COST PASS-THROUGH AND PRODUCT DIFFERENTIATION

Abstract

The objective of this paper is to model and estimate the effect of product differentiation on retail pass-through of cost shocks. We use a model with common and idiosyncratic costs and apply it to Canadian market prices for ready to eat soups. We measure product differentiation with a distance vector adding a spatial dimension to the approach. We find that more differentiated products show higher prices, lower cost pass-through of common price shocks, higher cost pass-through of idiosyncratic cost shocks, and a more sluggish price adjustment.

Keywords: Idiosyncratic and common shocks, cost pass-through, non-price competition; product differentiation, food retail
Introduction

What happens to the retail price of a product when its wholesale price and thus its cost to the retailer changes? Do cost changes fully translate to retail price adjustments or do retailers behave strategically and only adjust prices of some products and to some degree to disproportionately benefit from the underlying consumer preferences for the product in question? The dynamics of how retail prices respond to changes in wholesale prices and upstream cost shocks has been of fundamental interest to economists and marketing practitioners alike. As a key indicator of market efficiency, cost pass-through has become a cornerstone of economic models attempting to explain sluggish and incomplete pass-through patterns (Bils and Klenow 2004).

While the setting for research in pass-through has predominantly been importing manufacturers who set prices in response to exchange-rate shocks (Nakamura and Zerom 2010; Gopinath and Itshoki 2011) streams of industrial organization and marketing literature have traced incomplete or the outright absence of price pass-through to nominal rigidities (Eichenbaum et al. 2011; Bonnet et al. 2013), coordination failure (Ball and Romer 1991), the existence of menu cost (Levy et al. 2010), long-term contracts (Bettendorf and Verboven 2000) or adjustments of mark-ups along supply chains (Besanko et al. 2005; Bonnet et al. 2013), retailer strategic pricing and non-trivial consumer search costs (Tappata 2009; Richards et al. 2014).

More recently, factors in non-price retail competition including product differentiation, product quality, and service have come to the forefront of the study of retail price movements (Dubois 2014). While earlier theoretical work by Froeb et al. (2005) focused on merger synergy effects on pass-through rates in a differentiated products oligopoly, recent empirical evidence especially points to the roles strategic non-price competition through, for instance, quality-tiered differentiation (Ter Braak et al. 2013; Geyskens et al. 2010) and assortment variety (Richards et al. 2013) play in retailer product pricing decisions. However, studies that formally
model these relationships in the context of explaining heterogeneous retail pass-through rates of cost shocks remains scarce (Kim and Cotterill 2008; Loy et al. 2016).

The objective of this paper is to analyze theoretically and empirically to what extent the degree of product differentiation explains the degree and speed of retail pass-through of cost shocks.

The theoretical framework in this study builds on Shubik’s (1980) model of differentiated Cournot competition and its extension by Zimmermann and Carlson (2010) that links firm-specific pass-through of product-specific and common costs shocks to the level of intra-industry competition and the degree of product differentiation. While Zimmermann and Carlson (2010) investigate the performance of alternate market structures, we exploit the model’s conceptual linkage to explicitly analyze how product differentiation affects pass-through rates when holding market structure fixed.

We model product differentiation in an explicit spatial framework of product quality that allows us to gain deeper insights into the impact of product competition on retailer’s incentives to pass-through product-specific and industry-wide cost shocks. While a body of evidence has established incomplete and asymmetric retail pass-through behavior in fast moving consumer goods (FMCGs) markets (e.g. Loy et al. 2014), to our knowledge, cost pass-through of idiosyncratic and common cost shocks in the presence of heterogeneous product quality has not been analyzed empirically in one modeling framework to date.

Our study of micro-level retail and matching wholesale cost data reveals that more differentiated products show higher prices, a lower cost pass-through of common price shocks, a higher cost pass-through of idiosyncratic cost shocks and lower adjustment rates. Our results further emphasize the role of underlying price elasticities in retailer price setting behavior, which may evidence to the explaining retailers simultaneous use of synchronized and staggered pricing strategies.
The remainder of the paper is organized as follows. The next section presents the theoretical model framework followed by the introduction of the approach we employ to model product differentiation in section 3. Sections 4 and 5 introduce the empirical estimation strategy and retail scanner data, respectively. Section 5 presents our main empirical results. Section 6 concludes and provides suggestions for future research on open questions.

**A model of product differentiation and cost pass-through**

Product differentiation as a means of distinguishing a manufacturer’s and/or retailer’s supply from its competitors is a staple feature of non-price competition in modern grocery retailing. When making decisions about the placement of products, retailers in a competitive and non-cooperative market environment have to weigh the benefits of meeting the preferences of “mainstream” consumers and ability to capture market share against the risks of fiercer price competition with rival suppliers’ products; creating a fundamental trade-off prominent in the literature (Draganska et al. 2009).

To fully characterize competition among heterogeneous firms with differentiated product portfolios a comprehensive model of product differentiation needs to specify a large set of possible products, their associate attribute bundles and the tastes of consumers over the same set of products within one equilibrium concept. At any significant level of generality such a model would seem intractable. Attempting to approximate this complexity, models of spatial (Hotelling 1929; Salop 1979) or monopolistic competition (Chamberlain 1933; Dixit and Stiglitz 1979) have made rather strong simplifying assumptions regarding the nature and possible extent of competitive relationships between (neighboring) products.

We exploit the conceptual linkages between product differentiation, reduced price competition and a retailer’s ability to exert market power in pricing and product placement to gain deeper insight into how product differentiation may influence retailer’s pass-through behavior. Our
modeling approach builds on Shubik and Levitan’s (1980) model of Cournot oligopoly in differentiated products and extension by Zimmermann and Carlson (2010). We start with a market of \( i \) symmetric non-cooperative competitors offering \( n \) differentiated products, where \( \phi \in \{-1,0\} \) symbolizes the degree of product differentiation, and \( q_i \) is a vector of firm \( i \)’s output. \(^1\) Hence, an increase in \( \phi \) represents an increase in product differentiation and corresponding loss in substitutability.

\[
p_i = \alpha - q_i + \phi \sum_{j \neq i} q_j
\]

(1)

We set marginal costs (MC) equal to \( c \) and derive the profit maximizing quantity of firm \( i \) under a symmetric Cournot-Nash Equilibrium (sCN).

\[
p_i, q_i = \alpha q_i - q_i^2 + \phi \sum_{j \neq i} q_j
\]

(2)

and

\[
MR_i = \alpha - 2q_i + \phi \sum_{j \neq i} q_j
\]

(3)

where \( q_j \) is a vector of outputs excluding firm \( i \). Solving the reaction function for marginal costs \( c \) and symmetric firms, Equation (4) shows the optimal output at:

\[
q_i^{sCN} = \frac{\alpha - c}{2 - \phi(n-1)}
\]

(4)

and equilibrium price at:

\[
p_i^{sCN} = \frac{\alpha + (1 - \phi(n-1))c}{2 - \phi(n-1)}.
\]

(5)

The resulting cost pass-through under Cournot-Nash price equilibrium (6) \( \frac{\partial p_i^{sCN}}{\partial c} \) is positive yet smaller than one. For a given number of firms, perfectly differentiated products (\( \phi = 0 \)) produce

\(^1\) For ease of interpretation we define product differentiation reverse to the commonly used term \( \phi \in [0,1] \), where 1 captures perfect substitution.
a pass-through rate of 50 percent and firms are engaging in monopoly pricing; a result is equivalent to Bulow and Pfleiderer’s (1983) monopoly case.

\[
\frac{\partial p_i^{CN}}{\partial c} = \frac{1-\phi(n-1)}{2-\phi(n-1)} > 0
\]  

(6)

In a case where all competitors offer homogeneous products (\( \phi = -1 \)) cost pass-through becomes a function of the number of firms \( \frac{n}{n+1} \); a value that corresponds to the average industry-wide cost pass-through rate in a Cournot oligopoly with homogeneous output but firm-specific constant marginal costs (e.g. ten Kate and Niels 2005).

To infer the impact product differentiation has on firm’s equilibrium price setting, we solve Equation (5) for the product differentiation parameter, \( \phi \):

\[
\frac{\partial p_i^{CN}}{\partial \phi} = \frac{(n-1)(\alpha-c)}{(2-\phi(n-1))^2} > 0
\]  

(7)

The result implies that price increases in product differentiation against competing products. In order to determine the effect of product differentiation on the degree of cost pass-through we partially differentiate equation (7) with respect to \( c \):

\[
\frac{\partial^2 p_i^{CN}}{\partial c \partial \phi} = \frac{(1-n)}{(2-\phi(n-1))^2} < 0.
\]  

(8)

Thus, we find that cost pass-through decreases in the degree of product differentiation. In other words, less differentiated products indicate a higher cost pass-through. Qualitatively similar results can be obtained for the case of Bertrand competition and are not further outline here (see Shubik and Levitan 1980: 91-92).

\[2^{\text{Note that Zimmermann and Carlson (2010) take second derivatives with respect to cost and the number of firms.}}\]
The assumption of symmetric firm Cournot competition appears to be a rather restrictive assumption in light of the prevailing grocery retailing environment. Indeed, recent literature (e.g. Peltzman 2000; Richards et al. 2014; Draganska et al. 2009) would suggest that pass-through behavior in differentiated product categories would depend on firm- (or rather brand) specific factors that would necessitate further distinguishing between firm-specific and industry-wide cost shocks in triggering price adjustments.

We introduce asymmetry into the model following Wang and Zhao’s (2007) extension of the Shubik’s (1980) model that produces the following Cournot-Nash price equilibrium

$$p_{n}^{nsCN} = \frac{(n - \phi)\alpha}{2n - (n+1)\phi} - \frac{n\phi c(n - \phi)}{(2n - \phi)(2n - (n+1)\phi)} + \frac{nc_i}{2n - \phi},$$

(9)

where superscript $nsCN$ denotes non-symmetric Cournot-Nash and $q$ is firm outputs. To infer the impact of changes in the firm’s marginal cost on its price adjustment we obtain:

$$\frac{\partial p_{n}^{nsCN}}{\partial c_i} = \frac{2n^2 - n(n + 2)\phi + \phi^2}{(2n - \phi)(2n - (n+1)\phi)} > 0.$$  

(10)

While the degree of cost pass-through converges to one with an increase in the number of symmetric competing firms $n$, allowing for asymmetric responses to cost shocks limits the maximum pass-through to the monopoly outcome discussed above. Zimmermann and Carlson’s (2010: p.11) simulation of product differentiation over firms shows that cost pass-through rates decline as firm numbers move away from monopoly, but convergence back to the monopoly outcome as individual firms behave more competitively. In a case where products become more homogenous, however, the pass-through rate converges on the previous outcome for homogeneous products, yet driven by firm-specific cost shocks. Zimmermann and Carlson’s comparative model statics further suggests that pass-through for homogeneous products decreases as competition intensifies and firms increasingly act as price-takers. Increasing

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3 Note that in the following the differentiation parameter varies over the interval $\{ -\infty,0 \}$. 

product differentiation, however, when the effect of competition is accounted for, has the opposite effect in that it spurs an individual firm’s responsiveness and thus incentive to pass-through cost changes, even as the number of competitors \((n)\) increases.

Differentiating a firm’s pass-through of product differentiation into its price yields a positive relationship similar to that under symmetric firms (Equation 11).

\[
\frac{\partial^2 p_i^{ncCN}}{\partial c_i \partial \phi} = \frac{(-1+n)n\phi(2\phi+n(4+\phi))}{(2n+\phi)^2(\phi+n(2+\phi))^2} > 0 \quad \forall n>1
\]

(12)

An increase in the pass-through of changes in firm’s marginal costs with respect to product differentiation contrasts the result obtained for the symmetric case.

Assessing the robustness of the above Cournot model results the case of Shubik’s (1980) Bertrand model of competition reveals that pass-through is monotonically decreasing in \(n\). But the two major influences competition has on cost pass-through in the Cournot model are also present in the Bertrand model. Again, a more homogenous firm faces lower incentives to pass through costs as the number of competing firms increases, therefore acting more like price-taker.
Contrary to the Cournot model outcome, the presence of product differentiation reinforces the effect of intensifying competition in that an increase in $\phi$ positively affects a firm’s response to rivals’ output decisions. In other words, product differentiation further intensifies price-taking behavior there by leading to a compounding of the differentiation effect of competition and product differentiation under Bertrand competition so that cost pass-through strictly declines in the number of competing firms (Zimmerman and Carlson 2010).

The above model propositions fall in line with recent theoretical and empirical research that traces incomplete pass-through by retailers to prominent factors in non-price competition. The proliferation of product differentiation and retailer portfolio strategies (Richards and Hamilton 2015), variations in consumer search costs (Richards et al. 2014), the emergence of quality-differentiated retailer private labels (Loy et al. 2014; Anders and Beye 2015) and related roles retailer market power plays in explaining differential pass-through rates across (un-)differentiated products (Borenstein and Shepard 2002).

**Measuring product differentiation**

Despite its significance to product pricing and placement and being a central factor in non-price competition among rivals, the multi-dimensionality nature of product differentiation continuous to challenge economic modelling of retail competition ever since Hotelling (1929). While the literature has made considerable progress in characterizing competition among differentiated products (e.g. Feenstra and Levinsohn 1995; Berry et al. 1995; Nevo 2001; Draganska et al 2009) earlier concepts of variety and differentiation, including address-type models of product location reduced the dimensionality of the attribute space to fewer (single), fixed or exogenously determined factors that fell short of capturing the strategic considerations behind manufacturer’s and/or retailer’s product formulation choices.

We employ a distance metric (DM) approach to capture the multidimensional nature of product differentiation within the model framework of cost pass-through outlined above. In particular,
we exploit the growing availability of data on product ingredient composition across brands and flavors to generate a detailed matrix of product-level differentiation in both horizontal and vertical non-price dimensions across the entire attribute space spanned by all products stocked by the retailer in a given category. While this explicitly spatial model is able to better capture differentiation in a Lancasterian sense, the convenience of the DM approach comes at the loss of flexibility in modelling heterogeneity in subjective consumer preferences for product attributes. Previous applications of Pinkse and Slade’s (2004) DM approach (e.g. Pofahl and Richards (2009); Richards et al. (2010); Bonanno (2013) generate differentiation-adjusted, or spatially weighted, product prices as a means of mitigating the dimensionality problem in estimating category-level models differentiated product demand. However, none of the previous study has investigated the impact of the degree of product differentiation, or spatial attribute clustering, on retail cost pass-through dynamics.

To capture the relationships between any two products across a multiple dimensions, we first create a distance matrix for each product characteristic separately. In a second step, we combine those matrices into one final measure of distance. To determine the distance among continuous product attributes (e.g. caloric content, fat) we build a Euclidian distances matrix

$$d_{ij}^{cont} = \sqrt{\sum_m (z_{im} - z_{jm})^2},$$

where $z_{im} - z_{jm}$ denotes the difference of the ith and jth product with respect to attribute m.

To account for differences in the variance of the original attribute data, we normalize all attribute variables. To quantify the effect of discrete attributes ($d^D$) (brand and flavor) we define a zero-one matrix

$$d^D_{ij} = \begin{cases} 0 & \text{if identical attribute } D \\ 1 & \text{otherwise} \end{cases}. $$
We then add the formulation-, brand- and flavor-specific distance matrices generated from equations (13) and (14). Finally, we obtain single vector by row-wise adding:

\[ \Phi_i = f(d_{ij}^{\text{cont}}, d_{ij}^{\text{brand}}, d_{ij}^{\text{flavor}}). \]  

(15)

The distance metric \( \Phi_i \) quantifies a product’s average degree of differentiation over multiple product attribute dimensions. In other words, \( \Phi_i \) measures a product’s cumulative distance from any of its competitors in the product category.

**Empirical model**

We test the hypotheses of the theoretical model regarding the impact of product differentiation on cost pass-through starting with a standard reduced form cost pass-through model for \( k = 1, \ldots, K \) price series and, \( t = 1, \ldots, T \) time periods:

\[ p_{kt}^r = \beta^w p_{kt}^w + v_k + \epsilon_{kt}, \]  

(16)

with retail prices \( p_{kt}^r \) and wholesale product costs \( p_{kt}^w \) expressed in logarithms. Tying product attributes and industry-wide cost changes introduces cross-section correlation to the estimation problem. Assuming a long-term relationship, this implies, among other things, that retail prices \( p_{kt}^r \) may be co-integrated with the wholesale costs \( p_{kt}^w \) of other products. We identify the possibility of cross-section dependencies by distinguishing between common, category wide, and product-specific individual cost components. Common category-wide retail costs are defined as the cross-sectional mean of all wholesale prices \( p_{t}^{w,m} \) and product specific retail costs \( p_{kt}^{w,k} = p_{kt}^{w} - p_{t}^{w,m} \) are defined as the residuals of observed wholesale prices and the cross-sectional mean. A major source of variation in \( p_{kt}^r \) and \( p_{kt}^w \), the common cost component \( p_{t}^{w,m} \), introduces endogeneity to the model if not explicitly handled (Eberhardt and Bond 2009). We address this issue by using Phillips and Hansen’s (1990) fully modified OLS (FMOLS) in the estimation stage to correct for serial correlation and possible endogeneity of regressors in the
long-run. Assuming strictly exogenous regressors, Bai et al. (2009) demonstrate that if the common factor is known a priori and included in the regression, then no correction of variance is necessary, resulting in the following pass-through equation:

\[ p_{kt}^r = \beta_{w,k} p_{kt}^{w,k} + \beta_{w,m} p_{t}^{w,m} + v_k + \varepsilon_{kt}. \]  

(17)

We achieve identification of the common retail cost factor by decomposing wholesale prices into a factor related and a factor unrelated part. Assuming that retail prices are caused by both, common and product-specific cost components, \( p_{t}^{w,m} \) represents a common trend in causing retail prices. Thus, the co-movement between retail prices from which cross-sectional dependencies arise is explained by one common factor i.e. industry wide cost changes, which are conveniently intuitive to interpret.

The assumption that all product-level retail prices react equally to wholesale price shocks, however, is rather restrictive and stands in contrast to existing theoretical and empirical evidence (e.g. Bulow and Pfleiderer 1983; Richards and Hamilton 2015). Neglecting this potential source of heterogeneity may produce misleading estimates of pass-through rates, particularly if panel members are not uniformly exposed to common cost changes, i.e. not having the same factor loadings. We introduce heterogeneity in retail price response to common and idiosyncratic costs by introducing the distance vector of product differentiation, \( \Phi_i \), into the pass-through equation:

\[ p_{kt}^r = \Phi_i \beta^\Phi + \beta_{w,k} p_{it}^{w,k} + \beta_{w,m} \Phi_i p_{kt}^{w,m} + \beta_{w,m,\Phi} \Phi_i p_{t}^{w,m} + v_k + u_{kt}, \]  

(18)

The model in equation (18) allows us to test for differential impacts of common and product-specific cost pass-through into retail prices, weighted in terms of the multi-dimensional degree of product differentiation between competing products within a given retail category. Thus, allowing for heterogeneity in retail price responses and cross-sectional dependence enables us to directly quantify the effect of product differentiation has on the pass-through rates of different
cost shocks. Finally, we investigate dynamics in the cost pass-through process in form of a standard error-correction model by multiplying the error term $u_{kt-1}$ and distance vector $\Phi_i$ and add the product to the second-stage error correction regression. (Engle and Granger 1987).

$$\Delta p_{kt} = \delta u_{kt-1} + \delta^\Phi \Phi_i u_{kt-1} + \phi \Delta p_{kt}^w + \sum_{j=1}^{q-1} \beta_j^w \Delta p_{kt-j}^w + \sum_{j=1}^{k} \beta_j^r \Delta p_{kt-j}^r + v_k + e_{kt}. \quad (19)$$

Based on the predictions derived from the theoretical model we empirically test the following hypotheses:

i. $\beta^\Phi > 0$; more differentiated products exhibit higher retail prices.

ii. $\beta^{w,m,\Phi} < 0$; more differentiated products exhibit a lower cost pass-through of common price shocks.

iii. $\beta^{w,\Phi} > 0$; more differentiated products exhibit a higher cost pass-through of product-specific cost shocks.

iv. $\delta^\Phi > 0$; more differentiated products exhibit a more sluggish price adjustment path in the long run.

Data

The empirical analysis employs a set of proprietary weekly (w1/2004 to w22/2007, 178 weeks) store-level scanner data for a sample of stores of a major North American retail chain (SIEPR-Giannini Data Center 2012). The data consist of Universal Product Code (UPC)-level sales quantity, gross and net retail prices, and matching UPC-level wholesale prices paid by the retailer. We retrieve UPC-level product attribute information on ingredient formulation, brand and flavor from Mintel’s Global New Products Database (Mintel 2015).

We model intra-category product differentiation and its effect on pass-through in the highly differentiated category of canned soup products. Characterized by a saturated retail consumer market the oligopolistic structure of the canned soup category features horizontal and quality
differentiation based on differences in product formulation to the forefront of intra-category non-price competition.

From the available data we select the leading soup products by their market share (in revenue $) that together account for more than 90% of the retailer’s total sales of canned soups in the panel. We extract product-level retail and matching wholesale prices variables. Retail price, $p^*$, is defined as each product’s net unit price and wholesale price, $p^w^*$, is defined as the matching unit cost of each product to the retailer during the same week.

From Mintel’s (2015) GNDP database we further extract information on products’ ingredient formulation, brand and flavor group membership, from which we generate a set of additional attribute variables and distance vector of product differentiation, $\Phi_i$, summarized in Table 1. Finally, we norm and shift the resulting distance matrix such that the minimum equals zero and the standard deviation equals one. Figure 1 visualizes the degree and patterns of product differentiation in the canned soup category via a plot of the distance vector $\Phi_i$ in linear and circular representation.

[Figure 1]

Geometrically, the distance vector maps each product (N=568) to 19 homogeneous subgroups, each of which is represented by a dot. These 19 subgroups represent all combinations of brands and flavor combinations with corresponding product formulation attributes in the panel. For example a tomato flavored soup offered by brand one (B1) and brand 2 (B2), with $d_{4,7}^{Brand} = 1$, $d_{4,7}^{flavor} = 0$ and $d_{4,7}^{cont} > 0$, yield a distance vector $\Phi = 0.873$ for (B1) and $\Phi_i = 1.444$ for (B2), respectively. See Table 2 in the Appendix for detailed summary statistic. Measuring each product’s cumulative distance from any competing product the distance vector $\Phi_i$ indicates that tomato soup offered by B1 more closely resembles the formulation of the average product in the category than the soup product offered by B2 ($\Phi_4 < \Phi_7$) which shows a higher degree of differentiation when compared against the overall canned soup category.
**Estimation and Results**

We estimate the pass-through model in equation (18) using fixed effects and random effects estimators and also estimate a FMOLS specification of the model as a robustness check. $\Phi_i$ is excluded from the fixed effects and corresponding FMOLS estimation due to collinearity. We also included a set of brand and flavor dummies in the random effects and corresponding FMOLS estimations.

Finally, to capture the long-run dynamics in the cost pass-through process we estimate the error-correction model in equation (19) using the first-stage regression residuals. In line with previous retail cost pass-through literature (e.g. Richards et al. 2014; Loy et al. 2016), wholesale prices are assumed to be exogenous. Bivariate Granger-causality tests on the pairs $(p_{kt}^{w,m}; p_{kt}^{r})$ and $(p_{kt}^{w,i}; p_{kt}^{r})$ support this assumption. Following the approach by Hadri (2000) panel unit-root tests on retail and wholesale prices, both in levels and first differences, suggest that both price series are not higher integrated than of order one. Four panel co-integration tests following Westerlund (2007) reject the null hypothesis of no panel co-integration at 1% significance, implying a long-run relationship between retail and wholesale prices (Table 3).
Table 3: Reduced-form long-run wholesale-retail pass-through model

<table>
<thead>
<tr>
<th>VARIABLES</th>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
<th>(4)</th>
<th>(5)</th>
</tr>
</thead>
<tbody>
<tr>
<td>( p_{kt}^{w,k} )</td>
<td>( p_{kt}^{r} )</td>
<td>( p_{kt}^{r} )</td>
<td>( p_{kt}^{r} )</td>
<td>( p_{kt}^{r} )</td>
<td>( p_{kt}^{r} )</td>
</tr>
<tr>
<td>( p_{kt}^{w,k} \Phi_i )</td>
<td>0.151***</td>
<td>0.129***</td>
<td>0.145***</td>
<td>0.147***</td>
<td>0.0204***</td>
</tr>
<tr>
<td>( p_{kt}^{w,m} \Phi_i )</td>
<td>-0.0635**</td>
<td>-0.0674**</td>
<td>-0.0649**</td>
<td>-0.0647***</td>
<td>-0.0674**</td>
</tr>
<tr>
<td>( \Phi_i )</td>
<td>-</td>
<td>0.0205*</td>
<td>0.0263**</td>
<td>-</td>
<td>0.0362***</td>
</tr>
<tr>
<td>Constant</td>
<td>0.363***</td>
<td>0.333***</td>
<td>0.147***</td>
<td>0.273***</td>
<td>0.195***</td>
</tr>
</tbody>
</table>

Included:

- Company: YES
- Flavor: YES
- ID dummies: YES

Observations: 101,104

Source: Own calculation. Results based on fixed effects estimation (1), random effects estimation (2, 3) and FMOLS (4, 5). Robust standard errors reported in parenthesis. ***, **, * denote 1%, 5% and 10% level of significance. \( p_{kt}^{r} \) denotes retail prices; \( p_{kt}^{w,m} \) cross-section mean of wholesale prices; \( p_{kt}^{w,k} \) demeaned wholesale prices; \( \Phi_i \) distance measure.
Across model specification our results provide clear evidence that a product’s degree of product differentiation does influence cost pass-through. Moreover, we cannot reject the hypothesis that common cost shocks are not fully passed on to retail prices ($\beta^{w,m,\Phi} \neq 1$). In a retail category characterized by highly differentiated brands, the retail price dynamics of little differentiated products, with attributes that put them in close proximity to the category average ($\Phi = 0$) show almost complete pass-through rates of common cost shocks ($\beta^{w,m} = 0.929 \approx 1$), while product-specific cost pass-through remains incomplete ($\beta^{w,k} = 0.762 < 1$). Our results further show that with increasing degrees of product differentiation (e.g. $\Phi = 4$), product-specific cost shocks are fully passed through ($\beta^{w,k} + \beta^{w,\Phi} = 1.278 > 1$), while pass-through rates of common cost shocks clearly fall below one ($\beta^{w,m} + \beta^{w,m,\Phi} = 0.6504 < 1$). Coefficient estimates of $\beta^{\Phi}$ also confirm our theoretical model prediction that more differentiated products command higher retail prices ($\beta^{\Phi} > 0$).

Overall, our empirical estimates are in line with economic theory and seminal work by Tirole (1988: 278), Shepard (1991) and Blinder et al. (1998) suggesting that product differentiation is a crucial factor in non-price competition in grocery retailing, allowing national brands and retailers, through their private labels, to carve out category niches by creating additional product variety through differentiation or distance in observable product attributes as to avoid direct rivalry in price. Therefore, as we show in Figure 1, clustering effects in the multi-dimensional placement of products within the attribute space amplify the impact product-specific cost shocks ($\beta^{w,\Phi} > 0$) have on pass-through rates. And in turn, since common cost shocks emerge from the center of the circular model of product differentiation, their impact on retail prices diminishes for more differentiated products ($\beta^{w,m,\Phi} < 0$), those located at greater distance in the attribute space. Put differently, a product’s cumulative distance from any of its competitor’s decreases (increases) its retail price exposure to common (product-specific) cost shocks.

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4 In the discussion we refer to the results of the random effects estimation (2).
These result motivate future research on retailers’ incentives to set prices (in)frequently. For instance, in a framework of costly price adjustment (e.g. menu cost), where pricing decisions are endogenous to the firm’s profit maximization problem, the nature of cost shocks itself has been shown to hold implications for the timing of adjustment decisions across competition firms (e.g. Levy et al. 1998). In turn, state-dependency theory would predict a synchronized price response to fixed cost shocks (Caballero and Engel 1993; Dotsey and Wolman 1999), while staggered price adjustments would prevail in response to relative shocks where strategic considerations matter (e.g. inter-category non-price competition over market share) (Ball and Romer, 1989; Lach and Tsiddon 1996; Fisher et al. 2000). Accordingly, retailer price-setting for standard products of low differentiation at the center of attribute space is expected to be more synchronized due to the greater importance of a common cost component, whereas more differentiated products would exhibit a higher degree of staggered pricing as the retailers’ pass-through of product-specific cost components dominates pricing decisions. Table 4 presents the estimates of a dynamic model of retail cost pass-through.
Table 4: Panel error-correction model estimates

<table>
<thead>
<tr>
<th>Variables</th>
<th>Panel FE $\Delta p_{kt}$</th>
<th>Panel FE $\Delta p_{kt}^{r}$</th>
<th>Panel FE $\Delta p_{kt}^{r}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$u_{kt-1}$</td>
<td>-0.603*** (0.0230)</td>
<td>-0.396*** (0.0193)</td>
<td>-0.372*** (0.0179)</td>
</tr>
<tr>
<td>$\Phi_i u_{kt-1}$</td>
<td>0.0285*** (0.00558)</td>
<td>0.0192*** (0.00483)</td>
<td>0.0239*** (0.00494)</td>
</tr>
<tr>
<td>$\Delta p_{wt}^{w}$</td>
<td>0.944*** (0.00382)</td>
<td>0.943*** (0.00403)</td>
<td>0.942*** (0.00412)</td>
</tr>
</tbody>
</table>

Included:

- Lags of $\Delta p_{wt}^{w}$: 4, 12, 24
- Lags of $\Delta p_{kt}^{r}$: 4, 12, 24

Observations: 98,264 93,720 86,904

Source: Own calculation. Results based on fixed effects model specification (1). Robust standard errors reported in parenthesis. *** *, ** denote 1%, 5%, 10% significance. $p_{kt}^{r}$ denotes retail prices; $p_{kt}^{w}$ wholesale prices; $\Phi_i$ distance measure; $u_{kt-1}$ residual from first stage regression.

Depending on the lag length, our estimates show that retail prices adjust between 60.3% and 37.2% toward their equilibrium values each week in response to a change in wholesale prices. These results are in line with findings in Richards et al. (2014) who find a pass-through rate of 56.7% for the Los Angeles ready-to-eat cereal retail market, Bittmann and Anders (2016) who find pass-through rate to differ across seasons between 10% and 49% in the fresh retail category of a major U.S. retail chain in Canada and Loy et al. (2014) who find regime dependent pass-through rates between 55% and 15% for the German dairy retail market.

Our coefficient estimates clearly confirm the hypothesis of a more sluggish cost pass-through for more differentiated products ($\delta \Phi > 0$) across model specifications. Slower adjustment rates for more differentiated products, often strong national brands with distinct attribute profiles and few direct substitutes have previously been traced back to the existence of implicit contracts between the brand owner and consumers (Blinder et al. 1998), such that steady prices are remunerated in consumer loyalty and market share, essential factors in the context of retail non-price competition. Moreover, product-specific differences in menu costs (Loy et al. 2016) and product variety (Richards et al. 2014) have been found to be important factors in the
dispersion of cost pass-through in categories with similar degrees of product differentiation we find here. For instance, Loy et al. (2014) find manufacturer, retailer and brand characteristics to be important determinants of dynamic (asymmetric) cost pass-through rates for dairy products in the German retail market. The authors specifically point to the important role product differentiation plays in explaining retail price dynamics.

In contrast to previous studies we investigated the impact of product differentiation in terms of a multi-dimensional measure of distances between competing products. Thus we are able to model the effect of product differentiation in one framework instead of comparing pass-through rates of products with varying degrees of differentiation.

The evidence of delayed speed of retail price adjustment especially for differentiated products (brands) also finds strong backing in the retail price rigidity literature, which finds more differentiated goods to exhibit lower frequencies of price changes despite underlying fluctuations in cost factors (e.g. Anders and Beye 2015; Nakamura and Steinsson 2013; Eichenbaum et al. 2011). A typical limitation of studies working with large-scale scanner data is the assumption that product formulation and attribute characteristics are exogenous and static over time. Future research should therefore take into account the joint endogeneity of product differentiation and price responses (e.g. Richards et al. 2013) and empirically quantify their impact on retail cost pass-through.

Recent advances in modelling retail pass-through suggest that asymmetric cost pass-through rates may be a function of consumer search costs and retailers’ rational response. Since product differentiation and consumer search costs are closely related it seems logical that consumer search cost (switching costs) increase in the degree of product differentiation within a given

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5Price rigidity literature often investigates how discrete retailer prices respond to wholesale price changes, i.e. in terms of a probability of a price change. We model pass-through as a continuous concept in terms of adjustment towards equilibrium. A lower cost-pass-through rate corresponds to an overall lower probability of a retail price change in response to wholesale price changes.
category. The distance vector of product differentiation in our study may therefore serve as a proxy of (equilibrium) search costs. The methodological approach and empirical findings in this study may therefore hold important implications for the future modelling asymmetric retail cost pass-through and its causes in differentiated oligopolies (Cabral and Fishman 2012).

**Conclusion**

A majority of existing literature on cost pass-through has focused on the impacts imperfect competition, menu costs and consumer search costs have on the transmission of cost shocks in vertical supply chains. This study empirically estimates the effect of product differentiation on retail pass-through of wholesale cost shocks within a theoretically consistent equilibrium concept that distinguishes between industrywide (common) and individual (product-specific) cost shocks on pass-through rates. The model quantifies product differentiation employing a spatial distance vector that places individual products within a multi-dimensional attribute space.

The analysis confirm the theoretical model predictions in that more differentiated products show higher retail prices, a lower cost pass-through of common wholesale cost shocks, and a higher cost pass-through of product-specific cost shocks. To investigate the impact of product differentiation on dynamic adjustments, results of an error correction model are in line with theory in that more differentiated products adjust more sluggishly. These findings add evidence to the literature seeking to explain why firms vary in their application of synchronized and staggered pricing. While synchronization in price adjustment is expected for common shocks our analysis suggests that for more differentiated and higher priced retail products pricing responds more directly to product-specific wholesale cost shocks leading to less synchronization.
The results of this study point to the importance of cost specificity and product differentiation play in retailer price setting behavior; factors that need to be considered when making inference about retail pass-through patterns and their welfare implications. Future research may also consider extending the approach outlined in this paper to the analysis of exchange-rate pass-through, where the segmentation of the supply chains at the wholesale level has been found to drive cross-border differences in cost pass-through and retail price dynamics (Gopinath et al. 2011).

References


Figure 1: Aggregate attribute distance for selected Canned Soup

Source: Own calculation. Aggregate distance vector $\Phi_i$ in linear and circular representation. Number of observations: 101,104; Panel members: 568.

Appendix

Table 1: Summary statistics for selected Canned Soup (Panel members UPC: 568)

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<tr>
<th>Variables</th>
<th>mean</th>
<th>sd</th>
<th>min</th>
<th>max</th>
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Source: Own calculation. Summary statistics of retail prices $p^r*$, wholesale prices $p^w*$, distance measure $\Phi$, discrete and continuous product attributes of selected canned soup products. Data is obtained from SIEPR-Giannini Data Center (2012) and Mintel (2013). Number of observations: 101,104; Panel members: 568.
Table 2: Detailed summary statistics of distance measure $\Phi$. (Panel members UPC: 568)

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Source: Own calculation. Detailed summary statistics of distance measure $\Phi$, with discrete and continuous product attributes of selected canned soup products: Company, Brand, Flavor, Calories (per cup), Fat (g/cup), Cholesterol (mg/cup), Sodium (mg/cup), Carbohydrate (g/cup), Fiber (g/cup), Sugar (g/cup), Protein (g/cup), Package Size (ml). Number of observations: 101,104; Panel members: 568.