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Robert A. Ritz

June 2015

CEEPR WP 2015-009

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Abstract

In response to cost changes, prices often rise more strongly or quickly than they fall. This phenomenon has attracted attention from economists, policymakers, and the general public for decades. Many assert that it cannot be explained by standard economic theory, and is evidence for "anti-competitive" behaviour by firms. This paper argues against this conventional wisdom; it shows that simple price theory can, in principle, account for such asymmetric pass-through—even with perfect competition. From a policy perspective, knowledge of cost pass-through patterns in a market does *not* allow for strong inferences on the intensity of competition.

Keywords: Asymmetric price transmission, cost pass-through, electricity markets, price theory, rockets and feathers

1 Introduction & motivation

The phenomenon that, in response to changes in costs, prices often seem to rise more strongly or quickly than they fall has attracted the attention of economists, policymakers, and the general public, for decades.

In a famous article, Peltzman (2000) finds that across a broad sample of 242 markets, "prices rise faster than they fall" in around two thirds of cases. This finding is robust across markets that are perfectly competitive and those with significant industry concentration (market power). Many other studies have found asymmetric cost pass-through, with notable examples including markets for gasoline, various agricultural products, deposit markets in retail banking, and carbon emissions permits.

At the same time, however, there are many markets in which pass-through is symmetric (around 30% of Peltzman's sample, for instance) and, at least in some cases, prices appear to rise *less* strongly than they fall (Ward, 1982; Meyer and von Cramon-Taubadel, 2004).

*Assistant Director, Energy Policy Research Group (EPRG), Judge Business School & Faculty of Economics, Cambridge University, UK. Email: rar36@cam.ac.uk
I am grateful for the hospitality of MIT's Center for Energy and Environmental Policy Research (CEEPR) where large parts of this paper were written while I was a Visiting Scholar in Spring 2015.
My thanks are also due to Simon Cowan, Stephen Littlechild, David Newbery, Michael Pollitt, and David Stallibrass for helpful comments and suggestions. All views expressed and any errors are my responsibility.

These phenomena also receive much policy attention. For example, the June 2014 referral by Ofgem, the UK's energy regulator, of the electricity sector to the competition authority (CMA) was influenced by the public perception, true or false, that "rockets and feathers" is endemic to this sector. Indeed, in British political circles and public debate, there seems to be a widely-held view that such asymmetric pass-through is a strong indicator for an "uncompetitive" market.[1] One of the working papers produced by this investigation to date (CMA, 2015) is on cost pass-through at the retail level, though the analysis is so far only descriptive and does not draw any firm conclusions on the existence of, and explanations for, asymmetric price transmission.[2]

Over the last decade, various economic theories have been advanced with a view to explaining asymmetric pass-through. Perhaps most prominent are models with consumer search costs: some consumers are imperfectly informed about prices and/or firms' costs, and respond differently depending on whether costs rise or fall; asymmetric pricing on the upside can arise even where competition amongst firms is (otherwise) perfect (Tappata, 2009). Other explanations have been based on collusive behaviour, vertical integration, and various sorts of "adjustment costs".

Existing papers routinely claim that "standard theory" cannot account for asymmetric pass-through, so that this phenomenon represents both a failure of markets, and a failure of (textbook) economics. Peltzman (2000) writes that "In the paradigmatic price theory that we teach, input price increases or decreases move marginal costs and then price up or down symmetrically and reversibly" (p. 465), speaks of a "theoretical vacuum" (p. 488), and concludes that "This asymmetry is fairly labelled a 'stylized fact'. This fact poses a challenge to theory (...) the evidence in this paper suggests that the theory is wrong, at least insofar as an asymmetric response to costs is not its general implication (p. 493)." Kimmel (2009) writes "it is true that asymmetric pricing cannot happen in simplistically competitive market models" (p. 3). Tappata (2009) notes that "according to traditional economic theory, homogeneous firms that compete on prices earn zero profit, and cost shocks are completely transferred to final prices" (p. 674). It is striking that none of these papers make precise what *exactly* the "standard theory" being criticized actually is.[3]

This paper challenges the current state of thinking on pass-through. It shows that even the simplest economic theories, properly applied, can account for asymmetric pass-through; it is, as such, no "puzzle" for economists at all. Simple theory can explain why prices rise more strongly in some markets—but also why they rise equally strongly or less

[1] Some go further by claiming that the existence of asymmetric pass-through on the upside "proves" market power, and, conversely, that its absence demonstrates competition; in other words, a market is "uncompetitive" if and only if pass-through is asymmetric.

[2] The relevant passage states that: "We will assess qualitatively possible reasons why domestic energy prices were not reduced in periods when costs decreased substantially, as observed from our initial descriptive analysis ... We will then consider whether the reasons for asymmetric cost pass-through, if there is any, are inconsistent with competition" (CMA, 2015).

[3] Peltzman (2000) and Kimmel (2009) seem to have in mind a textbook model of perfect competition, with price-taking firms *as well as* a horizontal supply curve; by contrast, Tappata's (2009) discussion suggests the benchmark of oligopoly competition à la Bertrand, with price-setting firms and undifferentiated products.

strongly in others. These findings can arise under perfect competition as well as when firms have market power. By contrast, many of the more elaborate theories rely on imperfect competition and/or are tailored to only explain an asymmetry tilted to the upside.

The intuition is simply stated. Consider some model of competition in an industry and let the equilibrium price depend on a marginal cost, which is common to firms and can vary. If this equilibrium pricing function is linear, then a change in marginal cost translates equally into some change in price, regardless of whether it goes up or down. However, if the pricing function is (strictly) *convex* in cost, then starting from any point, a given *discrete* cost increase raises price by more than an identically-sized cost decrease cuts price. Put differently, with a convex pricing function, the marginal rate of pass-through exceeds the average pass-through, and so pass-through is higher at higher levels of cost (and price). This paper shows that such convexity can arise, under natural conditions, in both perfectly and imperfectly competitive settings. Under perfect competition, it obtains, e.g., if the market demand curve is convex and the supply curve is concave in price. The opposite conclusions apply if the pricing function is (strictly) concave.

Many models exclude the possibility of asymmetric pass-through by doing one of two things: (1) imposing *a priori* functional-form assumptions which imply that the equilibrium pricing function is linear in marginal costs (such as assuming that demand and supply curves are both linear), or (2) only considering infinitesimal cost changes which, as a feature of calculus rather than economics, mean that pass-through must be symmetric. The first of these assumptions is somewhat arbitrary, and perhaps difficult to empirically test, but is not implied in any way by economic principles; it is simply a special case. The second assumption is an analytical simplification, which can be useful and appropriate in some cases, but is problematic for a general analysis of pass-through; in the real world, (cost) changes are discrete.[4]

In short, "standard theory" can feature all of convex, linear, and concave pricing functions—depending on the underlying market fundamentals of demand and supply—and, in principle, can thus "explain" all of the increasing, constant, and decreasing cost pass-through found in the empirical work. So the right way to understand Peltzman's critique is that it is textbook expositions that may require revision, not necessarily standard price theory itself.

Section 2 presents a generalized version of a standard Cournot model of imperfect competition. Section 3 examines an elementary model of perfect competition. Section 4 discusses the relationship with the empirical literature, including static and dynamic aspects of pass-through. Section 5 makes concluding remarks.

[4] In recent important work, Weyl and Fabinger (2013) synthesize and extend many results in the theory of cost pass-through, and show how it is a useful statistic to think about competition and the division of surplus in markets. They do not discuss asymmetric cost pass-through.

2 Asymmetric pass-through under imperfect competition

This section shows how asymmetric pass-through arises in a reasonably general-yet-simple (static) model of imperfect competition, and identifies the underlying conditions in terms of demand and supplier conduct.

Model setup. An industry consists of a set of $N = \{1, 2, \ldots, n\}$ firms, facing a common inverse demand curve $p(Q)$, where Q is total output, which is downward-sloping, $p_Q < 0$. Let $\xi \equiv -p_{QQ}Q/p_Q$ denote a measure of the curvature of inverse demand, so demand is convex if $\xi > 0$, and concave otherwise. Demand is log-concave, that is, $\log D(p)$ is concave, if and only if $\xi < 1$. Firm $j \in N$ has constant marginal cost $c_j + t$, where t is a cost shifter common to all firms.

Competition is a generalized version of Cournot. Firm j chooses how much output q_j to sell into the market (so $\sum_{j \in N} q_j = Q$) so as to maximize its profits. The product market outcome is determined by a conduct parameter $\theta > 0$. When firm j changes its output by dq_j, it believes that industry output will change by $dQ = \theta(dq_j)$ as a result. The parameter θ serves as a summary statistic of the intensity of competition in the market; it may be regarded as a reduced-form representation of an (unmodelled) dynamic game. The Cournot-Nash equilibrium, in which each firm takes its rivals' actions as given, is nested where $\theta = 1$; lower values of θ correspond to more competitive outcomes, with perfect competition arising in the limit as $\theta \to 0$.

We assume that all $n \geq 2$ firms are active with strictly positive output throughout, and that the equilibrium is unique and stable. This requires that any cost differences between firms are "not too large" and that the demand curve is "not too convex", for which a sufficient condition is that industry revenue is concave in industry output, i.e., downward-sloping industry marginal revenue, $\frac{\partial}{\partial Q}(p + p_Q Q) < 0 \Leftrightarrow \xi < 2$.

Marginal cost pass-through. The first-order condition for firm j's choice of output is: $0 = p + p_Q\theta q_j - (c_j + t)$. Let $p^*(t)$ denote the equilibrium market price, as a function of the cost shifter, and let $\rho(t) \equiv \rho(p^*(t)) \equiv [dp^*(t)/dt]$ denote the *marginal* rate of cost pass-through.[5] This captures how the equilibrium price varies with a "small", i.e., infinitesimal, increase in firms' marginal costs.

Lemma 1. The marginal rate of cost pass-through under imperfect competition equals $\rho(t) = n/[n + \theta(1 - \xi)]$ and is less than 100% if and only if demand is log-concave $\xi < 1$.

Proof. Summing the $n \geq 2$ first-order conditions gives $0 = np + p_Q\theta Q - \sum_{j \in N}(c_j + t)$. This expression implicitly defines the equilibrium total output $Q^*(t)$ and the corresponding equilibrium price $p^*(t) \equiv p(Q^*(t))$. Differentiation gives $0 = [np_Q + p_Q\theta + p_{QQ}\theta Q]\, dQ - n \cdot dt$, from which the expression for pass-through follows since $\rho(t) = [p_Q \cdot (dQ/dt)]_{Q=Q^*(t)}$

[5] It is standard in the industrial-organization literature to look at the *rate* of pass-through, $dp^*(t)/dt$. The literature on international trade, for example, often instead considers the *elasticity* of pass-through $d \log p^*(t)/d \log t$; the arguments made in this paper could equally be applied to this measure.

and $\xi \equiv -p_{QQ}Q/p_Q$. The result that $\rho(t) < 1$ if and only if $\xi < 1$ follows by inspection, since $\theta > 0$. ■

Pass-through can take on a very wide range of values; the marginal rate is always positive but can lie *anywhere* between zero and infinity, depending on the particular values of n, θ, and ξ. All else equal, a larger number of firms pushes pass-through towards 100%, as does more competitive industry conduct (lower θ). More concave demand (lower ξ) pushes pass-through towards zero, and if demand is log-convex with $\xi > 1$ (e.g., with constant-elasticity demand), then pass-through exceeds 100%.

Many theory papers make the assumption that demand is log-concave, which corresponds to pass-through less than 100%. On the empirical side, there is evidence for a wide range of values for pass-through across different markets, including rates above 100%, although the case with "incomplete" pass-through is more common (see, e.g., Weyl and Fabinger (2013) for a useful recent summary).

Non-marginal cost pass-through. Now consider the case of a "large" or discrete increase in firms' marginal costs. In particular, suppose that the cost shifter t rises over an interval $[0, T]$, so that $\Delta t = T$. The non-marginal rate of pass-through is thus defined as $\kappa(T) \equiv \Delta p^*/\Delta t$.

Of course, the non-marginal pass-through is related to the underlying marginal rate. By construction, the discrete change in price satisfies $\Delta p^* = \int_0^T \rho(t)dt$. So the non-marginal rate of pass-through is simply equal to the *average* of marginal pass-through over the range $[0, T]$, that is, $\kappa(T) = \frac{1}{T}\int_0^T \rho(t)dt$.

It is immediate that marginal and non-marginal pass-through coincide if only if marginal pass-through does not vary with the level of the cost shifter t, $d\rho(t)/dt = 0$. This feature in turn corresponds to a linear (strictly speaking, affine) pricing equation: since $\rho(t) \equiv \rho(p^*(t)) \equiv [dp^*(t)/dt]$, it follows that $d\rho(t)/dt = 0$ if and only if $d^2p^*(t)/dt^2 = 0$. In such cases, "pricing is symmetric."

More generally, there can be asymmetric pass-through. In particular, marginal pass-through is increasing if and only if the industry's equilibrium pricing function $p^*(t)$ is (strictly) convex. In such cases, marginal pass-through lies above average pass-through, $\rho(s) > \kappa(s)$ for any $s \in (0, T)$. This has two key implications, starting at any given cost level: (i) the rate of pass-through for a "large" cost increase exceeds that for a "small" cost increase; (ii) a marginal cost increase is passed on more strongly than an identically-sized decrease in cost: "prices rise more strongly than they fall".[6]

The opposite conclusions apply in cases for which marginal pass-through is decreasing, i.e., where the market pricing equation is instead *concave* in costs—so then, on average, "prices rise less strongly than they fall".

The following result maps these arguments into industry characteristics.

[6] The first of these two points links to another literature, more closely associated with macroeconomics, on price inertia and menu costs, which we do not further pursue here.

Proposition 1 (a) Cost pass-through under imperfect competition is constant, $d\rho(t)/dt = 0$, if and only if $\frac{d}{dt}\left[\theta(p^*(t))(1-\xi(p^*(t)))\right] = 0$ for all $t \in [0,T]$; otherwise, there is either increasing or decreasing asymmetric pass-through somewhere on the interval $[0,T]$.
(b) Pass-through is increasing if the conduct parameter and demand curvature rise with price, $\partial\theta/\partial p \geq 0$ and $\partial\xi/\partial p \geq 0$, with at least one strict inequality, for all $t \in [0,T]$.

Proof. For (a), the necessary and sufficient condition follows by inspection of the expression for marginal pass-through from Lemma 1, recalling that the number of firms n is fixed, and making explicit the potential dependency of demand curvature ξ and the conduct parameter θ on the cost shifter t, via the equilibrium price $p^*(t)$. For (b), the sufficient conditions are immediate. ■

Since the number of firms in the market is fixed (here by assumption, not necessarily in practice), the only two industry characteristics that can cause variations in pass-through are the curvature of demand ξ and the conduct parameter θ. Pass-through is only constant where both ξ and θ are constants, or where they move exactly in such a way that $\theta(1-\xi)$ stays fixed.

Economic theory does not imply that either demand curvature or industry conduct are constants. Several frequently-used demand curves exhibit constant curvature; this is what gives tractability and makes them popular in the first place. Examples are linear demand ($\xi = 1$), exponential demand ($\xi \to 1$), and constant-elasticity demand ($\xi = 1 + \eta^{-1}$, where $\eta > 0$ is the price elasticity of demand). The class of demand functions that exhibits the constant-curvature property is known (Bulow and Pfleiderer, 1983); it corresponds to consumers' valuations being drawn from a Generalized Pareto Distribution (Ausubel, Cramton, Pycia, Rostek and Weretka, 2014), which is the class of distributions that generates a linear inverse hazard rate. However, for other specifications, demand is more convex at a higher price, $\partial\xi/\partial p > 0$, including Normal/Gaussian, Laplace and Logistic distributions (Weyl and Fabinger, 2014, Table 1; see also Cowan, 2012).

Unfortunately, there is scant evidence on what demand curves look like in reality; a typical empirical industry study measures an average value of the demand *elasticity*—but this says little about the *shape* of the demand curve (and thus about pass-through).

Similarly, the conduct parameter, in general, need not be constant—although, for a particular mode of competition, it may be. The canonical example is Cournot-Nash competition, for which always $\theta = 1$ regardless of market conditions. More generally, industry conduct may become less competitive as at a higher price, $\partial\theta/\partial p > 0$; for instance, firms may find it easier to tacitly coordinate on prices during demand booms, along the lines of Green and Porter (1984). If so, cost pass-through tends to be pro-cyclical with respect to price; pass-through is higher when price is already higher.

The bottom line is that even this basic theory can, in principle, explain why "prices rise more strongly than they fall"—by tracing this to variations in demand curvature and/or firm conduct.

Example. The results can be illustrated with monopoly pricing, for which $n = 1$ (and also $\theta = 1$ since there are no rivals). By Lemma 1, the marginal rate of pass-through satisfies $\rho(t) = 1/[2 - \xi(t)]$ =(slope of demand curve)/(slope of marginal revenue curve), where $\xi(t) = \xi(p^*(t))$ (Bulow and Pfleiderer, 1983). Evidently, pass-through is asymmetric and increasing whenever demand curvature $\xi(t)$ rises with t, or equivalently, rises with the market price, p.

Suppose that demand takes the logistic form $p(Q) = \alpha - \beta \log[Q/(1 - Q)]$, where market output $Q \in (0, 1)$. It is easy to check that the marginal rate of cost pass-through equals $\rho(t) = [1 - Q^*(t)] \in (0, 1)$. So this demand curve satisfies the usual assumption of log-concavity. Since demand slopes down and pass-through is strictly positive, optimal output falls as cost rises, $dQ^*(t)/dt < 0$.

It follows that pass-through is non-constant; specifically, marginal pass-through is *increasing*, $d\rho(t)/dt > 0$. So large price rises are passed on relatively more strongly than small increases—and prices rise more strongly than they fall.

Moreover, even in this basic model, the degree of asymmetry in pass-through can be very large. Suppose, as above, that the cost shifter varies on an interval $[0, T]$. It follows that pass-through rises monotonically from $1 - Q^*(0)$ to $1 - Q^*(T)$. In principle, that is, for some values of α, β, and T, this can be consistent with pass-through rising from close to 0% to almost 100% as cost rise (perhaps over time).[7]

This example also illustrates how a more profitable firm can have a greater incentive to "absorb" cost increases; this is a frequent claim, for example, in policy discussions around the impact of environmental taxes. Recall that an optimizing monopolist's profits decline as its cost rises (by revealed preference). It follows immediately that, in this example, situations with low costs involve *both* high profits and low cost pass-through. Furthermore, this is an implication of static optimizing behaviour that does not rely on any dynamic considerations.

3 Asymmetric pass-through under perfect competition

This section shows how the same phenomena of increasing, constant, and decreasing asymmetric pass-through can also arise in a simple model without any market power.

Model setup. Consider a competitive market with a direct demand curve $D(p)$ and an industry supply curve $S(p - t)$, where t is a cost shifter as in the previous section. Note that this defines demand in terms of the consumer price, p, and supply in terms of the producer price, $p - t$. Balancing supply and demand requires that $S(p - t) = D(p)$.

Marginal cost pass-through. Treat the resulting equilibrium price $p^*(t)$ as a function of the cost shifter, and, just as above, let $\rho(t) \equiv \rho(p^*(t)) \equiv [dp^*(t)/dt]$ denote the marginal rate of cost pass-through.

[7] The equilibrium output $Q^*(t)$ here solves the equation $\log[Q/(1 - Q)] + 1/(1 - Q) = (\alpha - c - t)/\beta$.

Lemma 2. The marginal rate of cost pass-through under perfect competition equals $\rho(t) = S'/(S' - D')$ and is always (weakly) less than 100%.

Proof. Differentiating the equilibrium condition gives $0 = -S'(p^*(t) - t) + S'(p^*(t) - t)(dp^*/dt) - D'(p^*(t))(dp^*/dt)$. Rearranging this gives the expression for marginal pass-through. ■

Under perfect competition, marginal pass-through can take on any value between zero and 100%, depending on the details of demand and supply conditions (in relative terms). In the special case with a horizontal supply curve (infinitely elastic supply), so that marginal cost is a constant, pass-through is always exactly 100%. Unlike in models with market power, it is not possible for it to exceed 100%, so the equilibrium producer price, $p^*(t) - t$, always falls (weakly) with higher cost.

The pass-through rate from Lemma 2 is often stated in terms of demand elasticities. Define the price elasticity of demand as $\eta_D \equiv [-pD'(p)/D(p)] > 0$, and the price elasticity of supply as $\eta_S \equiv [pS'(p)/S(p)] > 0$. Consider a "small" cost shifter, specifically the limiting case $t \to 0$. Then, recalling that $S(p^*) = D(p^*)$, marginal pass-through can be written as $\rho(0) = \eta_S/(\eta_S + \eta_D)$, where the elasticities are evaluated at the corresponding equilibrium price $p^*(0)$. Note that this simple expression in terms of elasticities holds *solely* for the case of an infinitesimal cost rise.

Non-marginal cost pass-through. Suppose now that the cost shifter t rises over an interval $[0, T]$, so that $\Delta t = T$. The non-marginal rate of pass-through is thus defined as $\kappa(T) \equiv \Delta p^*/\Delta t$, and using previous results, is equal to an average of the form $\kappa(T) = \frac{1}{T}\int_0^T \rho(t)dt$, so the two coincide only where $d\rho(t)/dt = 0$ (linear pricing).

Proposition 2 (a) Cost pass-through under perfect competition is constant, $d\rho(t)/dt = 0$, if and only if $\frac{d}{dt}[-D'(p^*(t))/S'(p^*(t) - t)] = 0$ for all $t \in [0, T]$; otherwise, there is either increasing or decreasing asymmetric pass-through somewhere on the interval $[0, T]$.
(b) Suppose that the supply curve is not horizontal, $S'(\cdot) < \infty$; then pass-through is increasing if the supply curve is concave, $S''(\cdot) \leq 0$, and the demand curve is convex, $D''(\cdot) \geq 0$, in price, with at least one strict inequality, for all $t \in [0, T]$.

Proof. For (a), the necessary and sufficient condition follows by inspection of the expression for marginal pass-through from Lemma 2, making explicit the potential dependency of the slopes of demand and supply curves on the cost shifter t, via the equilibrium price $p^*(t)$. For (b), the sufficient condition follows from performing the differentiation

$$\begin{aligned}\frac{d}{dt}\left[\frac{-D'}{S'}\right] &= \frac{-D''\rho S' - S''(\rho - 1)(-D')}{(S')^2} \\ &= -\frac{\rho}{S'}\left[D'' - S''\left(\frac{1-\rho}{\rho}\right)^2\right] < 0\end{aligned}$$

which holds if $S''(\cdot) \leq 0$ and $D''(\cdot) \geq 0$, with at least one strict inequality, as claimed (since $\rho \in (0,1)$ by Lemma 2). ■

Once again, cost pass-through will only be symmetric under special conditions on demand and supply. The obvious case is where *both* the demand curve and industry supply are both linear (or affine) functions, such that $D'(\cdot)$ and $S'(\cdot)$ are constants.

A simple sufficient condition for increasing cost pass-through is that the demand curve is *strictly* convex, combined with an industry supply curve that is weakly concave over the price interval $[p^*(0), p^*(T)]$. The demand condition is certainly plausible; several demand curves that are frequently employed by economists are everywhere strictly convex (including exponential and constant-elasticity demand), and others exhibit this property at least over some range (such as logistic demand from the monopoly example above). The condition of concave supply is consistent with marginal cost that rises with industry output and is weakly convex—which again seems a plausible case. For instance, with constant-elasticity supply of the form $S(p) = Kp^{\eta_S}$, the condition $S''(\cdot) \leq 0$ is equivalent to inelastic supply $\eta_S \leq 1$, that is, industry supply rises with price but proportionally less so at a higher price.[8]

As in the previous section, these conditions are not ruled out by anything in economic theory and are consistent with optimizing behaviour by all agents.

The bottom line is that, even in the absence of market power, economic theory can account for any of increasing, constant, and decreasing cost pass-through; which of these obtains in practice is simply a question of demand and supply.

4 Relationship with the empirical evidence

This section discusses the extant empirical findings on asymmetric pricing, from both static and dynamic perspectives, and their relationship with the results from the previous two sections.

The empirical literature on asymmetric cost pass-through and "rockets and feathers" contains a range of findings. The headline result, often associated with Peltzman (2000), is that "prices rise faster than they fall". What does this mean?

First is the result that, in the "short run" (say over a few months), a cost increase raises price by more than an identically-sized cost decrease pushes price down—but that in the "long run" (say over a few quarters), the absolute magnitudes of these responses are the same. Second, another finding is that the *long-run* price impact, in some markets, is also asymmetric, with rises more pronounced than falls.

Observe that the first result implies that pass-through, at some point between the short- and long-term, must be asymmetric and *decreasing*, with the cost increase feeding

[8] This has a somewhat similar flavour to the argument due to Kimmel (2009) that the administrative and organizational costs that firms incur in raising output, in response to a cost drop, are significantly higher than those required to decrease output faced with a cost increase; loosely speaking, this can be interpreted as a convexity in the marginal cost function.

through *less* strongly to cost, and that the second result implies that pass-through must also have been asymmetric on the upside at some point in the short- or "medium-term".

Can the above results from economic theory explain these results? Obviously a static theory cannot generate a dynamic price path, at least not without some auxiliary interpretation.[9] What the above models *can* explain is an asymmetry in the *equilibrium* price response. This can be thought of as the move from an "old" to a "new" equilibrium—as governed by Proposition 1 or 2. Depending on demand conditions and industry supply/conduct, there could be increasing, constant, or decreasing pass-through over a sufficiently long term to be consistent with equilibrium. And if the "end points" are different depending on whether costs have rises or fallen, it is much less surprising to see some asymmetric response along the way.[10] Put another way, differences in the *strength* of pass-through may equally rationalize differences in its *speed*.

The key point is that the empirical literature on asymmetric pricing to date has not actually tested whether or not simple theory can account for asymmetric pass-through. The simple theory is rejected out of hand at the outset; it then (implicitly) forms the basis for the null hypothesis of symmetric pass-through against which the empirical estimates are then compared. The point of this paper is that this symmetric "counterfactual" is misleading since even simple theory can yield asymmetric pricing.

A proper empirical test would have to compare the observed pass-through patters with those predicted by a simple theory, which itself is calibrated to the demand and supply conditions estimated from market data—and then determine to what degree pass-through patterns are *still* left unexplained. This is a much more challenging task which, as far as I am aware, the existing literature has not taken up.[11]

What pass-through patterns would be generated by a simple model with an convex pricing function depends on a range of detailed factors; this includes the fraction of up and down movements in costs, their magnitudes and volatility—as well as the fine sequencing of the cost changes. Again, the existing literature does not appear to engage much with such statistics as explanatory variables.

The bottom line is that the empirical literature to date has not seriously tested the explanatory power of simple theories, and that, in principle, these *might* account for a significant portion of observed pricing asymmetries—certainly those for the "long run" estimates covering 6 months or so. The real question for future empirical research lies in determining this degree of explanatory power of simple theory.

[9] It does not seem right or constructive to criticize a static theory *solely* on the grounds that it is static.

[10] The vast majority of static economic models are based on the existence of a unique equilibrium. If so, a given set of firms' cost conditions implies a particular market price. This applies both before and after any cost change, so the pass-through rate is also unique. Put differently, such models are not history-dependent; they cannot explain why identical cost conditions might lead to different prices (or pass-through). Yet it is not clear whether the existing empirical evidence on pass-through shows that exactly the same conditions—on firm costs and *everything* else—lead to different price outcomes.

[11] Another consideration is that cost measures used in practice may conflate marginal costs and fixed costs. From a theory viewpoint, this does not matter since changes in fixed costs do not affect prices, so any evidence for asymmetric pass-through must be due to changes in marginal costs.

5 Concluding remarks & policy implications

This paper has argued that asymmetric pass-through can be explained, in principle, even by simple price theory. This includes the phenomena of price rising more strongly, and more weakly, than they fall, and does not rely on imperfect competition.

Put sharply, the widespread claim that simple economics cannot explain asymmetric pass-through is false; put less sharply, whether or not simple models can explain asymmetric pass-through across different markets has not actually been formally tested in the empirical literature.

The purpose of this paper has not been to develop new models but rather to address the question of asymmetric pass-through by looking at some very well-known economic models in a slightly different way.

If anything, the shortcoming of the theory of pass-through is a failure to rule *out*—not a failure to rule *in*, as claimed in the existing literature. For suitably chosen demand and supply conditions, essentially *any* pass-through behaviour can be rationalized. Put differently, it is not easy to reject these models, at least not based on pass-through patterns alone.

To be clear, this paper does *not* say that the factors identified by the extant literature as drivers of asymmetric pricing—such as vertical integration or consumer search costs—are irrelevant or wrong. Rather it criticizes that these papers take a potentially misleading starting point by dismissing simple theory out of hand.

Deploying more richly specified models widens even further the economist's ability to rationalize observed pass-through rates. The analysis here has restricted attention to the "normal" case where pass-through is positive. However, it has been known for 100 years that pass-through can turn *negative* for a monopolist selling multiple products; this is "Edgeworth's taxation paradox" (Edgeworth, 1925).[12]

What can be learned from a policy perspective? The answer, alas, is "not all that much". Pass-through is a useful tool to understand competition in market, assuming the underlying competitive model is known (Weyl and Fabinger, 2013). In practice, however, the mode of competition is *unknown*, so the question becomes whether pass-through can help "identify" it. The basic conclusion from the present analysis is that it cannot. Suppose you had perfect knowledge that pass-through in a market is 70% and symmetric, or that it is asymmetric with, on average, 80% on the upside and only 60% on the downside. This says little about the mode of competition.

The only robust inference appears to be the following: A pass-through rate above 100%, under wide assumptions, is inconsistent with perfect competition, and so is strong evidence for *some* degree of market power (but not necessarily of collusion). Saying more than this requires *much* more detailed empirical analysis of a market.

[12] Alternatively, if cost movements induce changes in the set of *active* firms (entry and exit), so the market structure becomes "endogenous", then discontinuities and "perverse" pass-through patterns become even more likely.

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