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# DEMAND-DRIVEN INTEGRATION AND DIVORCEMENT POLICY†


## Abstract

Industrial organization's concern with vertical integration has traditionally been limited to considering the effects on market outcomes, in particular product prices: they increase because integration enhances market power, or they decrease because it yields efficiency gains. This note offers a theoretical argument for reverse causality, from prices -- more generally, demand -- to integration. If, as many organizational theories in suggest, integration has positive effects on production efficiency and has any costs that are largely independent of output, then bearing those costs is more attractive when prices are higher, as when there is high demand. Therefore high prices lead to more integration. We discuss evidence for this reverse causality and its implications for regulation.



JEL Classification: D23 and D43
Keywords: OIO, reverse causality, theory of the firm and vertical integration



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# 1 Introduction

A regulator observes that the firms in an industry he suspects of being imperfectly competitive have been vertically integrating over time. Armed with the traditional tools of industrial economics, he reckons that integration may be occurring because it enhances the productive or allocative efficiency of the firms in the industry, or because the firms are attempting to enhance their market power.[1] Efficiency can arise because integration or vertical restraints help the vertical chain to internalize some externalities (double marginalization, agency problems like free riding by distributors). Market power enhancement can either be due to foreclosure (increase rivals costs, refusal to supply) or to increased ability for vertical chains to collude; in both cases, we expect prices to raise either at the wholesale or the retail level and also for market shares to be reallocated to the integrated firms. Hence, theory suggests that integration may *lead* to higher or lower prices and market shares depending on whether the dominant effect is foreclosure or efficiency. Telling the difference is straightforward: if prices are falling with integration, efficiency effects predominate. If they are rising, likely the firms are succeeding in enhancing their market power.

In the former case, the regulator, whose main constituency is consumers, has little reason to be concerned. In the latter case, though, the regulator might be tempted to invoke a “divorcement” policy in order to limit the apparent effects of integration, either by intervening in the control structure of the production chain (for instance by ordering franchise gasoline retailers rather than their supplying refiners to make pricing decisions) or, more drastically, by ordering asset divestitures (as in the forced sale of pubs by the brewers that own and supply them). Being a practical person mainly interested in effective policy implementation, the regulator is not apt to ask the seemingly academic question of why integration has increased recently rather than some time in the distant past; the issue is how to act given the rise in prices. (In the case of falling prices, the regulator might take reasonable comfort in chalking it up to changes in the technology of production or distribution.)

But as is often the case, there are dangers in avoiding the academic questions. Indeed, in oft-studied cases in US retail gasoline and British beer, regulators imposed divorcement policies following long periods of increasing integration and rising prices. What ensued was a surprising continuation of rising prices instead of the expected fall. What is more, firms’ profitability fell as well, despite the price increases.

[1]See e.g., Lafontaine and Slade (2007); Rey and Tirole (1997). Identifying these two effects has proven challenging in practice but the empirical literature tends to provide support for the efficiency effect of vertical integration or vertical restraints (Cooper et al., 2005; Lafontaine and Slade, 2008).

Standard industrial economic theories have a hard time explaining these episodes, but they make sense in the light of more recent developments in organizational economics, which has traditionally been concerned with the causes of integration more than its consequences (at least for the market). In a nutshell, the combination of rising prices, increasing integration, and reduced profits with continued rising prices post-divorcement can all be attributed to efficiency effects *along with rising demand*: in this view, causality runs from demand to integration, rather than from integration to market outcomes. The basis for this explanation is very simple: if integration indeed increases productive efficiency (a view that has several, sometimes competing, sometimes complementary, foundations in organizational economics), then it follows from maximizing behavior that demand conditions must influence the integration decision: if integration is costly (as it should be, else firms would always integrate to the maximum possible extent), then the productivity gain it offers is only worth the cost when the extra output produced is sufficiently valuable, namely with high demand. If demand is low, the cost of integrating outweighs the benefit, and the firm remains non-integrated.

The influence of demand on integration is at the heart of a recent paper (Legros and Newman, 2013), which considers the case of perfect competition, where the logic is most transparent. In this case, the role of demand is represented entirely by the price of the final product that a perfectly competitive supply chain faces. Suppose that a chain's technology is represented by the cost function

$$\phi(d)c(q) + h(d),$$

where $q$ is output and $c(q)$ is a standard cost function; we assume that there are eventually diminishing returns to scale so that this chain is not able to serve the entire market at constant marginal cost. The choice variable $d$ is the *d*egree or *d*epth of vertical integration, for instance, the number of units in the supply chain that belong to a single firm with the rest remaining stand-alone firms.[2] The function $\phi(d)$ represents how integration affects productive efficiency; $h(d)$ represents costs of integration. Examples of the former include improved coordination (Hart and Holmström, 2010); better multitasking incentives (Holmström and Milgrom, 1991); alignment of control and incentives (Hart and Grossman, 1986; Hart and Moore, 1990); or reductions in the costs of transactions, adaptation, or opportunism (Williamson, 1971, 1975; Klein

[2]This is a drastic simplification, since combinations of the members of the supply chain into several non-singleton firms, let alone recombinations across supply chains, are not allowed. But it is enough to allow us to make the point.

et al., 1978). In many cases, costs $h(d)$ can be generated by the same factors: incentives over multiple tasks are difficult to balance, and ceding control often means exchanging one incentive problem for another, resulting in decisions that are difficult for some parties to achieve given training, prior investments, or vision. Or they may result from maintaining a communication and monitoring infrastructure within the firm.[3] Assuming that the chain chooses $d$ and $q$ to maximize its (joint) profits $Pq - \phi(d)c(q) - h(d)$ given market price $P$, a first observation is that $P$ affects the choice of integration level, just as it affects the choice of quantity produced, because it is a parameter of an optimization problem. To be more concrete, assume that $\phi(d)$ is decreasing and $h(d)$ increasing. Then profit is supermodular in the choices $(d, q)$ and has increasing differences in $(P, q)$. As a result, optimal $q$ and therefore optimal $d$ increase with $P$: when output is more valuable, and the chain therefore wants to produce more of it, it is worth investing more in the reduced costs of doing so.[4]

Now consider the policy maker's conundrum. If demand was increasing over time (and not compensated by entry), then price would be rising. This would induce firms to integrate more; their costs would be lower and profits (both net and gross of the integration cost) higher. Each firm would supply more (but not so much that the industry price would be reduced to its previous level, else firms would return to their previous integration and supply levels leading to excess demand). The new equilibrium price would be higher, but rather *despite* integration than because of it. For if the policy maker forced firms to reduce integration to the previous level, their costs would rise, industry supply would be lower and the price even higher. This outcome is evocative of what happened in the gasoline and beer episodes.

Of course, there are important differences, not least that neither these industries appeared to be *prima facie* competitive. Extending the perfectly competitive framework to an oligopolistic one is the task of this paper. We are not attempting any sort of generality here, only enough to highlight some of this issues. We consider a model of Cournot competition among supply chains that can choose the level of

[3]Typically in organizational models, at least part of the costs or benefits of integrating are private, unobservable, and in any case non-contractible. Practically speaking this may mean that they will be difficult for the empirical investigator or policy maker to observe. In particular a distinction between gross (i.e. revenue minus costs of measured inputs) profitability and net profitability (gross profits minus integration costs) is worth bearing in mind.

[4]To be sure, in some models, particularly those in which incentives play a role, the extent of the efficiency gains, or the costs of integrating, may depend on other variables besides $d$, such as the price $P$ or the distribution of the profits among the various production units. For instance in Legros and Newman (2013), both the integration benefit and the integration cost display decreasing differences in $(d, P)$, but the net effect is that $d$ is always increasing in $P$. Other models of firms may have non-monotonic predictions; indeed, the differences across models could enable market data to serve as a proving ground for organization theory (Legros and Newman, 2014).

vertical integration, which reduces their marginal production cost. The first finding is that there is a conflict of interest between firms and consumers concerning the level of integration: as in other efficiency models, consumers would like there to be a high degree of integration, since that tends toward low costs and therefore low prices. But from the point of view of the firms in the market, there is too much integration: each firm confers a negative externality on its rivals when it integrates, because the cost reduction results in a business stealing from the rivals. In equilibrium, while measured profits may be substantial due to low marginal production costs, net profits that take account of the cost of integration (but at least in some of the interpretations alluded to above would be difficult to measure), will be low.

Second, as we have already said, demand plays a role in determining the integration decisions that firms make. Increasing demand always increases integration. But whether it is accompanied by rising or falling prices depends on which parameter of the (linear) demand is shifting. Since the beer and gasoline examples are somewhat unusual in the trends that led to the (very unusual) policy responses, this is reassuring.

Third, we can address the question of whether integration serves to facilitate collusion, which seems to have been a particular concern for regulators in the concern for the British beer case (Spicer et al., 2012). A first answer is not at all: as we have suggested, the industry not only has a collective motive to restrict output, but also to reduce integration levels. Indeed, if they are able to sustain collusion through repeated interaction, then they will choose a *lower* integration level than they would in the non-collusive Cournot equilibrium. In this model, at least, high levels of integration serve as signs of low levels of collusion.[5]

But there is a sense in which integration can support collusion. For the punishment inflicted on a deviator from a collusive strategy profile in which low levels of integration and output are being sustained is to revert to the higher integration and output levels of Cournot equilibrium. If integration were exogenous, or at least capped at a low level, this punishment would not be so severe, and collusion more difficult to sustain. By threatening the very low Cournot payoffs that integration affords, it is the possibility of more integration, rather than its actuality, that helps sustain collusion.

This last observation leads us to our fourth finding, which concerns the effects of divorcement policy, modeled as an enforceable cap on the level of integration that

[5]To be sure, a collusive industry that experiences rising demand would increase its level of integration, just as a monopolist would. But a non-collusive industry would do the same, and would always have high er levels of integration than the non-collusive one.

each firm may choose. It follows from the over-investment result that if the industry is in the non-collusive equilibrium, then divorcement typically helps firms (unless it is very drastic and leads them to a level of integration far below their joint optimum). Consumers are not helped by this, of course, because marginal costs and therefore prices rise.

If the industry was colluding before the policy implementation, then two things can happen, assuming the policy is binding. Either collusion continues (say, because the policy is imposes relatively mild constraints on integration), in which case consumers are harmed relative to the pre-divorcement outcome because marginal costs have increased, or it is undermined, because the Cournot payoff is now relatively high and does not constitute an adequate threat against deviation. This provides a potential benefit to consumers that would have to be weighed against the increase in marginal costs. Thus divorcement policy could benefit consumers because it reduces an instrument of collusion, namely the threat of more integration. But avoiding the allocative inefficiency of collusion may come at expense of an organizational inefficiency that raises production costs, so it is possible that prices rise even if collusion is destabilized. As discussed in the final section of the paper, which considers evidence for reverse causality as well as the gasoline and beer divorcement episodes in more depth, it does not appear that this tradeoff was managed to consumers benefit in either case.

## 2 A Model of Integration

As in the previous section, we consider an industry populated by vertical supply chains that are isolated from each other except at the final downstream stage, where they sell in a common market. Intermediate goods along the supply chain have no market. This portrait of the industry is mainly for simplicity, but it is also in the spirit of much of the organization literature that emphasizes "relationship specificity." An example would be coal-fired electric generating station located next to a coal mine: coal is costly to transport and low in value, so the mine's market is limited primarily to the power plant, but the electricity can be sold in a national market via the power grid. Our reduced form model is consistent with richer theories of integration, e.g., Legros and Newman (2013).

The timing of the model is as follows:

- There are $n$ downstream producers indexed by $i$ or $j$, and each makes an integration decision $d$.

- Integration decision are observed and firms choose the quantity to produce.
- The product market clears, that is if $Q$ is the total quantity produced by the firms the price on the market is $P(Q) := a - bQ$, the price equal to value of the inverse demand function at $Q$, where $a > 0, b > 0$.

If the degree of integration in a firm is $d \in [0, \overline{d}]$, and the quantity produced is $q$, the cost to the integrated firm is

$$\phi(d)q + h(d).$$

For simplicity of the exposition, we impose the following conditions on $\phi, h$.

**Assumption 1.**

- *$h(d)$ is an increasing convex function of $d$, with $h(0) = h'(0) = 0$.*
- *$\phi(d)$ is a decreasing convex function of $d$, with $\phi(0) \in (0, a)$ and $\phi(\overline{d}) > 0$.*

The model is formally an endogenous sunk costs model (Sutton, 1991), with a difference: as the examples in the Introduction suggest, the cost $h(d)$ is best thought of as "fixed," that is independent of output or price, but incurred as long as the chain produces. Firms make a decision on the degree of integration and the higher this degree the higher is the fixed cost $h(d)$ and the larger is the reduction of marginal cost $\phi(d)$.[6] The key feature for our results is that the cost function has negative cross partials in $d, q$, that is the marginal cost of production is a decreasing function of the degree of integration.

## Cournot equilibrium

We consider subgame perfect equilibrium in integration decisions $\{d_i\}$, which are followed by integration-contingent quantity decisions $q_i$. Output choices are contingent on the choices of integration by all firms in the industry because the marginal costs of firms are affected by these organizational choices.

For a given set of integration decisions $\mathbf{d} := (d_1, \cdots, d_n)\}$, the continuation game is a standard Cournot game with marginal costs $\{\phi(d_i)\}$. Therefore the quantities,

[6] The distinction will become apparent when we consider sustainable collusion in a repeated game; in a static model the difference is one of interpretation.

price, and profit levels are (sums are over $j = 1, ..., n$ inclusive of $i$ unless otherwise noted):

$$q_i(\mathbf{d}) = \frac{a + \sum_j \phi(d_j) - (n+1)\phi(d_i)}{b(n+1)},\ Q(\mathbf{d}) = \frac{na - \sum_j \phi(d_j)}{b(n+1)},$$
$$P(Q(\mathbf{d})) = \frac{a + \sum_j \phi(d_j)}{n+1}.$$

The net profit $\pi_i(\mathbf{d})$ is the difference between gross profit (revenue $Pq_i$ less production cost $\phi(d_i)q_i$) and integration cost $h(d_i)$:

$$\pi_i(\mathbf{d}) = \frac{\left(a + \sum_j \phi(d_j) - (n+1)\phi(d_i)\right)^2}{b(n+1)^2} - h(d_i). \tag{1}$$

Note that the organizational choices are strategic substitutes since $\pi_i(\mathbf{d})$ has negative cross partials in $(d_i, d_j)$. Hence if firm $i$ expects other firms to integrate less, it will integrate more.

When firms choose their integration structure, they anticipate the equilibrium profit function (1). Some firms will necessarily choose integration in equilibrium when $\sum_j \phi(d_j) > 0$; because $h'(0) = 0$, these firms choose $d_i > 0$ such that[7]

$$-\phi'(d_i)\left(a + \sum_j \phi(d_j) - (n+1)\phi(d_i)\right) = b\frac{(n+1)^2}{2n}h'(d_i).$$

Because $h'(0) = 0$, a firm optimally chooses not to integrate when

$$-\phi'(0)\left(a + \sum_j \phi(d_j) - (n+1)\phi(0)\right) < 0,$$

and a sufficient condition for this not to be possible is that $a > (n+1)\phi(0)$, which we will assume from now on. Under this condition, all firms must choose a positive degree of integration. We will focus on symmetric equilibria; all firms choose the same degree of integration $d$.

**Lemma 1.** *When $a > (n+1)\phi(0)$, the symmetric Cournot equilibrium choice of*

[7] To simplify we assume that the second order conditions hold: for instance, $h$ is sufficiently convex.

*integration $d^*$ for each firm solves*

$$-\phi'(d)(a-\phi(d)) = b\frac{(n+1)^2}{2n}h'(d). \tag{2}$$

*Each firm produces $q^* = \frac{a-\phi(d^*)}{b(n+1)}$; the price is $P^* = \frac{a+n\phi(d^*)}{n+1}$.*

Note that a "Cournot planner" who chooses the (common) level of integration $d^P$ for each chain, assuming they go on to play Cournot equilibrium in quantities, maximizes $\pi^*(d) = \frac{(a-\phi(d))^2}{b(n+1)^2} - h(d)$ and regards the marginal benefit of integration as $\frac{-2(a-\phi(d^P))\phi'(d^P)}{b(n+1)^2}$, and equates this to the marginal cost $h'(d^P)$. But from (2), each chain regards the marginal benefit as $n$ times larger, because a cost reduction not only expands the market for the industry, but increases the market share of that chain. This business stealing effect implies that Cournot competitors over-invest in integration (from their point of view—of course, consumers would not agree), which is an additional motive over and above the usual output restriction motive for collusion.

## Collusive Outcome

We think of collusion as sustained in a repeated game in $(\mathbf{q}, \mathbf{d})$; since integration as well as quantity decisions have to be made each period, since they are both reversible and costly for as long as the supply chain is operating. Because integration decisions are observable, we will assume that collusion leads to the maximum per firm profit absent side-payments. That is, we assume that firms collude on

$$(d^M, q^M) = \arg\max_{d,q}(a - bnq - \phi(d))q - h(d),$$

The two first order conditions are $q = \frac{a-\phi(d)}{2bn}$ and $-\phi'(d)q = h'(d)$, implying that

$$-\phi'(d)(a-\phi(d)) = 2bnh'(d). \tag{3}$$

It is standard to show that the following strategy is a subgame perfect equilibrium of the repeated game when the discount factor is large enough.

- At time 1,
  - Each firm $i$ chooses $d_i$.
  - If there exits $i$ such that $d_i \neq d^*$, firms play the Cournot equilibrium action $q_i(\mathbf{d})$.

- If for each $i$, $d_i = d^M$, firms play $q_i = q^M$.

- At time $t \geq 2$, define an history to be collusive if at each previous period, each firm chose $(d^M, q^M)$, otherwise define the history to be not collusive.
  - If the history is collusive, play $d^M$. Once $\mathbf{d}$ is observed play $q^M$ if $d_i = d^M$ for each $i$; otherwise play the Cournot quantity $q_i(\mathbf{d})$.
  - If the history is not collusive, play $d_i = d^*$. For each observed $\mathbf{d}$ play the Cournot quantity $q_i(\mathbf{d})$.

For any $n \geq 1$, $(n+1)^2 < 4n^2$ and the right hand side of (2) is lower than the right hand side of (3). Hence if the equilibrium profit function under Cournot is concave, we will have $d^M < d^*$: when firms do not expect to collude, they will integrate more in order to lower their marginal cost of production and increase their competitiveness in the product market. [8]

**Proposition 1.** *Under concavity assumptions on the equilibrium profit functions, in the static Cournot game, firms integrate more than in the best collusive equilibrium.*

Could collusion be happening (in quantities only) at $d^*$? It is not hard to show (see footnote 12 in Appendix C) that if the firms are able to sustain collusion $(q^M(\mathbf{d}^*), d^*)$, i.e., monopoly quantities optimal for the high integration level $d^*$, they will also be incentive compatible to collude on $(q^M(\mathbf{d}^M), d^M)$, and since this is better for them, they might as well do so. Thus, observing a low level of integration $(d^M)$ is a sign of collusion, observing a high level $(d^*)$ a sign of non-collusion.

Under the concavity assumption, an increase in $a$ will lead to an increase in $d$; this is independent of the firms' conduct and is immediate from inspection of equations (2) and (3). A similar observation can be made for changes in the slope of demand.

**Proposition 2.** *Under concavity assumptions on the equilibrium profit functions, increasing demand (a higher or b lower) raises the degree of integration.*

However, while increases in $a$ and decreases $b$ both result in higher integration levels, they have different effects on the price level. By themselves, these demand shifts would increase price. But there is a countervailing effect brought on by the induced reduction in marginal cost. In fact it is not hard to show that reducing

[8]Since monopoly profit is larger than the Cournot profit, integration has a higher return for the collusive firm than it does for the Cournot planner: the function $A(a-\phi(d))^2 - h(d)$ has increasing differences in $(A, d)$ and therefore optimal $d$ increases with $A$. For monopoly, $A = \frac{1}{4bn}$, which exceeds the Cournot planner's value $A = \frac{1}{b(n+1)^2}$. Hence $d^P < d^M$.

$b$ always lowers price; increasing $a$ raises price under a slight strengthening of the concavity conditions that ensure interior solutions to firms' integration decisions (see Appendix B).

**Proposition 3.** *Under strengthened concavity assumptions on the equilibrium profit functions, price and integration covary with each other in response to changes in $a$; they covary negatively in response to changes in $b$.*

The fact that increases in demand do not universally generate co-variation in price and integration should not trouble us, since it is not universally observed. It is the possibility of such co-variation under demand-driven integration, which standard IO models cannot easily explain, that we are pointing out here. For the rest of the paper, we will simplify exposition by supposing that $\phi(d) = c - d$ and $h(d) = d^2$. In this case, the strengthened concavity condition in Proposition 3 is $b > \frac{n}{n+1}$ for Cournot and $b > \frac{1}{2n}$ for collusion; to save notation we assume $b = 1$.

Solving for the Cournot and the industry total profit maximizing cases, we have:[9]

$$\begin{aligned} d^* &= \frac{n(a-c)}{n^2+n+1},\ P^* = \frac{1}{n^2+n+1}a + \frac{n(n+1)}{n^2+n+1}c \\ d^M &= \frac{a-c}{4n-1},\ P^M = \frac{2n-1}{4n-1}a + \frac{2n}{4n-1}c \end{aligned} \tag{4}$$

These expressions provide direct verification that $d^* > d^M$, as in Proposition 1. Moreover, $\frac{dd^*}{da} > \frac{dd^M}{da}$: not only does Cournot equilibrium exhibit more integration than collusion, but the integration level is also more responsive to changes in market conditions. However $\frac{dP^*}{da} < \frac{dP^M}{da}$: the price level rises faster under collusion than under Cournot in the face of a trend increase in demand.

# 3 Divorcement Policy

Suppose to simplify that demand shifts once, and increases from $a$ to $a'$. If the conduct stays the same, this trend is accompanied by an increase in the integration of firms under Cournot and also when the firms succeed in colluding on the industry profit maximizing choices. As $a$ increases, both the Cournot and collusive prices increase; but it is the shift in demand that led to the increase in integration—there is reverse causality. (See Appendix A for stability conditions for collusion when $a(t)$ varies continuously.) Upon observing these joint upward trends, the regulator decides to prevent any integration above a level of $d^r$.

[9]In order for $d^*$ and $d^M$ to be less than $c$, it is sufficient to have $a < c\frac{(n+1)^2}{n}$.

Consider Cournot behavior first. Once the policy is in place, the firms play a Cournot game under constraint; $d_i$ is restricted to be less than $d^r$. Because integration strategies are substitutes, as we have already noted, when the other firms are constrained to choose $d_j \leq d^r$, firm $i$ will want to choose $d_i > d^*$ but is also constrained. Hence the constrained equilibrium is for all firms to choose $d^r$.

Cournot behavior under divorcement regulation is important for understanding collusive behavior as well, since it provides the punishment for deviations. We shall need the following

**Lemma 2.** *The Cournot profit $\pi^*(d)$ is decreasing on $[d^M, d^*]$.*

*Proof.* Write

$$\pi^*(d) = \frac{(a - \phi(d))^2}{(n+1)^2} - d^2$$

and therefore

$$\pi^{*\prime}(d) = \frac{2}{(n+1)^2}(a-c) - \left(2 - \frac{2}{(n+1)^2}\right) d$$

and the Cournot profit function is concave. Moreover, it is maximized at $d^P = \frac{a-c}{n(n+2)}$. Since from (4) the industry optimum is $d^M = \frac{a-c}{4n-1}$, $d^P < d^M$ as claimed. $\square$

Since $d^M < d^*$, a corollary is that the constrained Cournot profit $\pi^*(d^r)$ is a decreasing function of $d^r \in [d^M, d^*]$.

In the Cournot case, choosing $d^P < d^r < d^*$ yields an *increase* in the retail price $\frac{a+n(c-d)}{n+1}$ since firms have higher marginal costs $\phi(d^r) > \phi(d^*)$. Cournot firms have *higher* net profits however: the regulation allows them to solve their free rider problem in organizational choice. Without divorcement, they tend to over-invest in integration in order to be more competitive; divorcement limits this over investment and eventually increases the net profit of firms. Hence, consumers are worse off but firms are better off.

If firms can collude on the industry maximizing outcome, and $d^r$ is binding on this (i.e., $d^r < d^M$), the resulting price in the industry $\frac{a+c-d^r}{2} > \frac{a+c-d^M}{2}$ is higher following divorcement, so consumers are worse off. Firms are also worse off since they are constrained in their choice of collusion.

However, divorcement may modify the conduct of firms: divorcement may prevent firms from colluding while they could before. Indeed, if collusion is stabilized by trigger strategies, the discount rate is greater than a cutoff $\frac{\pi^{dev}-\pi^M}{\pi^{dev}-\pi^*}$, and this value is increasing in the constraint $d^r$: as $d^r \in [d^M, d^*)$, the industry maximizing choice is unchanged, as are the values of $\pi^{dev}$ and $\pi^M$, but by Lemma 2 the constrained

Cournot profit increases, making collusion less likely. As $d^r < d^M$, firms are constrained both in the Cournot case and in their choice of industry profit maximizing outcome and they will adopt the same organizational structure $d^r$. But then, the fixed cost $h(d^r)$ together with the per unit profit level $a - \phi(d^r)$ cancel out in the cutoff value which is only a function of $n$.[10] Whether or not the conduct of firms changes from collusion to non collusion depends on the level of the discount factor; if the discount factor is close to the initial cutoff, a decrease in $d^r$ will make collusion unstable.

**Proposition 4.** *Under the assumptions of Proposition 3:*

1. *If divorcement does not change the conduct of firms, consumers are worse off both in the Cournot and collusive cases. Cournot firms are better off while collusive firms are worse off.*

2. *If divorcement changes the conduct of firms, firms are worse off and consumers may be better off. A sufficient condition for consumers to be better off is that the Cournot price when $d^r = 0$ is smaller than the collusive price at $d^M$.*

The reason for the ambiguity in consumer welfare in the second part is that even if collusion is stopped by the policy, the firms will be operating at a higher marginal cost; thus a monopoly price at a low cost might be lower than a Cournot price at a high cost.

In Appendix C, we show that if collusion is possible at $d^M$ it is possible at any $d^r < d^M$. And if it is not possible at $d^M$, neither will it be below that. Thus, the regulator gains nothing by setting $d^r < d^M$: regardless of whether collusion is still sustainable at $d^r = d^M$, its sustainability is unchanged using a stricter regulation, but since $q^M(\mathbf{d}^r) < q^M(\mathbf{d}^M)$ and $q^*(\mathbf{d}^r) < q^*(\mathbf{d}^M)$, the stricter regulation results in higher prices.

Thus, a regulation $d^r \geq d^M$ that succeeds in stopping collusion, if it exists, must lower prices: there is a switch from the monopoly price at $d^M$ to the Cournot price at the weakly lower cost structure $d^r$. On the other hand, a regulation $d^r < d^M$, even if it is collusion destabilizing, may harm consumers because the Cournot firms will have high marginal costs. This cannot happen under our parametric assumptions but is a theoretical possibility.

One thing we have not considered so far is the effects of divorcement on exit, and while a full treatment is beyond the scope of this paper, we make some observations.

[10] This result is due to the linearity of the demand function and of $\phi(d)$.

If firms incur an additional fixed cost to operate, then a fall in net profits following divorcement may lead some to exit. There is evidence this happened in the British beer case. Exit may not be harmful of course if firms were making monopoly profits prior to the regulation. But if they were not colluding, the regulation will force costs to be higher, and after exit, the smaller number of firms combined ith higher costs will drive prices up even further. What is more, with fewer firms left, collusion may be more sustainable than before, raising the possibility that divorcement might facilitate collusion.

# 4 Some Evidence for Reverse Causality

Evidence for the effects of demand on integration is starting to be collected. Some suggestive evidence comes from some single-industry studies (e.g. Forbes and Lederman (2010), which shows that airlines are more prone to integrate with regional carriers on more “valuable routes (specifically those where failures are more costly); Forbes and Lederman (2009) also show that integrated relationships are more productive, which bolsters the key assumption in this paper.

A few papers try systematically to test the hypothesis that demand affects integration. An empirical challenge is to find exogenous sources of price variation and look for correlation with integration. One approach is provided in Alfaro et al. (forthcoming), which uses variation in the Most-Favored-Nation (MFN) tariffs applied by GATT/WTO members as a proxy for price variation. The idea is that tariffs affect prices, and through that integration, but (vertical) integration is unlikely to affect tariffs. The argument for exogeneity of MFN tariffs comes partly from the institutional structure by which they are set: long rounds of multilateral bargaining and a non-discrimination principle that forces uniform application of tariffs to all trading partners makes the MFN tariffs much more resistant to lobbying than other forms of trade barriers. Because tariffs raise product prices in the domestic market (as compared to the world price), reverse causality suggests that they should lead to more integration among firms selling in that market.

Following Fan and Lang (2000), the degree of integration is defined as the fraction of inputs (measured in value-added terms) that are produced within the firm; in the data, the average is about 6%. Tariffs should have stronger effects on firms that do not sell abroad, since exporters face the world price, not the just the domestic one. Focusing on the differential effect of tariffs on domestic firms relative to exporters, and using country-sector fixed effects to control for possible omitted variables that might be driving integration and tariffs, Alfaro et al. (forthcoming) find a strong effect of tariffs on the degree of integration. The estimated tariff elasticity of vertical integration is in the range $0.02-0.09$, which, since tariffs average around 5%, converts to a price elasticity in the range $0.4 - 2$.

The removal of trade barriers can provide another source of evidence for the causal effect of prices on integration. Such policies tend to reduce the price gap across countries and therefore affect the degree of integration of all firms (Conconi et al., 2011). Alfaro et al. (2015) find evidence for this price convergence effect since the differences in integration across countries are smaller in sectors in which differences in MFN tariffs (hence domestic prices) are smaller or where there is a regional trade agreement.

In both the British beer and US gasoline divorcement episodes cases, the regulator forced divorcement in vertical chains, admittedly because there was an increasing trend in prices and the fear was that this was due to foreclosure effects facilitated by vertical integration.

The econometric challenge to identify the effect of divorcement on prices is to control for the possibility that other factors, like changes in accounting conventions or tax rules for the beer industry, contributed to the increase in prices. If the foreclosure story was the right one, divorcement should have led to a decrease in prices. If divorcement led to an increase in prices, there is support for an efficiency view of integration.

Slade (1998*a*) documents the effects of the UK Monopolies and Mergers Commission decision in the 1980s to force divestiture of 14,000 public houses. Her model contrasts four types of organization in the vertical chain brewer-pub: company owned, franchised pubs (with or without fixed fees) and arms-length relationship. Company owned is akin to integration, while the two other forms are weak and strong forms of non-integration.

The upstream segment of the industry was relatively concentrated at the time of the decision, with seven large national brewers and a series of micro-breweries. The divorcement put ceilings on the number of pubs (licenses) that a brewer could have, with exceptions made when a brewer accepts not to tie the loan. The divestitures led to the emergence of public-house chains, which have long-term contractual agreements with national brewers, as well as a decision of some brewers to stop production and shift to retailing. The main finding was that following the decision, retail prices increased (in the tied-houses but not in the free houses) and profits of brewers decreased. Consistent with our results, following the policy, some brewers exited the industry.

Interestingly, some commentators on the beer case (e.g. Spicer et al., 2012) note that demand for pub beer was growing over the decade leading to Beer Orders, due to income growth and greater leisure time. They also document the strong industry opposition to the policy. In terms of our model, the evidence fits the scenario in which collusion was sustained both before and after the intervention: this accounts for the increased price, the fallen profits, and the industry opposition. If collusion had been stopped by the policy, most likely prices would have fallen; if there had been no collusion, brewers should have welcomed some version of the policy as a check on their over-investment.

Barron and Umbeck (1984) study the effects of the divorcement law enacted in 1974 in Maryland that prohibited refiners' control of gasoline stations, and re-allocated control rights for hours of operation and retail pricing to the stations.[11] Contrary to the beer example, here the refiners were not obliged to divest their assets but to move to a franchising system where the gas station franchisees would have control over operation decisions, including the retail price. Like for the previous example, the effect of the divorcement has been an increase in retail prices. Barron and Umbeck (1984) cite evidence that the supporters of the legislation included owners of independent gasoline stations, who are indeed likely to gain from the divorcement since price competition will be soften at the retail level, while opponents to the legislation included, obviously, refiners affected by the divorcement policy but also *consumers*.

These results are consistent with an efficiency view of integration, a point that has been made in many other empirical studies of vertical relationships (Lafontaine and Slade, 2007), but are especially useful for our purpose because the regulator stepped in and forced divorcement following a perceived upward trend in both retail prices and vertical integration. The fact that divorcement led to a further increase in prices suggests that the previous upward trend in prices was not primarily due to integration, and therefore provides some support that integration happened as a consequence of this upward trend in prices.

# 5 Conclusion

One of the challenging task in evaluating mergers or the performance of integrated firms is to disentangle the efficiency and market power effects of integration. Priors

[11] See also Barron et al. (1985); Slade (1998*b*); Vita (2000); Blass and Carlton (2001).

about the causal relationship between price levels and degrees of integration drives policy decisions. As we have argued for divorcement policies, the analysis of the causal relationship between past trends in prices and degree of integration should allow for reverse causality and be therefore part of policy discussions.

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# A Collusion When There is An Upward Trend in Demand

Suppose that the level of demand $a$ follows an upward trend $a(t)$, where $a(t) \in [\underline{a}, \overline{a}]$

The *test strategy* at time $t$ is for firms to choose the industry profit maximizing $(d^M(a(t)), q^M(a(t)))$. An history at time $t$ is collusive, if at any $\tau < t$ firms used the test strategy. Consider a generalization of the trigger strategy in the text.

- If the history is collusive, play the test strategy at time $t$.
- If the history is not collusive, play the Cournot strategy forever after.

With some abuse of notation we denote by $d^*(a), d^M(a)$ the integration choices when the conduct is Cournot or collusive and when the level of demand is $a$. The trigger strategy stabilizes collusion if and only if for any $t$, we have:

$$(1-\delta)\sum_{\tau\geq 1}\delta^{\tau-1}\pi^M(a(t+\tau-1)) \geq (1-\delta)\pi^{dev}(a(t)) + (1-\delta)\sum_{\tau\geq 2}\delta^{\tau-1}\pi^*(a(t+\tau-1)).$$

Since there is an upward trend in $a(t)$, the left hand side is greater than $\pi^M(a(t))$ while the right hand side is smaller than $(1-\delta)\pi^{dev}(a(t)) + \delta\pi^*(\overline{a})$. Hence a sufficient condition for stability is that

$$\delta \geq \max_t \frac{\pi^{dev}(a(t)) - \pi^M(a(t))}{\pi^{dev}(a(t)) - \pi^*(\overline{a})}.$$

# B Proof of Proposition 3

Since $P^M = (a + \phi(d^M))/2$ and $P^* = (a + n\phi(d^*))/(n+1)$, both prices increase with $b$ (i.e., decline when $b$ falls, which corresponds to increasing demand), since $d^M$ and $d^*$ both decrease (thus $\phi$ increases) with $b$.

For increases in $a$, $P^*$ increases if $1 + n\phi'(d^*)\frac{\partial d^*}{\partial a} > 0$ and $P^M$ increases if $1 + \phi'(d^M)\frac{\partial d^M}{\partial a} > 0$ Using (2) and (3), one finds that these conditions are satisfied if

$$\frac{b(n+1)^2}{2n}h''(d^*) + \phi''(d^*)(a - \phi(d^*) > (n+1)\phi'(d^*)^2$$
$$2bnh''(d^M) + \phi''(d^M)(a - \phi(d^M) > 2\phi'(d^M)^2.$$

These conditions are slightly stronger than the second order conditions for the optimization problems leading to solutions in (2) and (3), which are identical on the LHSs but replace the RHSs by $n\phi'(d^*)^2$ and $\phi'(d^M)^2$. For the case $\phi(d) = c - d$, $h(d) = d^2$, if $b \geq 1$, $P^*$ increases with $a$ for all $n$. For collusion, the condition is weaker, namely $b \geq 1/2$.

# C Proof of Proposition 4

We perform here the analysis under the assumption that there is a one time increase in $a$ that leads to an increase in price in the industry and the decision of the regulator to force firms to divest. Hence, we assume that we are at a time $T$ where $a(t) = a(T)$, for all $t \geq T$; the general analysis of collusion and regulation under a strictly increasing trend of $a$ is beyond the scope of this paper.

Without regulatory constraints, the collusive outcome is $d^M, q^M$, and there are two incentive compatibility conditions: a firm must not want to change its organization to $d \neq d^M$ and face Cournot profits $\pi_i^*(\mathbf{d^M} \setminus d_i)$, that is when firm $i$ uses organization $d_i$ while other firms use $d^M$; and a firm must not want to change its output given $\mathbf{d^M}$.

It turns out that the no-integration deviation is enforceable within a period, which simplifies things considerably. The first incentive compatibility condition requires that

$$\max_d \left\{ \frac{(a + (n-1)\phi(d^M) - n\phi(d))^2}{b(n+1)^2} - h(d) \right\} \leq \frac{(a - \phi(d^M))^2}{4bn} - h(d^M)$$

As we have noted in the text, since $(d_i, d_j)$ are strategic substitutes, and since

$d^M < d^*$, it follows that the best response to $d^M$ is greater than the best response to $d^*$, but then the value of $d$ maximizing the left hand side of the inequality is greater than $d^*$, hence greater than $d^M$. Thus $h(d) > h(d^M)$, and it is enough to show that

$$\frac{(a+(n-1)\phi(d^M)-n\phi(d))^2}{b(n+1)^2} < \frac{(a-\phi(d^M))^2}{4bn} \tag{5}$$

which always holds since $(n+1)^2 > 4n$ and $(a+(n-1)\phi(d^M)-n\phi(d) < a-\phi(d^M)$.

Hence the only incentive compatibility condition to verify is the usual no output deviation. In equilibrium, firms produce $q^M = \frac{a-\phi(d^M)}{2bn}$, and therefore the best deviation from this output maximizes

$$(a-\phi(d^M)-b(n-1)q^M-bq)q = \left((a-\phi(d^M)\frac{n+1}{2n}-bq\right)q,$$

that is $q^{dev} = (a-\phi(d^M))\frac{n+1}{4bn}$, and therefore the maximum profit of firm deviating from $q^M$ is

$$\pi^{dev}(\mathbf{d^M}) = (a-\phi(d^M))^2\frac{(n+1)^2}{16bn^2}.$$

There is an incentive to deviate if $\pi^M(\mathbf{d^M}) < (1-\delta)\pi^{dev}(\mathbf{d^M}) + \delta\pi^*(\mathbf{d}^*)$, that is when:

$$\delta < \delta^{no} \equiv \frac{\pi^{dev}(\mathbf{d^M})-\pi^M(\mathbf{d^M})}{\pi^{dev}(\mathbf{d^M})-\pi^*(\mathbf{d}^*)}. \tag{6}$$

Suppose a regulator decides to restrict integration and forces firms to divest down to $d^r$, $d^r < d^*$.

If $d^r \in [d^M, d^*)$, firms are constrained under Cournot but not under collusion, and the cutoff value for collusion on $(d^M, q^M)$ is

$$\delta(d^M, d^r) \equiv \frac{\pi^{dev}(\mathbf{d^M})-\pi^M(\mathbf{d^M})}{\pi^{dev}(\mathbf{d^M})-\pi^*(\mathbf{d^r})},$$

(thus $\delta(d^M, d^*) = \delta^{no}$). Since, as shown in the text leading up to Proposition 1, the Cournot equilibrium profit $\pi^*(\mathbf{d^r})$ is a decreasing function of $d^r$ in $(d^P, d^*)$, where $d^P < d^M$, $\delta(d^M, d^r)$ is decreasing in $d^r$ on $[d^M, d^*)$. Therefore, as the regulatory constraint is tighter, the discount rate has to be higher in order for collusion to be still stable. In particular, if $\delta \in [\delta^{no}, \delta(d^M, d^r))$, collusion is prevented by the imposition of the regulatory constraint.

If $d^r < d^M$, then both under Cournot and collusion, firms are constrained in their organizational choices and will settle on $d^r$. Because the profit levels under collusion, optimal deviation from collusion, and Cournot are of the form $\pi^l(\mathbf{d}) =$

$\alpha(n)\frac{(a-\phi(\mathbf{d^r}))^2}{b} - h(d^r)$, where $\alpha(n)$ is an expression depending only on $n$, and independent of the marginal cost and demand parameters, the ratio $\delta(d^r, d^r) = \frac{\pi^{dev}(\mathbf{d^r}) - \pi^M(\mathbf{d^r})}{\pi^{dev}(\mathbf{d^r}) - \pi^*(\mathbf{d^r})}$ is independent of $\mathbf{d^r}$. Hence, the regulation will destabilize collusion if $\delta \in [\delta^{no}, \delta(d^M, d^M))$.[12] In the text it is explained how consumers might gain from divorcement: impose a policy that breaks the cartel and leads to a lower cost structure, is such a policy exists. If not, then if $d^r \geq d^M$, the policy is neutral. But if $d^r < d^M$ the policy may be harmful. For instance, in the special case we are considering, put $d^r = 0$.

It remains to show that consumers may gain if collusive conduct changes. If putting $d^r = d^M$ suffices for collusion to stop, then the result is immediate: price falls from $P^M(d^M)$ to $P^*(d^M)$. If collusion does not stop when $d^r = d^M$, then no lower regulation will stop it either. However, lowering $d^r$ to a level far enough below $d^M$ may stop collusion and nevertheless make things worse for consumers, since a Cournot price with low integration (high marginal cost) may exceed a monopoly price at higher integration (lower cost).

Finally, if the regulator "overshoots" and imposes a low cap $d^r$, collusion may be prevented but the Cournot firms have high marginal costs since $d^r$ is small, and this raises the possibility that the Cournot price following divorcement will be larger than the collusive price prior to divorcement. This cannot be the case for the parametrization we used in the text since the Cournot price when there is no integration is equal to $P^*(0) = \frac{a+nc}{n+1}$ which is smaller than the collusive price $P^M$ whenever $a > c$.

[12]The independence $\delta(d, d)$ from $d$ tells us that if collusion in quantities is feasible at $\mathbf{d}^*$, it is also feasible at $\mathbf{d}^M$. For the optimal deviation punishment is to play $(d^*, q(d^*))$, leading to payoff $\pi^*(d^*)$, so the cutoff is $\delta(d^*, d^*) = \delta(d^M, d^M)$. But then the cartel might as well play $(d^M, q(d^M))$ since that generates a higher payoff.