration is present).

Such studies often implicitly assume symmetry in price transmission. Addressing questions about asymmetry requires additional testing and adds to model complexity, e.g., through the use of nonlinear threshold-based models. Nevertheless, the presence of neglected asymmetry can invalidate both parameter testing and cointegration testing in linear models (Tarassow and Greenwood-Nimmo 2015). This paper estimates utilises nonlinear ARDL (NARDL) techniques and conducts tests for short and long run asymmetry.

Given the UK is a relatively small price taker in the global fertiliser market, single equation approach assuming exogeneity of global fertiliser prices is deemed appropriate. For this reason, the paper opts for a single equation approach. Single equation models also have the benefit of permitting a more flexible lag structure that, say, a VAR/VEC approach.

Shin, Yu, and Greenwood-Nimmo (2014) set out the NARDL as an extension of the standard ARDL model. Extensive discussion of the NARDL methodology, its properties, and its derivation, can be found in Shin, Yu, and Greenwood-Nimmo (2014).

The NARDL (and its associated error correction form) expands upon the standard ARDL methodology by allowing for asymmetry in the nature and dynamics of the relationship between the explanatory and dependent variables.

A regressor x_t is decomposed into its respective partial sums x_t^+ and x_t^-, where

$$x_t^+ = \sum_{j=1}^{t} \Delta x_j^+ = max[0, \Delta x_j] \tag{1}$$

and

$$x_t^- = \sum_{j=1}^{t} \Delta x_j^- = min[0, \Delta x_j] \tag{2}$$

As Shin et al. demonstrate, the NARDL(p,q) can be directly estimated in error correction form:

$$\begin{aligned}\Delta y_t = \alpha_0 + \rho y_{t-1} + \theta^+ x^+_{t-1} + \theta^- x^-_{t-1} + \sum_{j=1}^{p-1} \beta \Delta y_{t-j} \\ + \sum_{j=0}^{q-1} \left(\gamma_j^+ \Delta x^+_{t-j} + \gamma_j^- \Delta x^-_{t-j} \right) + \varepsilon_t\end{aligned} \tag{3}$$

Where ρ and θ capture the long run dynamics, while γ coefficients capture the short run dynamics. As such, the NARDL allows for both short and long run asymmetry. Short run asymmetry manifests in different dynamics of adjustment, while long run asymmetry manifests in different overall adjustment. Testing for asymmetry is accomplished by testing for individual (or joint) equality restrictions on the short and long-run coefficients.

Identifying short-run asymmetry tests the null hypothesis:

$$\sum \gamma^- = \sum \gamma^+ \tag{4}$$

Identifying long-run asymmetry tests the null hypothesis:

$$\theta = \theta^+ = \theta^- \tag{5}$$

Tests are run as a Wald test with the restricted model compared against the unrestricted model.

It is also possible to jointly test for long and short-run symmetry (in which case the NARDL collapses into the standard ARDL). The NARDL is linear in parameters, so can be efficiently estimated using ordinary least squares.

Pesaran, Shin, and Smith (2001) develop the bounds testing procedure, which tests the null hypothesis that the coefficients of the lagged levels in the conditional ECM are jointly equal to zero, i.e., that there is no long-run relationship. The bounds testing procedure is only appropriate for a single cointegrating equilibrium, and requires weak exogeneity of the regressors. However, unlike other treatments of cointegration it is flexible to inclusion of both I(0) and I(1) variables. Tarassow and Greenwood-Nimmo (2015) showed that the bounds test is robust to neglected short-run asymmetry but not neglected long-run asymmetry.

Estimation and discussion

Augmented Dickey-Fuller tests and Phillips-Perron tests were performed on the logged level and differenced data (Said and Dickey 1984; Phillips and Perron 1988). Testing `straight_fertilisers_nitrogenous`, `urea_usd` and `fx` failed to reject the null hypothesis of a unit root in levels at the 5% level of significance, but rejected it in first differences, suggesting they are I(1). At less strict levels of significance, some results were ambiguous. However, the bounds test can accommodate both I(0) and I(1) variables.

Table 1: Stationarity tests

Variable	Method	Data	Statistic	P value
straight_fertilisers_nitrogenous	ADF test	level	−2.910	0.193
		differenced	−7.094	0.010
	PP test	level	−18.487	0.093
		differenced	−190.213	0.010
urea_usd	ADF test	level	−2.734	0.267
		differenced	−8.716	0.010
	PP test	level	−18.104	0.099
		differenced	−206.954	0.010
fx	ADF test	level	−3.255	0.079
		differenced	−6.809	0.010
	PP test	level	−12.739	0.396
		differenced	−210.862	0.010

Given the UK is not a market mover for fertiliser purchases, and that fertiliser is a small proportion of UK imports, it is safe to treat international price and the exchange rate as exogenous.

Since a conventional ARDL may have biased coefficients in the presence of neglected asymmetry, where sample size allows it is prudent to estimate a NARDL first and *then* test linear restrictions of asymmetry. Estimating a standard ARDL first is redundant, since it is a restricted case of the NARDL.

Model lag selection was aided by minimizing an information criterion, with AIC and BIC yielding the same model when selecting for up to 12 lags. A slightly longer lag structure was used than that suggested by the information criteria to address serial correlation in the residuals and to permit fuller exploration of dynamics. A NARDL(2,2,2,2,2) was estimated.

Breusch-Godfrey and Breusch-Pagan tests both yield test statistics below the critical value, so it is concluded that there is no serious serial correlation or heteroskedasticity (Breusch 1978; Breusch and Pagan 1979; Koenker 1981).

Table 2: Residual test results

Method	Statistic	P value
Breusch-Godfrey test for serial correlation of order up to 12	17.772	0.123
studentized Breusch-Pagan test	19.758	0.138

The RESET test also yields favourable results (p = 0.404) with the conclusion the model is adequately specified (Ramsey 1969). The distribution of residuals has fat tails, though is otherwise well-behaved, so the OLS estimator is still unbiased and consistent.

Table 3: Bounds test results

Method	Statistic	P value
Bounds t-test for no cointegration	-7.762	0.000
Bounds F-test (Wald) for no cointegration	12.755	0.000

Bounds test statistics (F and t statistics) exceed their respective critical values, rejecting the null hypothesis of no joint long-run relationship.

The error correction term in the restricted ECM is -0.19, meaning UK prices correct towards international prices at just under 20% per month, yielding a half life of around 4 months.

Table 4: Test for short-run asymmetry

Test	Statistic	P value
urea_usd	7.297	0.007
fx	0.001	0.973

The null hypothesis of short run symmetry with respect to shocks to bulk prices is rejected.

Table 5: Test for long-run asymmetry

Test	Statistic	P value
urea_usd	0.002	0.969
fx	0.028	0.867

Testing cannot reject the null hypothesis that the long-run effects of the USD urea price are symmetrical. The same is true for the exchange rate.

The computed short and long run multipliers are given in Table 6.

Table 6: Short and long-run multipliers

Horizon	Term	Estimate	Std error	T value	P value
SR	urea_usd_p	0.285	0.044	6.481	0.000
	urea_usd_n	0.057	0.048	1.201	0.231
	fx_p	−0.205	0.301	−0.678	0.498
	fx_n	−0.191	0.250	−0.764	0.446
LR	urea_usd_p	0.825	0.078	10.595	0.000
	urea_usd_n	0.822	0.080	10.242	0.000
	fx_p	−1.038	0.266	−3.907	0.000
	fx_n	−0.975	0.314	−3.106	0.002

The long run multipliers can be tested to ascertain if there is 100% pass-through.

Table 7: Test for unit elasticity

Test	Statistic	P value
urea_usd_p	55.199	0.000
urea_usd_n	57.946	0.000
fx_p	0.020	0.887
fx_n	0.006	0.938

There is sufficient evidence to reject the null hypothesis that there is unity pass-through from bulk to domestic prices. It cannot be rejected that the long-run multiplier for exchange rate shocks is equal to unity.

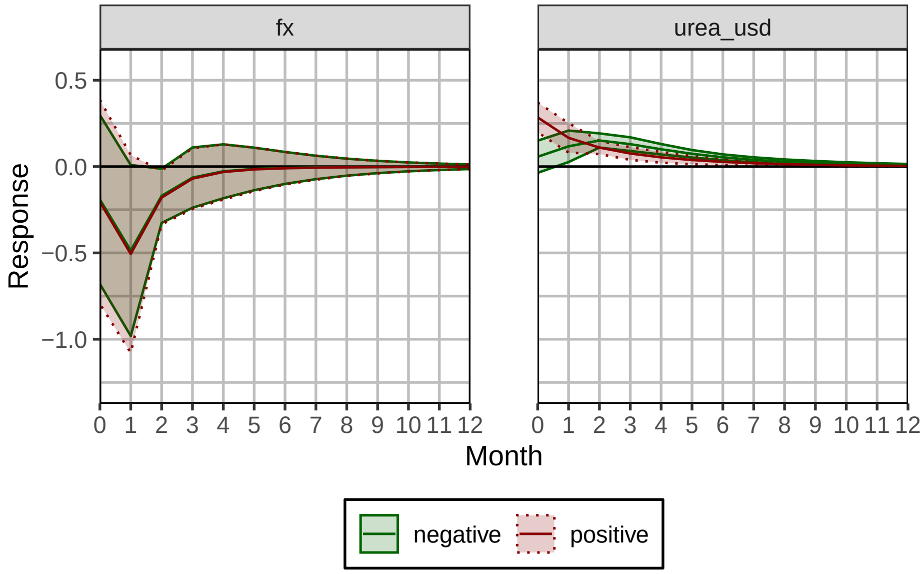

Figure 2: Delay multipliers

Plotting the delay multipliers over a 12-month period helps to show how quickly the bulk of an exchange rate shock (positive or negative) is passed through, while bulk nitrogen price shocks have a more gentle transmission to domestic prices. The asymmetry in bulk price shock pass-through can be seen by overlaying the positive and negative delay multiplier pathways.

The failure to reject the null hypothesis of long-run symmetry is unsurprising. While domestic production of fertiliser is relatively concentrated, importation and distribution of fertiliser is comparatively competitive. It is difficult to see how, in a competitive market, asymmetry in long-run pass-through would not create opportunities for profitable arbitrage or seizure of market share.

The finding of short-run asymmetry in bulk price pass-through is interesting for a number of reasons. While the techniques used in this paper can identify asymmetry they cannot conclusively ascribe a cause. A number of potential explanations exist. Anchoring effects from the cost basis of existing stock may make merchants reluctant to lower domestic asking prices while bulk markets are falling. Seasonal purchasing behaviour may mean new product arrives more slowly in falling markets. The lead-times involved in procuring new shipments may, in combination with risk aversion, make merchants unwilling to drop prices quickly.

While international prices represent bulk prices, domestic prices are not representative of landed prices but farm-delivered prices, and so include a marketing margin from domestic handling and resale. Seeing full pass-through would have been unusual. Consequently, it is possible that price shocks are being passed through in full while the domestic marketing margin remains unchanged.

Conclusion

This study examined price transmission dynamics in UK nitrogen fertiliser markets. The study found evidence of short-run asymmetry in pass-through of shocks to bulk prices, but failed to find evidence of long-run asymmetry.

The finding of short-run asymmetry is important as it provides evidence not only to support the existence of this phenomenon but to help map its dynamics. The finding of long-run symmetry is equally important, suggesting as it does that these differences are temporary and not therefore giving rise to any long-run ratchet effect.

Scope for expansion

There are numerous avenues to expand this study.

One straightforward expansion could explore alternative forms for the model. For example, inclusion of seasonal effects in domestic prices could help model any effects from storage costs and strong seasonal usage patterns. Additionally, there is room for closer examination for structural breaks. Inclusion of dummies for the COVID-19 pandemic did not noticeably improve model fit. Finally, the NARDL can accommodate partial asymmetry, so the model estimated in this paper could be re-estimated in light of the apparent long-run symmetry.

No testing has been conducted of out of sample performance. Expansion of this study could test models not only for their in-sample fit and residuals, but also their out of sample performance. This could help identify the models best suited to forward-looking analysis of the impact of international shocks on domestic fertiliser prices.

Finally, the same methodology can be applied to other fertiliser types.

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