AES 2016 Presidential Address

Forty Years of Price Transmission Research in the Food Industry: Insights, Challenges and Prospects

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Abstract

Price transmission refers to the process via which information is transmitted between participants in a market. Focusing on vertical markets such as the food chain, this Address considers developments in theory, methods and data that help economists understand how information is conveyed between food consumers and agricultural producers. Central to this understanding is the increasingly important role played by the food industry (retailing, manufacturing and processing) in price transmission. Not only is the food industry a major source of the price changes that producers and consumers face but it also mediates price signals originating in other parts of the food chain in increasingly nuanced ways, as revealed by highly detailed retail ('scanner') data that is becoming progressively available to researchers. While the speed, magnitude and asymmetry of price transmission are valuable descriptors of price adjustment in vertical markets, we should be wary of inferring too much about the competitive setting on the basis of prices alone. Theory-consistent empirical models are a step in the right direction and represent a useful complement to the approaches developed in the New Empirical Industrial Organisation (NEIO) literature which address the issue of market power directly. Being the mechanism underlying food inflation, price transmission also has an important macro-economic dimension, and concerns about competition surface here too. Given the rapidly changing nature of the food industry in many countries, the need to understand the forces shaping price transmission is as cogent as ever.

Keywords: Price transmission, food industry, market power, food inflation

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I. Introduction

Being the principal mechanism by which information is communicated, pricing plays a fundamental role in all markets, and economists have been studying how prices move through the food chain pretty much since the dawn of agricultural economics itself. For example, Allen (1959) reports elasticities of demand at various stages of the food chain that date back to the 1890s. So why confine this Address to the last forty years? The reason is that it was in 1975 that Bruce Gardener published his landmark paper 'The Farm-Retail Price Spread in a Competitive Food Industry' in the American Journal of Agricultural Economics. It represented a watershed and is worthy of homage. In contrast to so much of the literature in the area which is empirical in nature, Gardener's paper set out the relevant theory, and in doing so clarified the mechanisms and their implications in an area that has been characterised by its fair share of misunderstanding and overreach.

The literature on price transmission in agricultural and food markets is substantial. Kouyaté and von Cramon-Taubadel (2016), uncover 492 recent papers alone using price transmission as a search term. This Address focusses solely on price relationships in a 'vertical' food chain, such as that between farm-gate and retail counter, rather than 'horizontal' price transmission which is concerned with how prices of the same good (such as wheat) relate to one another at different localities. Nevertheless, as a review, it is inevitably selective. Furthermore, since many of the empirical results are country and product specific, I resist the temptation to discuss the full range of empirical results that have been obtained and apologise here to all whose informative work is not included.

While the topic of this Address is the transmission of prices within the food chain, the issues are common to many areas of economics, most obviously the literature on exchange rate pass-through of international economics (Goldberg and Hellerstein 2008), the incidence of taxes (Anderson et al 2001) and the domestic impact of oil price shocks (Blanchard and Gali 2007). Although the context may differ, common mechanisms are apparent. Moreover, these literatures are keen to emphasize the important role that competition and market structure plays in the process, something that features prominently in analysis of the food industry (Wohlgenant, 2001, Sheldon and Sperling 2003).

So why study price transmission in the food industry? One reason is that the extent and dynamics of adjustment as price signals pass between various stages of the food chain (such as farmer, manufacturer and retailer) are key indicators of the behaviour of participants in the chain and its overall functioning. Reports such as those initiated by the European Parliament and the UK Government (Agra CEAS Consulting 2007; Competition Commission 2000 respectively) were motivated in large part by the welfare consequences of an apparent divergence between producer and consumer prices. Indeed, pricing issues are high on the list of concerns of stakeholders and policy makers in the food chain. In a recent survey of 23 OECD countries, OECD (2015) report that price transmission and the link between unfair business practices was highlighted as a pressing priority in the majority of countries (see Table 1). While concern over pricing and competition would appear to have intensified in recent decades, it is far from new, the issue being voiced as far back as the 1920s in the US at least (Myers, Sexton and Tomek 2010).

Table 1: Key concerns about food prices in the OECD

Countries	Food price increase	Food price Volatility	Price transmission along the chain /unfair trading practices	Declining terms of trade	Other
Australia			+	+	
Belgium		+	+		+
Canada	+		+		
Chile			+	+	
Czech Republic	+				
Denmark	+		+		+
Estonia			+	+	+
European Union	+	+	+		
France	+	+		+	
Indonesia	+		+	+	
Israel	+		+		
Italy	+	+	+	+	
Latvia			+		
Lithuania	+				+
Netherlands			+	+	+
New Zealand			+		
Poland		+	+		+
Portugal			+	+	
Slovenia			+		
South Africa	+		+		
Switzerland	+	+	+		
Turkey	+	+	+	+	
United Kingdom	+			+	+

Source: OECD (2015), p. 4

Price transmission is not just a substantive issue for farmers and consumers but all agents in the food chain. As the marketing literature makes clear, the extent to which falling prices and discounts are passed on to consumers, so-called 'deal pass-through', is commonly cited as one of the most important issues facing processors and manufacturers (Gómez, Rao and McClaughlin, 2009, Nijs *et al.* 2010). The issue is all the more important in a world where (for the UK at least) some 40% of food purchased in supermarket is on promotion (Wisson, 2012). Not only are promotions something of defining characteristic of food retailing but they raise fundamental questions about the nature of pricing and price transmission, blurring consumer perceptions regarding the 'real' price of products, as the recent investigation by the UK's Competition and Markets Authority has illuminated (see CMA, 2016).

Another reason to study price transmission is that it demands we bring the food industry directly into the analysis, rather than assume it away. The USDA's now famous breakdown of consumer spending on food, the 'Food Dollar', shows the proportion of consumer expenditure on domestically produced food going to the 12 industries that make up the food chain in the US (Figure 1). As the data for 2014 reveal, nearly 90% of consumer spending goes to providers of non-agricultural goods and services in the US. Food service ('eating out') is the largest (and fastest growing) component, representing almost three times more than agricultural value added. Clearly, what goes on between the farm and the fork is simply too big to ignore as the recent literature on the impacts of the food industry on price transmission emphasises (Nakamura and Zerom 2010; Hong and Li 2015).

Figure 1: The Food Dollar (2014)

Source: Economic Research Service, USDA (2016)

There is clearly an important macroeconomic dimension to price transmission as the mechanism governing the inflationary process. Recent surges in commodity price inflation have brought food price inflation and its implications in to sharper focus (Leiptag 2009, IMF 2011). Food inflation is also one of the most volatile components of general inflation. The magnitude of recent commodity price spikes and the transmission of these shocks have become a pressing public policy concern not least because, as former IMF chief Professor Kenneth Rogoff puts it, if 'inflation is one of the cruellest and most regressive of all taxes', then food inflation must surely be its most regressive component.

In what follows, I begin by setting out the concept of price transmission, highlighting the misconceptions that arise when the food industry is relegated to the status of an add-on, or indeed is assumed away entirely. Gardener (1975) provides the key insights in competitive markets and has spawned a rich literature examining the influence of market power on transmission, which is briefly assessed. This performs the backdrop for a review of the empirical literature in Section III using aggregate time series data focussing on the notion of asymmetric price transmission (aka 'rockets and feathers') that is so often linked to the use of market power. The paper then turns to more recent developments in Section IV that exploit micro data, primarily supermarket scanner data, which has both deepened our appreciation of price transmission and highlighted the manifold levels on which it operates. Recent spikes in commodity prices remind us that in a macroeconomic context, price transmission is the mechanism underlying the inflationary process, and in Section V I briefly look at some recent work in that area. The Address closes with some concluding remarks.

II. Price transmission

Vavra and Goodwin (2005) define price transmission as "How quickly and to what extent, changes in farm prices are transmitted to the retail level and vice versa" (p.3). Price transmission is thus an umbrella term describing two processes. The first describes how price signals emanating at the farm level move downstream to retail prices ('pass-through'); the second how signals originating at the retail level move upstream to the farm gate ('pass-back'). Shocks to intermediate stages in the food chain (e.g. manufacturing) create pass-through and pass-back as signals move away from the source through the vertical food chain. Much of this Address will focus on how the difference between farm and consumer prices (the price spread or marketing margin) changes in response to shocks at these various stages.

Misconceptions

In the absence of an intermediate sector the product that consumers purchase is the same as that which farmers produce. This gives rise to three results, namely:

(i) Farm and retail prices co-move, so they cannot move in opposite directions;

(ii) There is perfect (one-for-one) transmission of price signals. A shock that increases farmgate prices by 10% increases retail prices by 10% and vice versa.

(iii) The variability of prices is the same at farm and retail levels.

Insights from theory

The seemingly innocuous introduction of an intermediate sector changes things substantively, so much so that none of the results listed above are true generally (at best they are special cases). They do however condition us in to presuming that they are 'natural outcomes' that are affected little, save for a price wedge to allow for marketing costs, and with it a fixed marketing margin. Gardner (1975) was the first to formally set out the relationships between equilibrium prices in perfectly competitive vertical chain (see Tomek and Robinson 1972 or Ritson 1978, for diagrammatic treatment) and by doing so illuminated these misconceptions clearly.

At the core of Gardner's 1975 paper is the acknowledgement that in a setting where farm and marketing inputs combine in a retail product, conditions of supply in one sector have direct bearing on the demand in the other, with implications for prices in all three. In other words, not only is the demand for the agricultural (marketing) product derived from that at the retail level, but that it is mediated via conditions of supply in the marketing (agricultural) sector. As such, notions of derived demand and interdependence in the vertical chain characterise the model. Specifically, demand for the farm (marketing) product is now directly dependent on conditions of supply in marketing (farm) sector. For example, an increase in the cost of the marketing input will make the final good more expensive. *Ceteris paribus*, consumers buy less of the retail product and hence less of both inputs in a ratio determined by the ease with which one input can be substituted for another in the final good (the elasticity of substitution). Importantly here, farmers see their prices falling as retail prices rise, exposing (i) as a misconception.

Similarly, the model shows that prices may be expected to be more volatile at the farm gate than at retail, discrediting (iii). By driving a wedge between retail and farm prices, the presence of a marketing sector reduces the price elasticity of demand for the farm product relative to that at retail. While this result was not new when inputs are combined in fixed proportion as they might be with raw milk per carton or eggs per box, (see Allen 1959) Gardner's formal analysis confirmed that it was also likely to be the case when inputs can be substituted, although the actual outcome depends on the size of the elasticity of substitution relative to the elasticity of demand. Since the opportunities for substitution in most food products is rather limited, demand for farm gate products can be reasonably expected to be more inelastic that at retail, with the implication being farm prices are more volatile (Gardner 1975, p. 405).

The source of the shock matters too; critically so. Not only do increases in marketing costs drive farm and retail prices in opposite directions but the factors that govern how shocks pass through the chain are not the same as those that govern how shocks are passed back. To see this clearly, we simply need to compare the pass-through elasticity (Gardner 1975, equation (19) p. 404):

$$\tau_{\text{pass-through}} = \frac{S_f(\sigma + e_m)}{e_m + S_f\sigma - S_m\eta}$$

with the pass-back elasticity ((Gardner 1975, equation (18) p. 403):

$$\tau_{\text{pass-back}} = \frac{\sigma + e_m}{\sigma + S_f e_m + S_m e_f}$$

Here, σ denotes the elasticity of substitution between farm (f) and marketing (m) inputs in the retail good; η is the price elasticity demand of the retail good; S_f and S_m are the shares of each input in the retail good and e_f and e_m are the price elasticities of supply in the farm and marketing sectors respectively. As close inspection reveals, equation (1) is not the reciprocal of (2), so pass-through does not in general equal pass back. In other words, a shock to retail demand that changes farm gate prices by 10% will have a different effect on retail prices than a shock to farm supply that changes farm prices by 10%. The elasticity of price transmission, so often reported in empirical work, is thus not a single number because it is not in general independent of the source of the shock. As Gardner formally establishes, in all admissible cases, pass through will be smaller than pass back (see Gardner 1975 p.404).

When there are exogenous shocks to both farm supply and retail demand, the elasticity of price transmission obtained is not (1) or (2) but a mixture of the two. Estimation of a single coefficient for these two effects represent a potentially serious identification problem and suggests we should be wary of price transmission studies that take no account of the source of the shock. Empirical studies that use pairs of prices alone to estimate 'the' transmission elasticity clearly need to address the causation issue.

And what of perfect price transmission? Gardner (1975) is decisive here too. For a shock originating at the farm (retail) level to be fully reflected in retail (farm) prices then its impact represents the share of agricultural product in food industry's cost function. As McCorriston, Morgan and Rayner (1998) set out, perfect price transmission implies that a 1% increase in the price of the farm input

increases retail price S_f times. In the absence of a marketing sector $S_f = 1$ and $\tau_{pass-through} = \tau_{pass-back} = 1$. However, as this shows, unit elasticity of price transmission represents little more than a trivial exception. More generally, $\tau_{pass-through} = S_f$; $\tau_{pass-back} = S_f^{-1}$ denotes perfect price transmission. This obtains when the supply of marketing inputs are perfectly elastic ($e_m = \infty$) and hence exogenous to the farm and retail markets.[2] So, perfect price transmission as commonly defined, is a special case, even in a perfectly competitive setting. While there may be cases when the exogeneity of the market sector is reasonable, it is important to realise that perfect price transmission is not necessarily the natural outcome of perfect competition, so considerable care is needed when using the transmission elasticity an indicator of well-functioning markets.

Another important corollary of the general result regarding price transmission is that there is no simple mark-up pricing rule (in absolute or relative terms) that accurately expresses the relationship between farm and retail prices, since what happens to farm and retail prices (and hence the price spread) depends on the source of the shock and the parameters of the model. In particular, a growing disparity between farm and retail prices, even where prices are diverging, is consistent with a competitive setting.

Gardner's model had many antecedents (see for example Brandow, 1962, George and King, 1971 Tomek and Robinson, 1972) and spoke to other issues not specifically mentioned here (see Wohlgenant, 2001). However, its contribution in the field of price transmission was seminal. It cautions us to be wary of bivariate models of prices transmission since these are not only subject to an identification problem but take no account of marketing costs, empirically the most important component in the price of food. It also emphasises the potentially important role played by the processing technology - the substitutability between agricultural and marketing inputs dampening price transmission relative to the fixed proportions case, a result which was subsequently found to be empirically important (Wohlgenant, 1989). Finally, this formal analysis stresses that if imperfect competition is suspected, a model explicitly addressing such behaviour is required in order to judge the implications of price transmission observations for the competitive behaviour of the sector.

Market Power

While text books often treat agricultural markets as the epitome of the competitive setting, the existence of a food industry between farmer and consumer clearly raises the prospect of market power. High levels of concentration, product differentiation and vertical coordination characterise the processing, manufacturing and retailing in food chains around the world (McCorriston, 2002; Saitone and Sexton, 2010; MacDonald and Korb, 2011).

Testing for market power in agricultural markets has a long tradition (see Sheldon and Sperling, 2003; Perekhozhuk *et al*., 2016). In terms of the impact of imperfect competition on price transmission, Holloway, 1991 and McCorriston, Morgan and Rayner, 1998 augment the Gardner (1975) model to examine the role of a oligopolistic food chain on price transmission. As in the

[2] To see this, multiplying the numerator and denominator of (1) and (2) by $1/e_m$. With $e_m = \infty$ (1) and (2) collapse to S_f and S_f^{-1}. In the absence of a marketing sector $S_f = S_f^{-1}$=1. For a given exogenous shock arising in the marketing sector, there are no circumstances that give rise to perfect price transmission.

perfectly competitive case, the numerical value of the price transmission elasticity reflects all the structural parameters, so it is not possible to infer the presence of market power from the pass-through elasticity alone. However, conditional on linear demand, Morgan, McCorriston and Rayner, 1998, demonstrate that oligopoly power dampens the degree of price transmission relative to the perfectly competitive benchmark with a perfectly elastic supply of marketing input.[3] This so-called 'under-shifting' (i.e. $\tau_{\text{pass-through}} < S_f$) arises because the mark-up over marginal costs that characterises oligopoly itself adjusts when costs change as the oligopolistic food sector absorbs some of cost shock. As a result retail prices change less than farm gate prices. Should the imperfectly competitive food industry give rise to greater efficiency, as captured by increasing returns to scale, McCorriston, Morgan and Rayner, 2001, demonstrate that under-shifting is weakened. Moreover, in some plausible scenarios, the effect is reversed, leading to 'over-shifting' (i.e. $\tau_{\text{pass-through}} > S_f$) whereby food prices rise by more than farm gate cost increase. Indeed, apart from cases where retail demand and supply functions are linear, the impact of oligopoly power on the degree of price transmission is ambiguous.

Reflecting growing concerns over buyer (retailer) power in the UK in particular (e.g. Competition Commission 2000) Weldegebriel, 2004, developed a model to investigate the effect of oligopoly and oligopsony power on price transmission (individually and also where they co-exist). Importantly, his results (see Table 1 p.112 for a summary) demonstrate that buyer power need not exacerbate seller power and may in certain situations offset it, so that relative to the competitive benchmark the effect on price transmission cannot be ascertained *a priori*. Much depends on the functional forms that are assumed for the supply and demand schedules, about which little is known. Although uncomfortable, theoretical analysis highlights the fact that, without careful consideration of the range of factors involved, little can be inferred about market power from the low (or high) value of the price transmission coefficient alone.

[3] The result does nevertheless hinge on linear demand. Given a constant elasticity demand function, the degree of price transmission in the presence of oligopoly power is identical to the degree of price transmission in a perfectly competitive market.

III. Empirical Analysis

Developments in time series econometrics have had a profound effect in many areas of applied economics, but arguably none more so than in price transmission. Work predating the 'unit root revolution' (Perron, 1989) focused on testing the direction of causality in price transmission and/or on the estimation of a correlation coefficient for prices at different stages of the marketing chain (e.g. Heien, 1980, Lamm and Westcott,1981). Following the (Nobel prize winning) work of Engle and Granger, 1987, in which the duality between cointegration and error correction was established, testing for unit roots, co-integration and error correction using price data has become mandatory in empirical work. Armed with these new techniques, price transmission studies using bivariate price regressions proliferated. For instance, Palaskas, 1995, focused on the three major hypotheses: (i) whether producer and consumer prices in vertically-related markets are tied in a long run economic relationship (i.e.co-integrated); (ii) whether price changes at the farm level are fully transmitted to the retail stage, which was taken to occur when the elasticity of price transmission equals unity; (iii) the speed of short term adjustment. Empirical findings using these reduced form regressions showed that in general prices at different levels of vertically-related markets are co-integrated, that shocks from the raw input sector transmit fully to consumers in the long-run and that price adjustment in the short run is sluggish. By embedding notions of long and short run behaviour in the empirical framework, modern time series methods can offer many insights into the process of price transmission, not least in respect of the adjustment dynamics and the direction of causality in the vertical chain. However, as highlighted in the previous section, the bivariate regression has serious limitations, not least one of identification, since in general pass-through does not equal pass-back. While causality tests can be brought to bear on this issue, equating perfect price transmission with unit elasticity between retail and producer prices is problematic since in general it cannot be given this interpretation.[4]

In an attempt to move away from the bivariate regression a number of empirical studies attempted to augment the price spread with exogenous shifters (Lloyd et al., 2001; Sanjuan and Dawson, 2003). Motivated by the dominance of the national retail chains in the UK (Competition Commission, 2000) Lloyd et al., 2009, present a simple theoretical model of oligopsony which delivers quasi-reduced form retailer-producer pricing equations in which the presence of buyer power and can be detected using readily available market data. Relative to the perfectly competitive benchmark, their analysis predicts that that with linear demand retail buyer power reduces pass-through and increases pass-back. Augmenting retail and producer prices with measures of marketing costs and variables to capture the exogenous shocks at the retail and farm levels (such as food scares and farm gate costs respectively), the influence of buyer power is assessed by coefficient restrictions on pass-through and pass-back in the equation describing the retail-farm price spread. Applying a cointegrated vector autoregression to 12 years of monthly data they find results consistent with buyer power in 7 out of 9 agricultural product markets in the UK. Where behaviour consistent with buyer power was detected, estimated coefficients were correctly signed and statistically significant in 90% of cases, corroborating the findings of the Competition Commission's Inquiry. While attempts such as this move us away from the limitations of the bivariate regression in a tractable and theoretically

[4] Where adjustment is made to the prices to facilitate comparison between levels of the food chain (e.g. converting retail prices to carcase weight equivalents) perfect pass through corresponds to a unit coefficient between prices expressed per kg but not the elasticity. See Agra CEAS Consulting 2007 for conversion factors.

consistent way (see also Reed and Clarke, 2000 for the US), results obtained from time series analysis using aggregate data at best represent a 'first pass' evaluation, since they inevitably embody many untested assumptions regarding the nature of technology, functional forms and the elasticity of marketing services, all of which play potentially decisive roles in vertical price transmission. At very least, studies based on time series analysis need to be underpinned by a thorough understanding of the vertical chain under scrutiny.

Putting detailed industry knowledge to work is a characteristic of the structural econometric models that emerged in the New Empirical Industrial Organisation (NEIO) literature (Sheldon and Sperling, 2003, Perekhozhuk et al., 2016). Central to this literature is the modelling and testing of imperfect competition. Structural econometric models also deliver measures of price transmission and place the analysis of price transmission on firmer ground, because they explicitly identify its determinants. As before, the effect on price transmission depend on a range of structural parameters, although in general market power tends to impede price pass through relative to the competitive benchmark. Early applications to the food industry in this direction include Azzam and Pagoulatos, 1990 Holloway, 1991; Wann and Sexton, 1992. One attraction of this approach is that parameters measuring the degree of oligopsony and oligopoly power may be derived, facilitating comparison across markets in the food chain and countries (Perekhozhuk *et al*., 2016). While early studies were criticised for their inherently static characterisation of price transmission and, owing to data constraints, a level of aggregation that tended to underestimate the degree of imperfect competition (Sexton, 2000) more recent studies have gone a long way in addressing these issues following the advent of retail scanner and firm-level data (see Section IV).

Rockets and Feathers

Time series analysis of the price transmission process has often found that the rate of adjustment depends on whether prices are rising or falling (Vavra and Goodwin, 2005). As with growing price spreads in general (particularly when coincident with falling farm prices) asymmetric price transmission (APT) is invariably attributed to market power. This reflects the commonly held view that an anti-competitive food industry will be more eager to pass on changes that squeeze their margins than those that increase them, but, as with much in price transmission, this is not necessarily the case. Asymmetry can arise in competitive markets characterised by such factors as menu costs (Bailey and Brorsen, 1989) inflation (Ball and Mankiw, 1984) or partially informed consumers (Tappata, 2009). As von Cramon-Taubadel, 1998, reminds us, such behaviour can even be generated by Gardner's 1975 competitive model, when shocks originate in both farm and retail sectors.

In an influential US study, Peltsman, 2000, found that prices rise faster than they fall - the so-called 'rockets and feathers' phenomenon was the norm in the 282 products (including 120 food products) he analysed.[5] These results have been contested on methodological grounds (Hassouneh *et al*.,

[5] The 'rockets and feathers' phenomenon describes positive asymmetry. While this predominates, negative asymmetry has been found and reasons put forward to account for it (see Meyer and von Cramon-Taubadel, 2004).

2015) and a meta analysis of 35 recently published papers conducted by Bakucs, Falkowski and Fertö, 2014, found evidence of asymmetry in roughly half (53/101) of the agricultural markets studied. Despite APT being consistent with a range of theoretical explanations, their results provide evidence suggesting that it is more likely in the presence of factors that lower farmers bargaining power whether with respect to retailers or processors, and that symmetric transmission is more likely in sectors with the greatest 'political clout'.

Other factors have been shown to have an important bearing on the findings obtained from APT studies, and a number of comments are noteworthy. The first concerns data quality, which is paramount in finding asymmetry; aggregation over products and time (data frequency) blurring the responses that the methods are employed to detect. Second, APT testing is something of a methodological minefield. Frey and Manera, 2007, catalogue six approaches and two further methods have since been developed (see Kilian and Vigfusson, 2011, and Hamilton, 2011). While the asymmetric vector error correction model popularised in agricultural economics by von Cramon-Taubadel, 1998, and elaborated by Goodwin and Serra, 2003, to include thresholds, is the workhorse of much of the literature, the model dependent nature of results in general confounds the delivery of unequivocal messages. Third, as Meyer and von Cramon-Taubadel, 2004, make clear, cointegration restricts asymmetry to the speed (not magnitude) of adjustment, since were the magnitude to be asymmetric, rises and falls in prices would force prices apart over time, violating the cointegration property. The implication is that where APT is in magnitude, cointegration should not be expected and APT testing should be conducted outside the cointegration framework. In itself, this would not be such a problem if it weren't for the fact that most asymmetry testing is conducted within the cointegration framework, so considerable care is required when testing. Fourth, APT is typically undertaken in the bivariate setting and is thus subject to the caveats discussed above. As Bakucs, Falkowski and Fertö, 2015, found, of the 78 cases that tested the direction of causality, 33 report it running from farm to retail, 8 from retail to farm and 33 running in both directions. The latter statistic alone suggests that pass-through and pass-back may have been conflated.

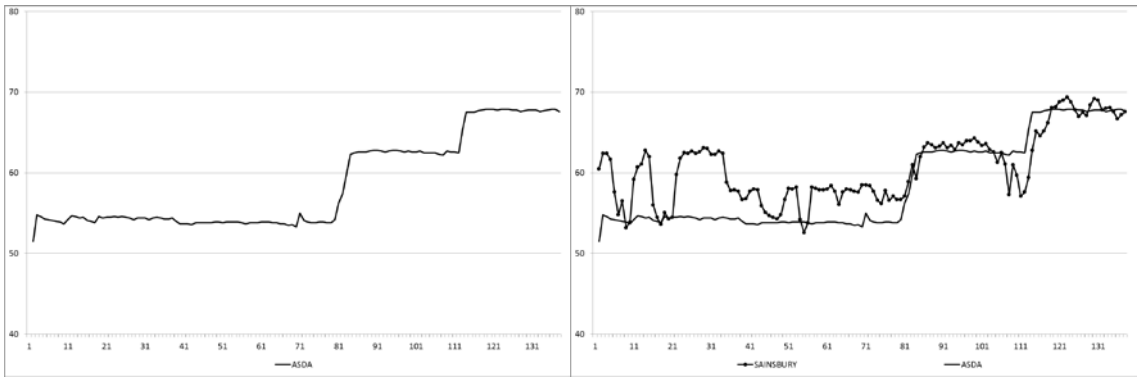
As with time series studies of price transmission in general, average prices at the food group level (e.g. pork, milk and fish) are typically the unit of analysis in studies of APT. Hence, a thorough understanding of the markets and pricing practises being investigated is required if observed behaviour is to be credibly attributed to specific causes. As Azzam, 1999, puts it " . . . . so far asymmetry tests are more useful in describing how markets look than how they work" p.525. Make no mistake though, studies of this sort are vital to our understanding of agricultural market and price dynamics, irrespective of market power. Like other 'first pass' analyses, they provide useful summary indicators of observed behaviour. Additional insight into the practices that lead to such behaviour has recently been obtained using high frequency, barcode specific data, to which attention now turns.

IV. New Data, New Developments

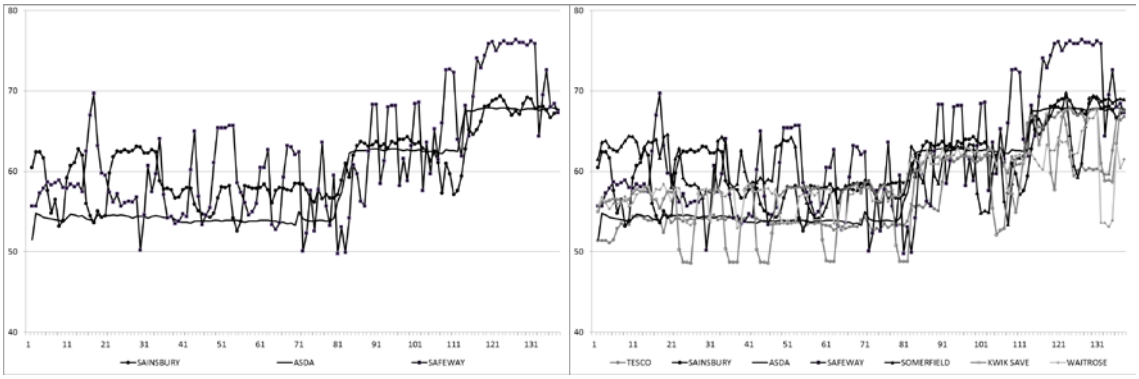
Much of the work on price transmission has been applied at the (national) market level for categories of products such as eggs, beef, lamb and bread, reflecting the data that has typically available to researchers (Hassouneh et al., 2015). The introduction of barcode and laser-scanning technology has not only revolutionised stock control and pricing in modern supermarkets but facilitates a much richer understanding of the price transmission process. These 'scanner data' represent a new kind of data since they relate to highly detailed (barcode-specific) prices of products that consumers actually buy, rather than the broad aggregates that have traditionally been made available from official sources. Consider, for example, an everyday and seemingly homogenous product 'bread', which is actually amalgamated into 'Bread rice and cereals' in the UK's Cost of Living and Food Survey (Office of National Statistics 2011). This single category is represented by 583 separate time series in the dataset of supermarket prices analysed in Lloyd, 2014, each of which relates to a specific branded product available in each of seven national retailers.[6] Figure 2 shows the price of one branded loaf over a 137 week period. Panel (a) shows the average price in one national retailer. Subsequent panels superimpose the prices of that barcoded product in the other national retailers during the 2.5 year sample period. As these data reveal, there is a striking degree of heterogeneity in prices at the barcode level, a feature that is common to a wide range of food products sold in supermarkets in the UK and elsewhere (Lloyd et al., 2014; Kaplan and Menzio, 2015).

Figure 2: The Price of a Loaf in Seven National UK Retailers

(Kingsmill 800g white sliced, weekly, pence)



[6] Even this represents only a sample of the bread products available in those retailers. Scanner data also permits analysis of prices at the individual store level. The Billion Project at the Massachusetts Institute of Technology began recording scanner data in a number of countries in 2008 and surpassed its 'billion' label in under two years (see Cavallo and Rigobon, 2016).



What these scanner data reveal is that price dispersion at the barcode level is the norm, the average range in a typical week across the 507 products analysed in that study being some 26%. While much is made of 'price matching', the data suggest that such behaviour is very much the exception than the rule, in UK retailing at least. Indeed, notions of the 'representative firm' and the 'law of one price' break down at the micro level in food retailing, and a more accurate representation is one where the products purchased by consumers reflect two dimensions of the products attributes, the product itself and the retailer; an identical brand stocked in a rival retailer being for the most part a distinct product.

Two other important dimensions are worth noting: the rise of private (or own) label products, on which British food consumers now spend more than branded products; the importance of price promotions, 40% or food being purchased when 'on sale' in the UK (Wisson, 2012). Both features are common to many countries, reflecting the changing nature of contracting within the food chain and have potentially important impact on price transmission itself (Berck et al., 2009). For example, using a large scanner dataset of milk and butter prices in Germany, Loy *et al.*, 2015, find that private label products adjust faster (and more asymmetrically) to commodity shocks than national brands. This recent literature seeks to account for the heterogeneity in both speed and asymmetry of price transmission that is observed at the barcode level, attributing it econometrically to factors such as measures of market power, the degree of vertical integration, costs of consumer search and menu costs (e.g. Hong and Li, 2015, Richards *et al*., 2014, Loy *et al*., 2015). Interestingly, in their study of US breakfast cereals, Richards et al., 2014, find that, contrary to 'conventional wisdom', it is the costs of consumer search that impedes the process of price transmission rather than retail market power, and that measures that reduce these costs (such as advertisements) are more likely to have the greatest impact on price transmission. Moreover, the price patterns they attribute to market power alone are beneficial rather than detrimental to the process, powerful retailers more likely to pass on promotional discounts to consumers.

Significant progress has also been made with scanner datasets in the structural approach to price transmission (see, inter alia, Kim and Cotterill, 2008; Nakamura and Zerom, 2010; Bonnet and Réquillart, 2013, Yonezawaa and Richards, 2016). In line with many recent time series studies using retail scanner data, the structural approach exploits the increasingly detailed upstream (typically, manufacturer cost) data in order to get more refined estimates of the price cost mark-up and indeed price pass-through itself. While data requirements present significant

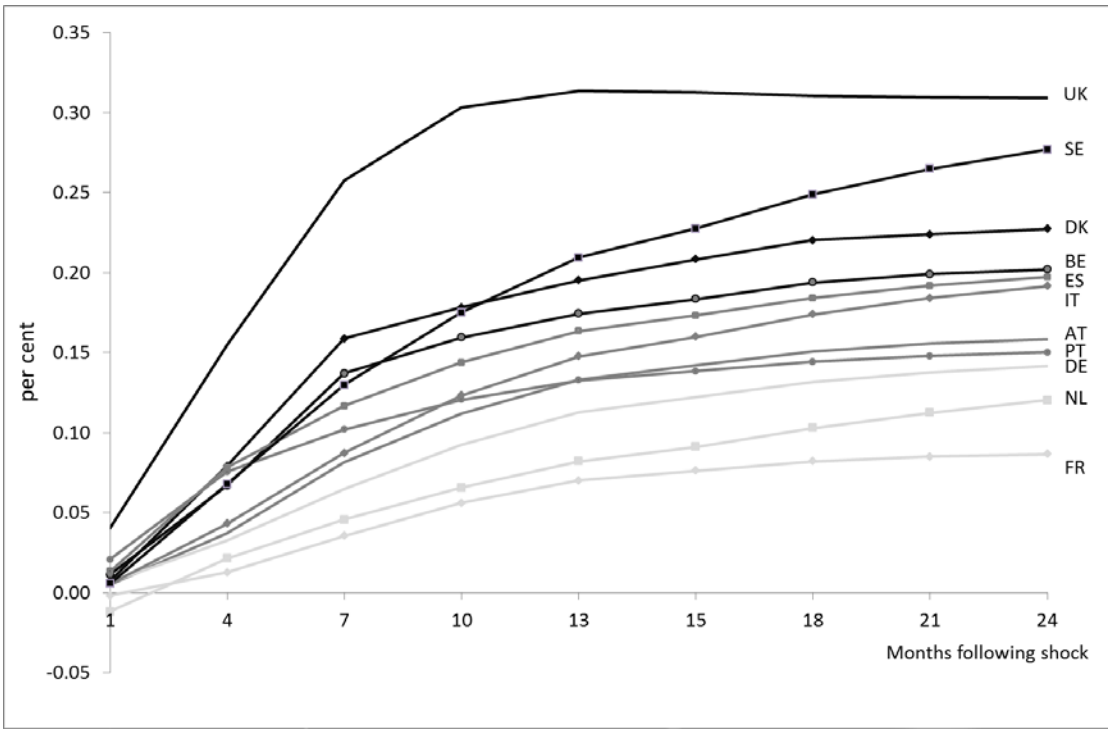
challenges to the application of these methods, where data availability permits, estimates of pass through are obtained that explicitly take into account factors such as characteristics of consumer demand, and the type of contracts linking manufacturers and retailers (see Bonnet et al., 2015 for a good recent example). Recognition that price transmission is directly affected by the multiple product nature of food retailing has been emphasised by Hamilton and Richard, 2011, and leads to over-shifting of costs. In contrast, Nakamura and Zerom, 2011, provide a range of explanations that account for the under-shifting of costs they observe. Importantly, this literature reinforces the notion that, far from being a single number, pass through varies not only by retailer, but by manufacturer, type of contract between the two, brand status (private labels) as well as highly specific factors such as the product specific demand elasticities, and even by pack size (Yonezawaa and Richards, 2016). Studies using scanner data highlight that heterogeneity in price transmission is ever-present with manifold causes. Whether cost shocks are over-or-under shifted very much depends on the interaction of these factors, underlining the fact that because so few generalisations are possible, it is all the more important to understand the market under consideration.

V. A Macroeconomic Perspective

So far, the review of price transmission in this Address has been largely micro-economic in focus. However, price transmission has an important macroeconomic dimension, the pass through of costs being the mechanism that generates food inflation (Porqueddu and Venditti, 2013). Recent commodity price shocks have brought international commodity price transmission and the factors that govern the process in to sharper relief (IMF, 2011,) as well as prompted a wide range of analyses of commodity prices on economic growth (e.g. Collier and Goderis, 2012; Addison *et al*., 2016). As Yang *et al.*, 2015, make clear in their GCE analysis of the effects of commodity price volatility on consumer prices, the food sector dampens commodity pass-through, reiterating the point made in Section 2, that commodities are not food. Moreover, they find that that commodity price transmission is inversely related to income level so that lower rates of pass-through are observed in higher income countries, where the food industry plays are more important role, echoing Ferrucci *et al*., 2012, who find commodity price transmission in emerging economics to be twice that in advanced countries.

Of course, in practice there are many factors that can affect the transmission of world commodity shocks into domestic food inflation, not least exchange rate movements (international commodities being prices in US dollars), trade policy stance and simply that different countries have different food baskets (Davidson *et al*., 2016). Highlighting the differences in price transmission among EU Member States to common shocks on the world wheat market Lloyd *et al*., 2015, find that even when controlling for such factors as exchange rate, domestic demand oil prices, the transmission of shocks in the UK is 3 times that in France (see Figure 3 below).

Figure 3: Impulse Response Functions of Bread Prices to a one percent shock in World Price of Wheat.



These results also suggest that for most EU countries developments in the food sector itself have impacted more on the evolution of domestic retail bread prices than international commodity price shocks. As an average of the 11 countries they analyse, model estimates suggest that 44% of bread prices can be attributed to the influence of the domestic retail sector compared with 39% from developments in the international wheat prices. This contributes to a growing literature pointing to important role played by market structure and competition in the food sector in accounting for the difference in food price inflation observed in the EU (Bukeviciute et al., 2009; Ciapanna and Rondinelli, 2014). In doing so, a convergence in the macroeconomic and microeconomic literatures is apparent. While a cross fertilisation of theory and methods can only prosper future work in both fields, it also highlights issues that they have in common, namely the importance of information on the competitive setting and how it functions. Above all, identification of the structural causes of price transmission requires models and data fit for that purpose.

VI. Concluding remarks

In this Address I have tried to give a flavour of the work that has been carried out in an area that is both important economically and of interest to me professionally. Despite the ubiquity of prices, the process of price transmission often misunderstood and for this reason I have given prominence to theory in order that we may better understand the observed outcomes and

underlying mechanisms. The picture that theory offers however is not a simple one. Not only are there a large number of factors that impact on the process of transmission but they are likely to co-exist, confounding attribution of cause to effect. That is not the fault of theory, whose purpose is to define the possibilities in order to interpret empirical findings. In this light, it is imperative that we understand the institutional setting in which price transmission takes place if we are to interpret empirical findings correctly.

Recent work also shows that the forces that impact on price transmission occur at levels of detail that were unimagined at the time Gardner wrote his landmark paper. Originating with aggregate market level data we now have the theory, techniques and data to investigate issues at the barcode level and beyond. What is really surprising is that by focusing on this seemingly quantum detail we are able to offer insight to address some big questions about consumer behaviour, competition in the vertical chain and food inflation. Clearly, there is still much work to do, not least because of the rapidly changing nature of the food industry itself.

Price transmission gives us a yardstick with which to measure the functioning of markets, and a brief review of the micro and macro dimensions uncovers a unifying theme, namely the importance of competition in the food chain. Indeed, much of the work in price transmission has been motivated by the increasing levels of concentration in the food industry, although the nature of contracts and product differentiation are equally relevant as the more recent literature makes clear. What we have also learnt is that in order to assess the impact of these factors we require more than mere price data alone and work that recognises the structural characteristics of the markets under scrutiny offer more promise than the bivariate models of the past. While structural approaches offer most clarity, data requirements and sensitivity to assumptions and estimators mean that reduced form models, especially those that incorporate a modicum of structure, will continue to play a useful role. Given the complexity of the processes at hand, results from the quasi-reduced form equations are at best indicative 'first passes', emphasising once more that a deep understanding of the institutions and practices in the markets being analysed is imperative if we are to use the findings form price transmission appropriately.

As is customary in many a Presidential Address I would like to close with an appeal for more data. While retail scanner data has been illuminating for price transmission researchers, much of the food industry remains a 'black box' where paucity of data is the norm. Making data on wholesaling, processing and manufacturing available that can be matched to that at retail is a challenge for the future. Steps to improve data on these intermediate sectors have been made in a number of countries (e.g. the UK's Office of National Statistics Virtual Microdata Laboratory) and offers great promise for future analyses. While it is clear we have come a long way in forty years, the availability of new data (which are the trigger for new theory and methods) can only improve our understanding of the mechanisms that govern price transmission and its economic impacts.

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