ISSN 2282-6483

Alma Mater Studiorum - Università di Bologna
DEPARTMENT OF ECONOMICS

Collusive Vertical Relations

Stefano Bolatto
Luca Lambertini

Quaderni - Working Paper DSE N°1103

Collusive Vertical Relations

Stefano Bolatto and Luca Lambertini
Department of Economics, University of Bologna
Strada Maggiore 45, 40125 Bologna, Italy
stefano.bolatto@unibo.it; luca.lambertini@unibo.it

Abstract

We investigate the possibility for two vertically related firms to at least partially collude on the wholesale price over an infinite horizon to mitigate or eliminate the effects of double marginalisation, thereby avoiding contracts which might not be enforceable. We characterise alternative scenarios envisaging different deviations by the upstream firm and different punishments. This allows us to show that the most efficient case is that in which the upstream firm deviates along its best reply function and the punishment prescribes the disruption of the vertical relation for good after a deviation from the collusive path.

JEL Codes: D43, L13, L42

Keywords: collusion, double marginalisation, supply chain, vertical integration

1 Introduction

Recent literature has drawn attention to the possibility for vertical integration to facilitate collusion, which was already envisaged in earlier contributions (for a comprehensive survey, see Riordan, 2008). This may happen both upstream (Nocke and White, 2007; Normann, 2009) and downstream (Piccolo and Miklós-Thal, 2012; Biancini and Ettinger, 2017).

We propose an alternative view, considering that vertically related firms might collude, at least to some extent, to reduce as much as possible the loss caused by double marginalisation. The traditional remedy consists in a contract based on a two-part tariff (TPT) made up by upstream marginal cost pricing and a fee extracting the whole surplus generated by monopoly pricing on the market place, possibly accompanied by a Nash bargaining solution ensuring positive profits to the downstream firm. This solution, however, relies on the enforceability of such contracts. This can be a delicate issue when vertical relations take place in different countries (or continents), with different legal systems. Here, we propose a different solution to the vertical externality, based on the theory of repeated games and therefore on firms' intertemporal incentives, rather than on written (but not necessarily enforceable) contracts.

To this aim, we construct a supergame over an infinite horizon, involving two firms fixing the wholesale price and the market price, respectively.[1] Collusion takes place on the wholesale price, whose level lies between the marginal production cost borne by the upstream firm and the noncoopera-

[1] Our approach is close in spirit to the debate considering collusion in principal-agent models (see Tirole, 1986; and Strausz, 1997, *inter alia*), where, however, there exists asymmetric information. The setup closest to ours is in Bonanno and Vickers (1988), where vertical separation is isomorphic to strategic delegation, as in Vickers (1985).

tive level corresponding to the Stackelberg solution of the supply chain game. The punishment consists either turning to the noncooperative outcome or interrupting the vertical relation forever. Deviation by the downstream firm takes place along its best reply (because it faces the final consumer), while the upstream firm may either deviate along its best reply or apply a two-part tariff transferring upstream the entire profits of the vertical channel.

By comparatively assessing the resulting scenarios, we find out that the most efficient structure of the supergame is that in which the upstream firm's deviation takes place along its reaction function and the punishment prescribes the abandonment of the vertical relation forever after an initial deviation from the collusive path. An interesting feature of this case is that, while collusion is defined as the attempt at tuning the wholesale price as close as possible to marginal cost, indeed the burden of stabilising collusion falls entirely on the downstream firm, as deviating along the best reply makes the upstream firm perpetually faithful to collusive pricing.

The remainder of the note is structured as follows. Section 2 describes the basic setup. The supergame and its main results are illustrated in section 3.

2 The benchmark model

In its simplest version, a supply chain consists of two firms, the upstream firm U, the manufacturer or producer of an input, and D, the downstream firm which is either a pure intermediary between U and market demand or a producer using the input supplied by U. The profit functions of the two firms are, respectively, $\pi_U = (w - c)q$ and $\pi_D = (p - w)q$, where c is the unit cost of firm U; w is the transfer price set by U when selling to D. Productive activity by D - if any - takes place at a constant marginal cost which is set to zero for simplicity; and p is the market price paid by the final consumer. We assume a linear demand function $q = a - p$, with $a > w$.

This setup defines the model commonly used in dominant textbooks (e.g., Tirole, 1988; Shy, 1995) to illustrate the inefficiency of vertical separation. This result is typically achieved by interpreting the equilibrium under vertical separation as a Stackelberg solution, with U leading and D following. By backward induction, D's profit-maximizing price is $p^* = (a + w)/2$, while U sets $w^S = (a + c)/2$. Hence, the Stackelberg outcome is characterized by a market price $p^* = (3a + c)/4$, with individual profits $\pi_U^S = (a - c)^2/8$ and $\pi_D^S = (a - c)^2/16$.

In turn, the equilibrium under vertical integration would entail *division* U setting $w = c$ and therefore $p^* = (a + c)/2$. This yields higher consumer surplus and overall profits $\pi_{VI} = (a - c)^2/4 > \pi_U^S + \pi_D^S$. Vertical integration is therefore desirable because it eliminates double marginalization and the resulting deadweight loss.

As is well known, this goal can be achieved on firm U's initiative, with no need to merge the two firms vertically. It suffices that U applies a TPT on its sales to firm D, with a lump sum fee as well as a per-unit charge. To reproduce the vertically integrated outcome, U may sell each unit at marginal cost c and charge a fee $f = \pi_{VI}$, leaving nothing to D. The existence of the supply chain then hinges on the outside option for D, that we assume to be zero (the same applies to firm U). Alternatively, a Nash bargaining solution should be included in the contract, which leads us to the issue of enforceability in court.

3 Infinitely repeated games

So far, we have considered a static version of this basic model of supply chain, in which U and D engage into Stackelberg competition only once and may resort to a TPT as a remedy to double marginalisation. We now turn to a version in which production occurs in many rounds, and every time a contract has to be signed for the transfer of the good from U to D. Hence, we assume that the vertical relation repeats forever, over time $t = 0, 1, 2, ..., \infty$.

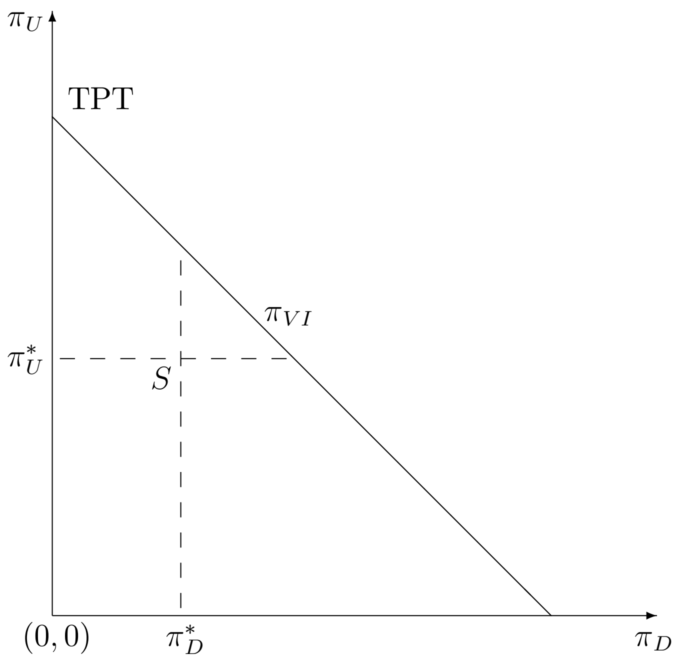
The potential gains generated by the supergame can appreciated by looking at Figure 1, portraying the profit frontier along which $\pi_D + \pi_U = \pi_{VI}$, and the outcome generated as a Stackelberg equilibrium, point S. Additionally, it is worth noting that the profit frontier starts at $(0, \pi_{VI})$, which is the point associated with the adoption of the TPT delivering full monopoly profits to U. Any move towards the monopoly frontier can be seen as the outcome of some degree of implicit collusion along the supply chain during the supergame, relying on either the Stackelberg outcome or the disruption of the vertical relation (point $(0, 0)$) as a threat to deter unilateral deviations.

Now consider that firm D will always choose p to solve its first order condition for profit maximization, and suppose implicit collusion aims at sustaining some $w^C = \varepsilon c + (1 - \varepsilon) w^S$, $\varepsilon \in [0, 1]$. If so, the two firms' individual profit functions are

$$\pi_U(\varepsilon) = \frac{(a-c)^2 (1-\varepsilon^2)}{8}; \pi_D(\varepsilon) = \frac{(a-c)^2 (1+\varepsilon)^2}{16} \tag{1}$$

and the overall profits attained by the supply chain are $\Pi^C(\varepsilon) = \pi_U(\varepsilon) + \pi_D(\varepsilon)$. Hence, ε measures the intensity of collusion, driving the supply chain to replicate the vertically integrated performance at $\varepsilon = 1$. Note that collusion here mitigates or eliminates double marginalisation and is therefore welfare improving, with no antitrust implications.

Figure 1 The profit frontier and the vertically separated outcome



The collusive payoff accruing to firm $i = D, U$ at any t is generated by a Nash bargaining solution:

$$\pi_i^C = \pi_i^S + \frac{\Pi^C(\varepsilon) - \pi_D^S - \pi_U^S}{2} \tag{2}$$

and the rules governing the supergame are:

1. at $t = 0$, firms U and D play w^C and $p^*\left(w^C\right)$, respectively;

2. at any $t \geq 1$, firms play $\left(w^C, p^*\left(w^C\right)\right)$ iff they played $\left(w^C, p^*\left(w^C\right)\right)$ at $t-1$; otherwise, if any deviation occurred at $t-1$, both firms play their respective punishment strategies.

The second part of rule 2, revealing that any deviation disrupts collusion forever, contains a prescription which can be specified in two different ways. The first instructs firms to revert to the Stackelberg outcome, with individual profits π_i^*; the second causes the vertical relation to break down forever, with zero profits. Collusion at ε is stable iff the time preferences of firm i, measured by the common discount factor $\delta \in (0,1)$, satisfy

$$\frac{\pi_i^C}{1-\delta} \geq \pi_i^d + \frac{\delta \pi_i^P}{1-\delta} \tag{3}$$

where π_i^P is the punishment payoff (either π_i^S or zero) and π_i^d is the deviation payoff. The design of individual deviations identifies three different scenarios. In the first,

$$\pi_D^d = \pi_D(\varepsilon) = \frac{(a-c)^2 (1+\varepsilon)^2}{16}; \pi_U^d = \Pi^C(\varepsilon) \tag{4}$$

In this case, D deviates by retaining $\pi_D(\varepsilon)$ for itself while U prices at w^C; and U deviates by using the TPT to appropriate the whole surplus generated by the vertical relationship. In the second scenario, the unilateral deviation profit by D is as in (4), while firm U deviates using w^S instead of w^C (i.e., U sets $\varepsilon = 0$), whereby $\pi_U^d = \pi_U^S = (a-c)^2/8$. The third scenario is that in which firm D keeps the whole profits for itself, with $\pi_D^d = \Pi^C(\varepsilon)$, while firm U may deviate by using either w^S or the TPT yielding, respectively, π_U^S and $\Pi^C(\varepsilon)$.

Having defined the rules of the supergame and the deviation and punishment profits, we may quickly go through the calculations related to the different versions of the stability condition (3).

3.1 Scenario I

In the first subcase, U adopts the TPT and any deviation destroys the vertical relation forever after. The two stability conditions are

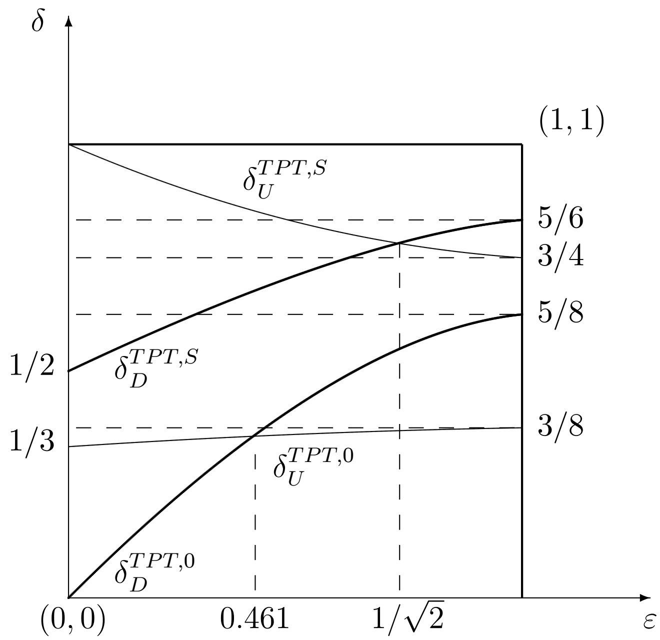
$$\begin{aligned}
&\frac{\pi_U^C}{1-\delta} \geq \Pi^C(\varepsilon) \Leftrightarrow \delta \geq \frac{2+\varepsilon(2-\varepsilon)}{2(1+\varepsilon)(3-\varepsilon)} \equiv \delta_U^{TPT,0} \\
&\frac{\pi_D^C}{1-\delta} \geq \pi_D(\varepsilon) \Leftrightarrow \delta \geq \frac{\varepsilon(2+3\varepsilon)}{2(1+\varepsilon)^2} \equiv \delta_D^{TPT,0}
\end{aligned} \tag{5}$$

In the second, any deviation drives firms back to the Stackelberg equilibrium of the constituent game, with

$$\begin{aligned}
&\frac{\pi_U^C}{1-\delta} \geq \Pi^C(\varepsilon) + \frac{\delta\pi_U^S}{1-\delta} \Leftrightarrow \delta \geq \frac{2(1+\varepsilon)-\varepsilon^2}{2[1+\varepsilon(2-\varepsilon)]} \equiv \delta_U^{TPT,S} \\
&\frac{\pi_D^C}{1-\delta} \geq \pi_D(\varepsilon) + \frac{\delta\pi_D^S}{1-\delta} \Leftrightarrow \delta \geq \frac{2+3\varepsilon}{2(2+\varepsilon)} \equiv \delta_D^{TPT,S}
\end{aligned} \tag{6}$$

In (5-6), TPT, 0 and S respectively indicate that the upstream firm's deviation takes the form of the traditional two-part tariff, and the punishment consists either in the interruption of the vertical relation forever, or in the perpetual replication of the noncooperative Stackelberg outcome.

Figure 2 The critical thresholds of discount factors for partial collusion in scenario I



The picture emerging from (5-6) is portrayed in Figure 2, where critical δ's are plotted against ε. Thick curves represent $\delta_D^{TPT,S} > \delta_D^{TPT,0}$, while thin ones draw $\delta_U^{TPT,S} > \delta_U^{TPT,0}$. A quick look at the graph reveals the obvious fact that adopting a harsher punishment facilitates collusion for any ε. We also see that

Lemma 1 *For any* $\varepsilon \in [0,1]$, *collusion along the supply chain is stable for all* $\delta \geq \underline{\delta}^J \equiv \max\left\{\delta_D^{TPT,J}, \delta_U^{TPT,J}\right\}$, $J = 0, S$.

In both cases, the initial portion of the upper envelope $\underline{\delta}^J$ determining the critical threshold of the discount factor corresponds to $\delta_U^{TPT,J}$. This happens because, for low levels of ε (or, collusion intensity), the incentive for firm U to appropriate all of the channel's profits is so strong to prevail upon the corresponding deviation incentive of firm D.

3.2 Scenario II

Here, all else equal, the deviation by firm U takes place along its best reply, so that $w = w^S$. This has a straightforward implication: since $\pi_U^d = \pi_U^S$, condition (4) always holds as a strict inequality for the upstream firm, for obvious reasons. Hence, the burden of sustaining collusion is entirely on the shoulders of firm D, whose critical thresholds coincide with $\delta_D^{TPT,S} > \delta_D^{TPT,0}$, depending on the nature of the punishment, as in scenario I. These facts imply

Lemma 2 *If firm U deviates along its best reply, then, for any $\varepsilon \in [0,1]$, collusion along the supply chain is stable provided that firm D's time preference satisfy $\delta \geq \delta_D^{TPT,J}$, $J = 0, S$, with $\delta_D^{TPT,J} \leq \underline{\delta}^J$.*

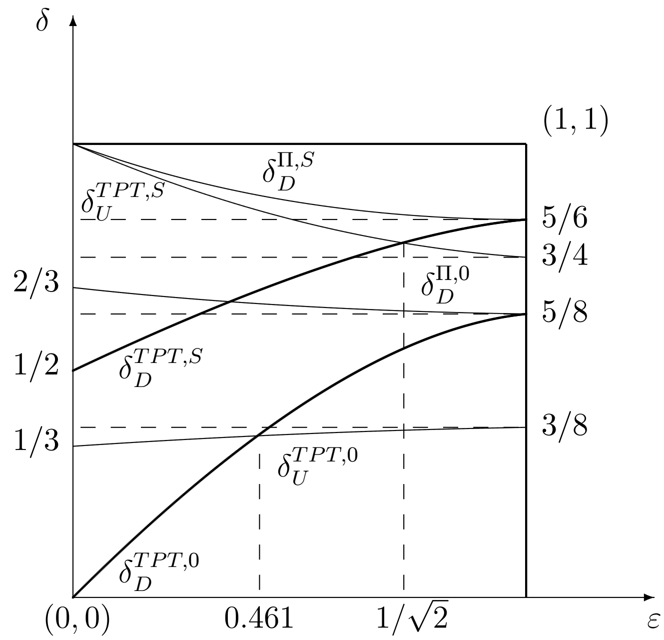
This result tells that, if U deviates along its reaction function, collusion is by construction stable from the standpoint of the same firm because deviation profits coincide with those generated by the noncooperative Stackelberg solution, and therefore the resulting threshold is at most equal to $\underline{\delta}^J$. The resulting graph would portray only the thick curves $\delta_D^{TPT,J}$ in Figure 2.

3.3 Scenario III

There remain to investigate the stability conditions for D when it does not transfer any profits to U, keeping $\pi_D^d = \Pi^C(\varepsilon)$ for itself. This exercise is summarised by

$$\begin{aligned} \frac{\pi_D^C}{1-\delta} \geq \Pi^C(\varepsilon) \Leftrightarrow \delta \geq \frac{4+\varepsilon(2-\varepsilon)}{2[3+\varepsilon(2-\varepsilon)]} \equiv \delta_D^{\Pi,0} \\ \frac{\pi_D^C}{1-\delta} \geq \Pi^C(\varepsilon) + \frac{\delta \pi_D^S}{1-\delta} \Leftrightarrow \delta \geq \frac{4+\varepsilon(2-\varepsilon)}{2[2+\varepsilon(2-\varepsilon)]} \equiv \delta_D^{\Pi,S} \end{aligned} \tag{7}$$

Figure 3 The critical thresholds of discount factors for partial collusion in scenarios I-III



The critical thresholds $\delta_D^{\Pi,J}$ appear in Figure 3, together with those pertaining to scenarios I-II. Both $\delta_D^{\Pi,J}$'s are decreasing and convex in ε, and their most relevant feature is captured by $\delta_D^{\Pi,J} \geq \delta_D^{TPT,J}$, $J = 0, S$. This reveals an intuitive result, which is a consequence of $\Pi^C(\varepsilon) > \pi_D(\varepsilon)$:

Lemma 3 *In terms of the resulting stability of collusion, from D's standpoint deviating to* $\pi_D(\varepsilon)$ *is weakly preferred to deviating to* $\Pi^C(\varepsilon)$ *for all* $\varepsilon \in [0,1]$, *given* $J = 0, S$.

We may now formulate our main result. Recalling $\delta_D^{TPT,S} > \delta_D^{TPT,0}$, Lemmata 1-3 jointly imply:

Proposition 4 *The most efficient design of the supergame contemplates U deviating along its reaction function and the punishment consisting in interrupting the vertical relation forever, in such a way that the only requirement to be met is* $\delta \geq \delta_D^{TPT,0}$, *i.e., the mildest one.*

In a nutshell, the above Proposition says that there exists an appropriate supergame structure delivering a single condition on the downstream firm's time preferences which, if met, ensures a reduction of the vertical externality generated by double marginalisation, or even its complete elimination (if $\delta \geq 5/8$ at $\varepsilon = 1$). Hence, the supergame is observationally equivalent to an implicit contract which, if the related stability condition holds, is altogether independent of legal aspects and therefore does not expose firms to the perspective of possible litigation in court.

References

[1] Biancini, S. and D. Ettinger (2017), "Vertical Integration and Downstream Collusion", *International Journal of Industrial Organization*, **53**, 99-113.

[2] Bonanno, G. and J. Vickers (1988), "Vertical Separation", *Journal of Industrial Economics*, **36**, 257-65.

[3] Nocke, V. and L. White (2007), "Do Vertical Mergers Facilitate upstream Collusion?", *American Economic Review*, **97**, 1321-39.

[4] Normann, H.-T. (2009), "Vertical Integration, Raising Rivals' Costs and upstream Collusion", *European Economic Review*, **53**, 461-80.

[5] Piccolo, S. and J. Miklós-Thal (2012), "Colluding through Suppliers", *RAND Journal of Economics*, **43**, 492-513.

[6] Riordan, M.H. (2008), "Competitive Effects of Vertical Integration", in P. Buccirossi (ed.), *Handbook of Antitrust Economics*, Cambridge, MA, MIT Press, 144-82.

[7] Shy, O. (1995), *Industrial Organization*, Cambridge, MA, MIT Press.

[8] Strausz, R. (1997), "Collusion and Renegotiation in a Principal-Supervisor-Agent Relationship", *Scandinavian Journal of Economics*, **99**, 497-518.

[9] Tirole, J. (1986), "Hierarchies and Bureaucracies: On the Role of Collusion in Organizations", *Journal of Law, Economics and Organization*, **2**, 181-214.

[10] Tirole, J. (1988), *The Theory of Industrial Organization*, Cambridge, MA, MIT Press.

[11] Vickers, J. (1985), "Delegation and the Theory of the Firm", *Economic Journal*, **95** (Conference Papers), 138-47.

Alma Mater Studiorum - Università di Bologna
DEPARTMENT OF ECONOMICS

Strada Maggiore 45
40125 Bologna - Italy
Tel. +39 051 2092604
Fax +39 051 2092664
http://www.dse.unibo.it