On the benefits of contractual inefficiency in quality-differentiated markets*

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July 30, 2013

Abstract

Contractual inefficiencies within supply chains increase an input price above its marginal cost, therefore they are considered detrimental to consumer surplus. We argue that such inefficiencies may be beneficial to consumers in quality-differentiated markets. Indeed, enhancing contractual efficiency in high-quality supply chains may adversely affect the market structure by driving low-quality vertical chains out of the market, and, consequently reduce consumer surplus. Due to the finiteness property, (counter-)integration in the low-quality channel does not allow this channel to be in business. Our result holds irrespective of whether the contractual inefficiencies originate from the double marginalization or the "commitment effect", and contribute to the recent debate (see DOJ&FTC, 2010) on the possible anticompetitive effects of reductions in product variety.

Keywords: Vertical product differentiation, vertical integration, linear tariff, two-part tariff, consumer surplus.

JEL classification: L13, L22, L4.

*A previous version of this paper circulated with the title "Vertical relations and number of channels in quality-differentiated markets".

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1 Introduction

In supply chains, any wedge between the marginal production cost of an input and its price reduces the contractual efficiency of the chain itself. This is believed to negatively affect the surplus of consumers. Conversely, tools that eliminate such inefficiency are considered positively. A case in point is the double marginalization arising with linear tariffs: vertical integration is a classical solution to eliminate this inefficiency and, unless it gives rise to foreclosure, is considered pro-competitive (Spengler, 1950).

In this paper we reassess the benefits arising from vertical integration (or the use of efficient contracts) in markets for quality-differentiated products where the *finiteness property* holds. One of its implications, which is central to our analysis, is that, when the degree of consumer heterogeneity is sufficiently low the highest-quality firm preempts the market.[1] Unlike the extant literature, we do not focus on the possibility for the newly integrated firms to foreclose their rivals.[2] Rather, we delve into the impact that boosting the *contractual efficiency* within the supply chains has on the competitive structure of the downstream market. Our main finding is that integration (or the adoption of efficient contracts) in supply channels producing high-quality goods may prevent low-quality channels from operating in that market, because of the harsher competition that efficiency gains from integration entail. This results in a trade-off. On the one hand, production of the high-quality good is more efficient; on the other, competition is milder. The first force pushes consumer surplus up, while the second has the opposite effect. We show that the second force may overtake the first, so that consumer surplus actually decreases after vertical integration. The crucial point of our analysis is that, because of the finiteness property, (counter-) integration in the low-quality channels (or efficient contracting) has no influence on their survival on the market. The "paradoxical" result of our paper is then that even though *all* firms have the same possibility to increase their contractual efficiency, this may be of *no use* for the low-quality firms, and may ultimately entail a *decrease* in consumer surplus.

To illustrate our point we consider a simple model of vertical product differentiation with two supply chains, each made up of an upstream and a downstream firm. Input exchange takes place only within a given supply chain, where each upstream firm sells exclusively to its downstream partner. The latter transforms the input into a consumption good and sells it to the final consumers. The upstream firms produce inputs of different, exogenously given qualities; and the final product's quality depends only on the quality of the input used.[3] We first present the market equilibrium when chains are not integrated, and then briefly look at integrated channels. In the case of non-integration, in order to explore the effects of contractual inefficiency, we assume that the upstream price in each supply chain is

[1] The finiteness property (Gabszewicz and Thisse, 1979; Shaked and Sutton, 1983) is one of the key findings in the analysis of vertically differentiated markets. This property dictates that, if unit variable costs do not increase too steeply with quality, the number of firms with a positive market share is finite and depends on the degree of consumer heterogeneity.

[2] For theoretical analyses around vertical mergers and foreclosure see e.g. Salinger (1988), Hart and Tirole (1990), Ordover *et al.* (1990), Salinger (1991), Church and Gandal (2000), and Chen (2001).

[3] See, e.g. Gabszewicz and Turrini (2000).

determined by secret *inefficient* (linear) contracts.[4] We thereafter identify the region in the parameter space where the market can support both the high- and the low-quality chains.[5] We show that the size of this region negatively depends on the degree of contractual efficiency within the high-quality supply channel, and is minimal when the high-quality channel is contractually efficient (upstream price equals upstream marginal production cost). The intuition for this result is that the more efficient the high-quality channel is, the more aggressive it is in setting the price. Such a competitive pressure may eventually drive the low-quality channel out of the market. This allows us to maintain that vertical integration within the high-quality chain may reduce to zero the market share of the low-quality product, hence reducing product variety and ultimately consumer surplus. The crucial hinge for our result is that (counter-)integration within the low-quality channel does not allow it to be in business, due to *the finiteness property.* The same outcome may be obtained when the firms within the high-quality chain, instead of integrating, sign secret efficient (two-part) contracts.[6]

The results of our paper firstly relate to the literature that analyzes vertical relationships and product differentiation (see e.g. Choi and Yi, 2000; Belleflamme and Toulemonde, 2003; Avenel and Caprice, 2006; Bonroy and Lemarié, 2012; Milliou and Apostolis, 2013). Several pieces of research have explored the effects of vertical integration on quality choice. Economides (1999) shows that independent vertically-related monopolists provide products of a lower quality than does an integrated monopolist. Furthermore, in an integrated monopoly, market coverage, consumer surplus and profits are higher than in the non-integrated case. Recently, Hernán-González and Kujal (2012) and Zenger (2009) produced findings pointing to the contrary, that is to say that vertical integration may lead to lower qualities. We focus, on the contrary, on the effect of vertical integration on the number of operating supply chains rather than on quality choice for a given number of supply chains. In this respect, our paper points out that consumers may be worse off even if vertical integration does not lead to variations in the products differentiation levels of the supplied commodities.[7] Related to our line of research, the recent paper by Reisinger and Schnitzer (2012) shows that, in an upstream and downstream entry game in the circular city, two-part tariffs may generate a lower consumer surplus than linear contracts, depending on the levels of upstream and downstream transport and entry costs.

Our findings have antitrust implications. Usually, policy concerns about vertical integration are associated with the fear of vertical foreclosure.[8] Our paper suggests that the efficiency gains from integration may adversely affect the market structure even in the absence of foreclosure, and that the balance of these two forces may harm consumers.[9] Conversely, vertical externalities may have

[4] In Section 4, we show that our results hold in the case of public inefficient (linear and *non*-linear) contracts.

[5] The market is *covered*, in the taxonomy of Wauthy (1996).

[6] This is a direct consequence of the *neutrality result* (Katz, 1991).

[7] Battigalli *et al.* (2007) show that an increase in buyer power (corresponding, in our paper, to a more integrated channel) may dampen welfare because it lowers the quality supplied to the market. In a Hotelling-type location model, Matsuhima (2009) shows that vertical integration may lead to maximal product differentiation and to higher downstream prices, which causes consumers to be worse off.

[8] See, e.g. OECD (2007).

[9] From this standpoint our paper relates to Avenel (2008), who shows that foreclosure is not necessary to raise antitrust

positive effects on consumer surplus, because they foster competition by allowing the low-quality firms to be in business. Thus, even without foreclosure, the evaluation of a vertical merger may involve the navigation a trade-off between efficiency and market power, as in the case of the evaluation of horizontal mergers (see e.g. Williamson, 1968; Nocke and Whinston, 2010). Our results confirm, from a "vertical" standpoint, the concerns the U.S. Department of Justice and the Federal Trade Commission (DOJ&FTC, 2010) have recently expressed about the possible anti-competitive effects of a reduction in the product variety following a horizontal merger.

The paper is organized as follows. Section 2 presents our basic model and characterizes its equilibrium. Section 3 analyzes the effects of vertical integration. Section 4 checks the robustness of our main results to some extensions of the model. Finally, Section 5 concludes.

2 The model

2.1 Demand side

We first briefly outline the demand side of the model.[10] Assume that two products of different quality, labeled 1 and 2, are available for consumption. Let s_i, $i = 1, 2$ denote the quality of the good, and let $s_2 > s_1 > 0$, so that good 2 is of a higher quality than good 1. Following Mussa and Rosen (1978), a consumer enjoys an indirect utility $U(\theta) = \theta s_i - p_i$ if she buys a product of quality s_i sold at price p_i, and zero if she refrains from buying. Consumers differ in their quality appreciation θ, which is uniformly distributed with density $\frac{1}{\overline{\theta}-\underline{\theta}}$ over $\left[\underline{\theta}, \overline{\theta}\right]$, with $\underline{\theta} > 0$. Market demands are defined as follows:

$$D_1(p_1, p_2) = \frac{1}{\overline{\theta} - \underline{\theta}} \left(\frac{p_2 - p_1}{s_2 - s_1} - \frac{p_1}{s_1} \right), \quad D_2(p_1, p_2) = \frac{1}{\overline{\theta} - \underline{\theta}} \left(\overline{\theta} - \frac{p_2 - p_1}{s_2 - s_1} \right). \tag{1}$$

As in a standard vertical differentiation model, three market configurations may arise at the price (sub-)equilibrium, namely an uncovered, a covered and a preempted market. In the first case, some consumers purchase the good (either the high or the low-quality) but some others abstain from consumption, which requires $\frac{p_2-p_1}{s_2-s_1} > \frac{p_1}{s_1} > \underline{\theta}$. In the second all consumers purchase either the high- or the low-quality, requiring $\frac{p_2-p_1}{s_2-s_1} > \underline{\theta} \geq \frac{p_1}{s_1}$. Finally, in the third, all consumers purchase the high-quality only, which requires $\underline{\theta} \geq \frac{p_2-p_1}{s_2-s_1} > \frac{p_1}{s_1}$.

In what follows, in order to deal with the situation where the finiteness property is at work, we focus on the covered market configuration with an interior solution. In this case downstream prices are such that

$$\frac{p_2 - p_1}{s_2 - s_1} > \underline{\theta} > \frac{p_1}{s_1}, \tag{2}$$

concerns in case of vertical mergers.

[10] We build on the standard duopoly model of vertical product differentiation. The interested reader is referred to Wauthy (1996) for more details.

and, accordingly, demands are written as:

$$D_1(p_1,p_2)=\frac{1}{\overline{\theta}-\underline{\theta}}\left(\frac{p_2-p_1}{s_2-s_1}-\underline{\theta}\right),\quad D_2(p_1,p_2)=\frac{1}{\overline{\theta}-\underline{\theta}}\left(\overline{\theta}-\frac{p_2-p_1}{s_2-s_1}\right). \tag{3}$$

2.2 Supply side

Let two supply chains operate in the market described above. In each chain one upstream firm produces a quality-differentiated input at no cost and sells it to its exclusive downstream partner. The quality of the input s_i, $i=1,2$, fully determines the quality of the output. Downstream firms transform the input into the final good at no cost and sell it to final consumers.[11]

Assume that the firms within each chain are not integrated. Their interaction unravels around two stages. At stage 1, the upstream and downstream suppliers within each chain bargain over the upstream tariffs. We assume that the outcome of the bargaining is determined by the generalized Nash bargaining solution. We further assume that contracts are secret, and, following e.g. de Fontenay and Gans (2004), we assume that firms have passive beliefs, so that in each negotiation the outcome of the other negotiation is taken as given. At stage 2, downstream firms set the prices of their variants in the final market. We solve the game backwards to obtain perfect Bayesian equilibria.

To make our point, we focus on secret linear contracts for the input.[12] In general, these contracts are not efficient, because the upstream price exceeds the marginal production cost of the manufacturer. Let w_1 and w_2 denote the unit upstream price for the low- and high-quality input, respectively. Because production costs are normalized to zero, w_i is the marginal production cost borne by the downstream firm. The profits for the upstream and downstream firm in each channel are, respectively,

$$\Pi_i(p_i,p_j,w_i)=D_i(p_i,p_j)w_i,\quad \pi_i(p_i,p_j,w_i)=D_i(p_i,p_j)(p_i-w_i), \tag{4}$$

with $i,j\in\{1,2\}, i\neq j$. Standard computations yield the following best replies at the price stage

$$\hat{p}_1(p_2,w_1)=\frac{1}{2}[p_2+w_1-(s_2-s_1)\underline{\theta}],\quad \hat{p}_2(p_1,w_2)=\frac{1}{2}[p_1+w_2+(s_2-s_1)\overline{\theta}]. \tag{5}$$

According to the passive beliefs approach, we define (see, e.g., Pagnozzi and Piccolo, 2012)

$$\hat{\Pi}_i(p_j,w_i)\equiv\Pi_i(\hat{p}_i(p_j,w_i),p_j,w_i),\quad \hat{\pi}_i(p_j,w_i)\equiv\pi_i(\hat{p}_i(p_j,w_i),p_j,w_i). \tag{6}$$

Let us now tackle the upstream price (sub-)game. We use the generalized Nash bargaining solution to obtain the upstream prices $w_i, i\in\{1,2\}$.[13] We assume that if no agreement is reached, then

[11] Section 4.1 considers the case of positive, quality-dependent, marginal production costs.

[12] In Section 4.2, we show that our main results are robust to public (inefficient) linear and non-linear contracts.

[13] The Nash bargaining solution is a concise tool to drive a wedge between marginal production cost and the upstream price within the chain without making any specific assumption about distribution of bargaining power between upstream and downstream firms. Furthermore, the Nash bargaining solution enables one to consider some buyer power. See e.g.

downstream firms cannot produce any good and upstream firms may sell on a spot market at marginal cost. The outside option for all firms is therefore zero. Accordingly, the Nash products are written as follows:

$$B_1(w_1, p_2) = \hat{\pi}_1 (w_1, p_2)^{\mu} \hat{\Pi}_1 (w_1, p_2)^{1-\mu}, \tag{7}$$

$$B_2(w_2, p_1) = \hat{\pi}_2 (w_2, p_1)^{\nu} \hat{\Pi}_2 (w_2, p_1)^{1-\nu}. \tag{8}$$

where ν (res. μ) is the bargaining power of the high-quality (res. low-quality) downstream firm in the bargaining (sub-)game. Note that when $\nu = 1$ (res. $\mu = 1$) the Nash bargaining solution of (8) (res. (7)) coincides with the upstream price that would be set by the high-quality (res. low-quality) downstream firm if it were backwards integrated with the supplier. Symmetrically, when $\nu = 0$ (res. $\mu = 0$), the Nash bargaining solution of (8) (res. (7)) coincides with the upstream price that would be set by the high-quality (res. low-quality) upstream firm if it were endowed with full monopoly power over the high-quality (res. low-quality) downstream firm. We can therefore interpret ν (res. μ) as a measure of the efficiency in the contractual outcome within the high-quality (res. low-quality) chain. We state:

Lemma 1. *The upstream and downstream equilibrium prices are the following.*

$$w_1^* = \frac{2(1-\mu)(s_2 - s_1)[(3-\nu)\overline{\theta} - 4\underline{\theta}]}{7 + 3(\mu+\nu) - \mu\nu}, \quad w_2^* = \frac{2(1-\nu)(s_2 - s_1)[4\overline{\theta} - (3-\mu)\underline{\theta}]}{7 + 3(\mu+\nu) - \mu\nu}; \tag{9}$$

$$p_1^* = \frac{(3-\mu)(s_2 - s_1)\left[(3-\nu)\overline{\theta} - 4\underline{\theta}\right]}{7 + 3(\mu+\nu) - \mu\nu}, \quad p_2^* = \frac{(3-\nu)(s_2 - s_1)[4\overline{\theta} - (3-\mu)\underline{\theta}]}{7 + 3(\mu+\nu) - \mu\nu}. \tag{10}$$

Proof. See Appendix A. □

Note that the values of equilibrium upstream and downstream prices have been obtained under the assumption of a covered market with an interior solution. We shall, therefore, identify the parameter constellations for which (10) and (9) do indeed define such an equilibrium. By plugging (10) back into (2) and rearranging the terms we obtain that, at equilibrium, the market is covered with an interior solution for:

$$\frac{\overline{\theta}}{\underline{\theta}} \in \left]\frac{4}{3-\nu}, \Phi\right[\tag{11}$$

with $\Phi \equiv \frac{4s_2(3-\mu) - s_1[5-\mu(7-\nu)-3\nu]}{(s_2-s_1)(3-\mu)(3-\nu)} > \frac{4}{3-\nu}$, $\forall(\mu,\nu) \in [0,1]^2$ and $s_2 > s_1$.

It is easy to ascertain that for all

$$\frac{\overline{\theta}}{\underline{\theta}} \in \left]1, \frac{4}{3-\nu}\right] \tag{12}$$

only firm 2 enjoys a positive market share at equilibrium (the market is *preempted*) because of the

O'Brien and Shaffer (2005), and Chambolle and Villas-Boas (2008).

finiteness property. In the same way, a range of parameter values exits, where at equilibrium the market is uncovered or covered with a corner solution (see Appendix B).

We thus obtain a first result on the effect of vertical relationships under vertical product differentiation.

Proposition 1. *The number of products which have a positive market share at equilibrium depends on both the heterogeneity of consumers* $\left[\underline{\theta}, \overline{\theta}\right]$ *and the contractual efficiency in the high-quality supply channel* (ν)*. The higher the efficiency in that channel, the smaller the region where the low-quality product has a positive equilibrium demand.*

This has, as immediate consequence,

Corollary 1. *The number of products available for consumption does not depend on the contractual efficiency in the low-quality channel* (μ)*.*

As in a standard model of vertical differentiation, the number of products which have a positive market share at equilibrium depends on the heterogeneity of consumers $\left[\underline{\theta}, \overline{\theta}\right]$ (see Gabszewicz and Thisse, 1979; Shaked and Sutton, 1982). In addition, our analysis points out that the number of products surviving at equilibrium also depends on the *contractual efficiency* in the high-quality supply channel. The intuition for this result is as follows. A positive ν decreases the marginal production cost of the downstream firm, and thus the price charged to consumers. This worsens the position of the low-quality chain as now it faces a more efficient rival. As a consequence, the region where the market is preempted grows with ν.

Interestingly, Corollary 1 shows that the contractual efficiency (μ) in low-quality chain does not play any role in the survival of the low-quality product, which results from the fact that the boundaries of the region in (12) do not depend on μ. Figure 1 helps to understand this result. This diagram depicts w_1^* and p_1^*, given in Lemma 1, and the equilibrium demand for the low-quality product, D_1^*, as a function of $\overline{\theta}$, for given s_1, s_2, μ, ν and $\underline{\theta}$. As $\overline{\theta}$ decreases, so does the heterogeneity of consumers. This results in fiercer price competition and a shrinking demand for the low-quality product, which also reduces the gross profit to be shared within the low-quality chain, and, consequently, the upstream price w_1^*. This has an efficiency-boosting effect within this chain because it curtails double marginalization. Ultimately, when $\overline{\theta}$ equals (or is smaller than) $\frac{4\underline{\theta}}{3-\nu}$, the market becomes preempted, and the demand for the low-quality product disappears. Consequently, the gross profit of the chain is reduced to zero, which means that both the upstream and the downstream prices of the low-quality good are zero, for any given bargaining power distribution within the chain. In other words, when the distribution of consumer characteristics is such that the market is preempted, the low-quality chain is "constrained" to be contractually efficient irrespective of the bargaining power distribution within the chain.

For future reference, it is worth noting that, if the firms within each chain are integrated, the marginal production cost for each variant of the good is zero. In this case, standard computations

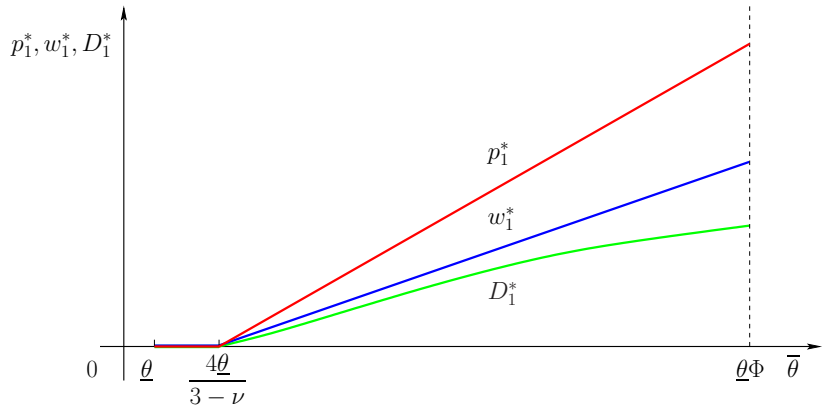

Figure 1: p_1^*, w_1^* and D_1^* as a function of $\overline{\theta}$.

yield the Nash equilibrium prices for the final goods. Given these prices, the equilibrium condition to have a covered market with interior solution is $\frac{\overline{\theta}}{\underline{\theta}} \in \left]2, \frac{2s_2+s_1}{s_2-s_1}\right[$, while the equilibrium condition to have a preempted market is $\frac{\overline{\theta}}{\underline{\theta}} \in]1, 2]$, see (Wauthy, 1996, p. 347-348). It is also easy to ascertain that when the contracts within each chain are efficient ($\mu = \nu = 1$), the former condition boils down to (11), and when the contract in the high-quality chain is efficient ($\nu = 1$), the latter condition coincides with (12).

3 Vertical integration, product variety and consumer surplus

Proposition 1 shows that the number of products available on the market depends on contractual efficiency of the high-quality chain (ν). Direct inspection reveals that the upper bound of condition (12) monotonically increases in ν and is equal to 2 for $\nu = 1$. As mentioned above, the case where $\nu = 1$ corresponds to the situation where the high-quality channel is integrated. Hence, vertical integration in the high-quality channel results in a null market share for the low-quality product for all

$$\frac{\overline{\theta}}{\underline{\theta}} \in \left]\frac{4}{3-\nu}, 2\right]. \tag{13}$$

This suggests that, while vertical integration is generally deemed good for consumers because it rules out double marginalization, it may also harm them by reducing the number of variants actually available on the market.

To investigate this point, we modify our model as follows. Assume that the downstream firms may enter the market by paying a positive and arbitrarily small cost $\varepsilon \to 0$. If a downstream firm enters the market, it enters an exclusive vertical relation with one upstream supplier. It may then decide whether

to integrate backwards with its upstream partner or not.[14] If integration occurs, the upstream price equals the marginal production cost; if not, Nash bargaining over linear tariffs takes place as in the preceding Section. Finally, downstream prices are set. If one firm does not enter, it receives a payoff equal to zero.[15] Let us focus on the case where $\frac{\overline{\theta}}{\underline{\theta}} \in \left]\frac{4}{3-\nu}, 2\right]$. As pointed out above, in this parameter region, vertical integration in the high-quality supply chain does not allow for a positive demand for the low-quality product. As a consequence, the low-quality downstream firm does not enter the market if it anticipates that the rival firms are willing to integrate.[16] In this case, the integrated high-quality firm is alone on the market, and the sub-game perfect Nash equilibrium coincides with the monopoly outcome given by:[17]

$$p_2^I = \underline{\theta} s_2 \text{ and } D_2(p_2^I) = 1. \tag{14}$$

It is worth stressing again that the contractual efficiency μ and, consequently, the decision whether to integrate or not within the low-quality supply chain has no influence on the survival of the low-quality variant. Accordingly, potential integration within the low-quality chain is not an effective strategic response to the integration of the high-quality channel, such as in Hart and Tirole (1990). We formalize these observations as follows.

Proposition 2. *For all* $\frac{\overline{\theta}}{\underline{\theta}} \in \left]\frac{4}{3-\nu}, 2\right]$ *i) the high-quality downstream firm always finds it profitable to integrate backwards; ii) integration in the high-quality chain reduces equilibrium product variety; and iii) (counter-)integration in the low-quality chain does not allow it to operate in the market.*

Proof. See Appendix C □

As pointed out in Section 2, when the preference space is such that the demand for the low-quality product is zero due to the finiteness property, the low-quality chain becomes *de facto* efficient; therefore integration cannot help this chain to operate in the market through a "further" increase in efficiency. The finiteness property "prevents" the low-quality channel from having effective counter-measures to the enhancement in the rival's efficiency. Therefore even if both chains are given the *same option* to integrate, and so to increase their contractual efficiency, yet this option has "no value" for the low-quality chain.

So far, we have shown that integration in the high-quality chain may have a structural impact, in the sense that, after integration, price competition may become too vigorous for the low-quality channel to earn non-negative profits. Furthermore, we have proven that, because of the finiteness property, the

[14] We rule out credit constraints here for the downstream firms.

[15] We assume that upstream firms are always present in the market. This is the case when an alternative spot market exists, where they can sell their input at marginal cost.

[16] Two remarks are worth making here. First, we model an entry game for the sake of intuition only. Alternatively we could obtain the same results by comparing two scenarios, one where firms are non-integrated and sign linear contracts, and another where firms may integrate. In this case ε may be thought of as an arbitrarily small production cost. Second, under both interpretations, the cost ε, is just a device to rule out "unreasonable" equilibria where the low-quality chain enters (or remains active) in the market even if it sets a price equal to zero, it serves no demand and earns zero profits.

[17] For $\frac{\overline{\theta}}{\underline{\theta}} \in]1, 2]$ the monopoly covers the entire market with the price $p_2^m = \underline{\theta}\ s_2$.

low-quality channel has no effective counter-move to remain in business. In the following, we argue that the consequences of integration may extend negatively from market structure to consumer surplus. In particular, we show that, although integration increases overall welfare, it may reduce consumer surplus, and, therefore, be considered anti-competitive both under US and EU antitrust law.[18] We state:

Proposition 3. *Let* $\frac{\overline{\theta}}{\underline{\theta}} \in \left]\frac{4}{3-\nu}, 2\right]$. *There exists a cutoff level* $\tilde{s}_1$ *for* s_1 *such that for all* $s_1 \in [\tilde{s}_1, s_2]$ *integration in the high-quality chain increases the joint profit in the chain, but is detrimental to consumers.*

Proof. See Appendix D. □

The intuition for the reduction in consumer surplus is as follows. When the high-quality supply chain is not integrated, two forces contribute to determining consumer surplus. The first one derives from the fact that upstream prices for the high-quality product are higher than marginal production costs, which causes the price of the high-quality variant to increase. By strategic complementarity, the price of the low-quality variant increases as well. This effect clearly harms consumers. The second force is due to the presence of two supply chains operating in the same market. This triggers competition, the extent of which inversely depends on the degree of product differentiation. A higher s_1, for given a s_2, makes variants more homogeneous, thus increasing competition.[19] This second effect benefits consumers. When the high-quality chain is integrated the competitive effect vanishes, because this chain is monopolist for any arbitrarily small entry cost. On the other hand, upstream prices equal marginal production costs, which results in a lower price because of increased contractual efficiency. When s_1 is "large enough", integration generates a large loss in consumer surplus due to competition disappearing, and this loss is not offset by the increase in contractual efficiency itself. This observation suggests that the anti-competitive effects of vertical integration in the high-quality supply chain are more likely to be observed in markets regulated through Minimum Quality Standards, where the quality range is compressed (Ronnen, 1991). Furthermore, it is worth noting that the reduction in consumer surplus is not related to a reduction in the mass of consumers that purchase one of the two variants. In fact, the total size of the demand for the differentiated good is one both with and without integration. Our result is in accordance with the intuition of Reisinger and Schnitzer (2012) that linear pricing generates a greater consumer surplus than integration (or efficient contracts) when competition in the downstream market is (potentially) harsh in an game where upstream and downstream firms enter in the circular city. Yet, our results are driven by the limited extent of quality differentiation of goods rather than the level of entry (or transport) costs.

[18] Integration increases total welfare because, although product variety is reduced, *all consumers* now purchase the high-quality good. Monopoly pricing then transfers most of the surplus to the firm thereby harming consumers.

[19] The level of competition also has a feedback effect on upstream prices, because harsher competition reduces the size of the chain's profits to be shared between upstream and downstream firms, see (10). This, in turn, entails lower upstream prices and, therefore, lower downstream prices as well.

Finally, it should be noted that the argument presented until now as far as vertical integration is concerned, remains valid for all the tools that increase efficiency within channels up to the integration level. One clear example is that of contracts based on a two-part tariff. Indeed, with secret contracts and passive beliefs, the well-known neutrality result (Katz, 1991) applies to our model and entails $w_2 = 0$ at equilibrium. Clearly, this would trigger the "exit" mechanism we have pointed out in the case of vertical integration.

4 Extensions

In this section we check the robustness of our analysis in three respects. First, we extend the model to include asymmetric and quality-dependant marginal production costs. Second, we explore the effects of public contracts.

4.1 Asymmetric production costs

One question that our above analysis may naturally raise concerns the extent to which the anti-competitive effect that we have pointed out hinges on the simplifying hypothesis that firms have symmetric (and zero) production costs. In this extension we check the robustness of our results against the introduction of asymmetric marginal production costs. By focusing on the covered market case, without loss of generality we can still let the low-quality chain have production cost. By contrast, a positive and constant marginal cost $c_2 > 0$ is borne –either by the upstream or by the downstream firm– within the high-quality supply chain. Note that c_2 is a technological variable, and cannot be influenced by the choice of whether to integrate or not. This modification does not qualitatively alter our results.

Indeed, for $c_2 < \underline{\theta}(s_2 - s_1)$, the region where integration in the high-quality chain leads to a zero equilibrium demand for the low-quality one is given by

$$\overline{\theta} \in \left] \frac{4\underline{\theta}}{3-\nu} - \frac{c_2(1+\nu)}{(3-\nu)(s_2-s_1)}, 2\underline{\theta} - \frac{c_2}{(s_2-s_1)} \right]. \tag{15}$$

This region is decreasing in c_2.

For $c_2 \geq \underline{\theta}(s_2 - s_1)$, the region defined in (15) disappears and is replaced by one where integration in the low-quality chain may drive the high-quality one out of the market , given by:

$$\overline{\theta} \in \left] \frac{(3-\mu)\underline{\theta}}{4} + \frac{c_2(1+\mu)}{4\,(s_2-s_1)}, \frac{1}{2}\left(\underline{\theta} + \frac{c_2}{(s_2-s_1)}\right) \right]. \tag{16}$$

It is possible to check that this region is increasing in c_2 for all $\mu < 1$.

This suggests that integration in chains operating in vertically differentiated markets hurts the firm

that is the least technologically efficient in respect of the quality of the good it produces.

Finally, an entry game similar to that described in Section 3 may be set-up. Using such a game, it can be shown that integration is profitable for the downstream firm that is the most technologically efficient in respect to the quality produced, and that integration may harm consumers.[20] As in the base model without production costs, integration within the less technologically efficient channel has no effect on its survival in the market.

4.2 Public contracts

In the preceding sections we have presented the mechanics of our example by comparing the market outcomes in the case of secret contracts. In particular, we have contrasted the case of inefficient linear contracts with that of vertical integration.[21] One may legitimately wonder whether our results extend to the case of public, non-renegotiable contracts. In the following, we consider the zero-production cost model again and show that our results remain qualitatively unchanged if we consider both linear and non-linear public contracts.

4.2.1 Public linear contracts

The model is the same as that of Section 2, except for the fact that all the upstream and downstream profits at the bargaining stage of the game now depend on both w_1 and w_2. The analysis too unfolds as in the case of secret linear contracts. In particular, the region where integration in the high-quality chain leads to a zero equilibrium demand for the low-quality one is

$$\frac{\overline{\theta}}{\underline{\theta}} \in \left] \frac{(5-\nu)}{2(2-\nu)}, 2 \right]. \tag{17}$$

As before, the size of the region where both chains can survive at equilibrium depends on the degree of contractual inefficiency in the high-quality channel (ν). The equivalent of Propositions 2 and 3 may furthermore be demonstrated in this case. In particular there exists a cutoff value for s_1 such that for all s_1 between the threshold and s_2 integration in the high-quality chain (i) increases the joint profit in the chain and (ii) reduces consumer surplus.[22]

4.2.2 Public non-linear contracts

Consider, now, that the firms within each channel bargain over a *publicly observable two-part tariff* $(F_i, w_i), i \in \{1, 2\}$. The contracts are assumed to be non-renegotiable. Here, we again focus on the

[20] The complexity of the equilibrium values does not allow for an analytical appraisal of the effects of integration on consumer surplus. Yet, numerical examples confirm that, in this region, if qualities are "close", integration reduces consumer surplus. Calculations are available upon request.

[21] As noted above, in our framework the outcome of integration coincides with that of non-linear contracts.

[22] All proof is available upon request.

covered market with interior solution configuration.[23] Calculations are used to prove that, at the unique subgame-perfect Nash equilibrium of the game with public non-linear contracts, the upstream and downstream prices and the fixed part of the tariffs are as follows:[24]

$$w_1^{tpt} = \frac{(s_2 - s_1)\left(2\overline{\theta} - 3\underline{\theta}\right)}{5}, \qquad w_2^{tpt} = \frac{(s_2 - s_1)\left(3\overline{\theta} - 2\underline{\theta}\right)}{5}; \tag{18}$$

$$F_1^{tpt} = \frac{(1-2\mu)(s_2 - s_1)(2\overline{\theta} - 3\underline{\theta})^2}{25(\overline{\theta} - \underline{\theta})}, \qquad F_2^{tpt} = \frac{(1-2\nu)(s_2 - s_1)(3\overline{\theta} - 2\underline{\theta})^2}{25(\overline{\theta} - \underline{\theta})}; \tag{19}$$

$$p_1^{tpt} = \frac{2(s_2 - s_1)\left(2\overline{\theta} - 3\underline{\theta}\right)}{5}, \qquad p_2^{tpt} = \frac{2(s_2 - s_1)\left(3\overline{\theta} - 2\underline{\theta}\right)}{5}. \tag{20}$$

The firms in each chain agree on an upstream unit-price w_i that is greater than the upstream marginal production cost, in order to relax downstream price competition. This is due to the well-known *commitment effect* generated by public, non-renegotiable contracts (see e.g. Caillaud and Rey, 1995). Note that, conversely to the values reported in Lemma 1, equilibrium prices here do not depend to the bargaining powers μ and ν. To understand this outcome, recall that setting the two-part tariff through the Nash bargaining solution involves first choosing the w_i that maximizes the joint profit $\pi_i(w_i, w_j, F_i) + \Pi_i(w_i, w_j, F_i), i, j \in \{1, 2\}, i \neq j$, and, second, apportioning the total profit according to the sharing rule dictated by the bargaining weights. Clearly, the joint-profit maximization does not depend on the bargaining power distribution within chains.[25]Accordingly, the downstream equilibrium prices and hence the demands do not depend on μ and ν. The region where vertical integration in the high-quality chain leads to a zero equilibrium demand for the low-quality one is then given by

$$\frac{\overline{\theta}}{\underline{\theta}} \in \left]\frac{3}{2}, 2\right]. \tag{21}$$

For all $\frac{\overline{\theta}}{\underline{\theta}} \in]3/2, 2]$, integration in the high quality chain drives the low-quality chain out of the market. As in the secret contract case, because of the finiteness property, integration of the low-quality supply chain does not allow the chain itself to endure the more vigorous competition of its integrated rival. As above, a cutoff level $\tilde{s}_1^{tpt}$ exists, such that for all $s_1 \in [\tilde{s}_1^{tpt}, s_2]$ integration in the high-quality chain increases the chain's joint profit, but is detrimental for consumers, see Appendix E *ii*).

The message drawn from the case of secret linear contracts, namely that it is the contractual inefficiency in the high-quality channel that allows the operations of the low-quality one, is confirmed by the analysis of public non-linear contracts. It is noteworthy, however, that in the secret linear contract case, contractual inefficiency stems from double marginalization, whereas with public two-

[23]For the comprehensive subgame-perfect Nash equilibrium partition see Appendix E *i*).

[24]The structures of the proofs is identical to those provided in the paper, the details of the calculations are available from the authors.

[25]Joint profit maximization, in this case, does not correspond to the case of integration within chains ($\nu = 1$ or $\mu = 1$). Indeed, if chains are integrated the upstream price w_i is by definition equal to marginal cost. Hence the commitment effect cannot play a role.

part contracts, it emerges from the chains' endeavor to soften price competition.

5 Conclusion

This paper delves into the effects of enhancing the contractual efficiency within supply chains that operate in vertically differentiated markets characterized by the finiteness property. We have shown that, in this framework, integration, the use of efficient contracts–which are usually deemed as positive because they curtail inefficiencies– may turn out to be detrimental for consumer surplus. In fact, the boost in contractual efficiency within the channels may trigger the finiteness property and, therefore, have a structural impact on the market. In particular, competition in the final market may become too vigorous for the low-quality chain to remain in business. We have argued that the reduction in competition due to the structural impact of integration may overtake the positive effect of lower marginal production costs of the high-quality chain. If this is the case, consumer surplus is reduced after integration or the adoption of efficient contracts. Furthermore, and again because of the finiteness property, (counter-)integration, or the adoption of efficient contracts in the low-quality chain, is ineffective to keep this channel in operation.

Our paper also contributes to the antitrust policy debate about the pros and cons of vertical integration, which is usually framed in the comparison between gains in efficiency and damages from foreclosure. Indeed, our analysis suggests that the effects of the elimination of contractual inefficiencies within supply chains should be carefully assessed in vertically differentiated markets. Finally, our exercise suggests that a certain degree of contractual inefficiency –which may be due either to double marginalization or to the strategic effect of commitment– may actually benefit the final consumers, because, although raising marginal production costs, it spurs competition.

Acknowledgements

The authors wish to thank E. Avenel, G. Calzolari, C. Constantatos, J. Gabszewicz, A. Mantovani, C. Millou, M. Motta, M. Pagnozzi, S. Piccolo, M. Reisinger, E. Tarantino, X. Wauthy and the audiences at the conferences EARIE 2012 Rome, INRA-IDEI 2012 Toulouse, "Product differentiation and innovation on related markets", Grenoble 2013 for useful comments and suggestions. The usual disclaimer applies.

Appendices

A Proof of Lemma 1

Consider first the maximization of (8). The solution to the first-order conditions $\frac{\partial \log[(B_2(p_1,w_2)]}{\partial w_2} = 0$ is

$$w_2(p_1) = \frac{(1-\nu)}{2}\left[p_1 + (s_2 - s_1)\overline{\theta}\right]. \tag{22}$$

By solving the system defined by the best replies at the price stage (5), we get

$$p_1(w_1,w_2) = \frac{1}{3}[w_2 + 2w_1 + (s_2 - s_1)(\overline{\theta} - 2\underline{\theta})], \quad p_2(w_1,w_2) = \frac{1}{3}[2w_2 + w_1 + (s_2 - s_1)(2\overline{\theta} - \underline{\theta})]. \tag{23}$$

By plugging (23) into (22), we obtain

$$w_2(w_1,w_2) = \frac{1-\nu}{6}\left[w_2 + 2w_1 + 2(s_2 - s_1)(2\overline{\theta} - \underline{\theta})\right], \tag{24}$$

and, by solving for w_2, we get

$$w_2(w_1) = \frac{2(1-\nu)[w_1 + (s_2 - s_1)(2\overline{\theta} - \underline{\theta})]}{5+\nu}. \tag{25}$$

We apply the same procedure to (7) and get

$$w_1(w_2) = \frac{2(1-\mu)[w_2 + (s_2 - s_1)(\overline{\theta} - 2\underline{\theta})]}{5+\mu}. \tag{26}$$

From (25) and (26), w_1^* and w_2^* may be obtained. Finally, substitution of the optimal upstream prices into (23) returns the equilibrium downstream prices. To guarantee existence of a maximum and its uniqueness, there remains to check the concavity of the objective functions at the two stages. The second-order conditions at the price stage are globally satisfied for all $s_2 > s_1$ and $\overline{\theta} > \underline{\theta}$, which hold by assumption. The second-order conditions for the maximization of (7) and (8) are satisfied locally, namely $\left.\frac{\partial^2 B_i(\cdot)}{\partial w_i^2}\right|_{\substack{p_j = p_j^* \\ w_i = w_i^*}} < 0$, $i, j = 1, 2, i \neq j$, for all $(\mu, \nu) \in [0,1[^2$. This, together with the uniqueness of the solutions to the first-order conditions for upstream and downstream prices, completes the proof.

B SPNE equilibrium partition

The Bayesian-perfect Nash equilibrium partition is as follows.

1. For $\frac{\overline{\theta}}{\underline{\theta}} \in \left]\frac{16s_2 - s_1(3-\mu)(3-\nu)}{(s_2-s_1)(3-\mu)(3-\nu)}, \infty\right[$ the market is uncovered.

2. For $\frac{\overline{\theta}}{\underline{\theta}} \in \left[\frac{4s_2(3-\mu)-s_1[5-\mu(7-\nu)-3\nu]}{(s_2-s_1)(3-\mu)(3-\nu)}, \frac{16s_2-s_1(3-\mu)(3-\nu)}{(s_2-s_1)(3-\mu)(3-\nu)}\right]$ the market is covered with a corner solution.

3. For $\frac{\overline{\theta}}{\underline{\theta}} \in \left]\frac{4}{3-\nu}, \frac{4s_2(3-\mu)-s_1[5-\mu(7-\nu)-3\nu]}{(s_2-s_1)(3-\mu)(3-\nu)}\right[$ the market is covered with an interior solution.

4. For $\frac{\overline{\theta}}{\underline{\theta}} \in \left]1, \frac{4}{3-\nu}\right]$ only the high-quality product has a positive demand.

C Proof of Proposition 2

i) Let $\pi_2(p_1^*, p_2^*, w_2^*) = \frac{(s_2-s_1)(1+\nu)^2[4\overline{\theta}-(3-\mu)\underline{\theta}]^2}{(\overline{\theta}-\underline{\theta})(7+3(\mu+\nu)-\mu\nu)^2} \equiv \pi_2^*$ be the high-quality downstream firm's equilibrium profits in the case of non-integration and linear secret contracts. Similarly, let $\pi_2^I \equiv s_2\underline{\theta}$ be the high-quality chain's equilibrium profits in case of integration. It is a matter of easy calculations to show that for all $\frac{\overline{\theta}}{\underline{\theta}} \in \left[\frac{4}{3-\nu}, 2\right]$ we have $\pi_2^* < \pi_2^I$. ii) and iii) follow from Corollary 1.

D Proof of Proposition 3

Let $SC^* \equiv \frac{1}{(\overline{\theta}-\underline{\theta})}\left[\int_{\underline{\theta}}^{\theta_{12}^*}(\theta s_1 - p_1^*)\mathrm{d}\theta + \int_{\theta_{12}^*}^{\overline{\theta}}(\theta s_2 - p_2^*)\mathrm{d}\theta\right]$ be the consumer surplus in the non-integrated environment, where $\theta_{12}^* \equiv \frac{p_2^*-p_1^*}{s_2-s_1}$ is the equilibrium marginal consumer, and let $SC^I \equiv \frac{1}{(\overline{\theta}-\underline{\theta})}\left[\int_{\underline{\theta}}^{\overline{\theta}}(\theta s_2 - p_2^I)\mathrm{d}\theta\right]$ be the consumers' surplus in the integrated environment. Direct comparison reveals that $SC^* > SC^I$ for $s_1 \in [\overline{s}_1, s_2]$; with

$$\overline{s}_1 \equiv \frac{s_2(-\alpha\overline{\theta}+4\underline{\theta})\left[\overline{\theta}(\Phi+53+25\nu)+4\underline{\theta}(\mu(\mu+2\nu-4)-6\nu-13)\right]}{-\alpha\overline{\theta}^2(\Phi+25\nu+53)+2\overline{\theta}\underline{\theta}\alpha\beta(15+7\mu+7\nu-\mu\nu)+2\underline{\theta}^2[17\mu^2+\beta^2\nu^2+2\beta\nu(3\mu-1)+10\mu-55]},$$

where $\alpha \equiv 3-\nu, \beta \equiv 3-\mu$ and $\Phi \equiv \mu(6-\mu)(3-\nu)$.

There remains to prove that the restriction $s_1 > \overline{s}_1$ is compatible with condition (11). By using the definition of Φ, the condition on the upper bound of (11) may be rearranged as $s_1 > \overline{\overline{s}}_1 \equiv \frac{s_2(3-\mu)\left[\overline{\theta}(3-\nu)-4\underline{\theta}\right]}{\overline{\theta}(3-\mu)(3-\nu)-\underline{\theta}(5-3\nu-7\mu+\mu\nu)}$. It is a matter of algebra to prove that $\overline{s}_1 > \overline{\overline{s}}_1$ for all $\frac{\overline{\theta}}{\underline{\theta}} > \frac{4}{3-\nu}$. Finally, it may be easily ascertained that the condition $\Phi > 2$ (which guarantees that the set $\left]\frac{4}{3-\nu}, 2\right]$ given by (13) is included in the set $\left]\frac{4}{3-\nu}, \Phi\right[$ given by (11)) may be rearranged as $s_1 > \frac{2s_2(3-\mu)(1-\nu)}{13+\mu-3\nu+\mu\nu} \equiv \dot{s}_1$. The comparison between $\overline{s}_1$ and $\dot{s}_1$ depends on the parameter values. Thus, we may conclude that for all $\frac{\overline{\theta}}{\underline{\theta}} \in \left]\frac{(5-\nu)}{2(2-\nu)}, 2\right]$, $SC^* > SC^i$ for $s_1 \in [\tilde{s}_1, s_2]$ with $\tilde{s}_1 \equiv \max[\overline{s}_1, \dot{s}_1]$.

At last, it may be easily shown that, for both $\frac{\overline{\theta}}{\underline{\theta}} \in \left]\frac{4}{3-\nu}, 2\right]$ and $s_1 \in [\tilde{s}_1, s_2]$, the inequality $\pi_2^I > \pi_2^* + \Pi_2^* = \frac{(s_2-s_1)[4\overline{\theta}-(3-\mu)\underline{\theta}]^2(3-\nu)(1+\nu)}{(\overline{\theta}-\underline{\theta})(7+3\mu+3\nu-\mu\nu)^2}$ always holds.[26] Which implies that integration in the high-quality chain increases the profits of the whole chain.

[26] With $\Pi_2^* \equiv \Pi_2(p_1^*, p_2^*, w_2^*)$.

A numerical example may be useful to understand the previous conditions. Assume that, $\mu = \nu = 1/2$, condition (11) becomes $\frac{\overline{\theta}}{\underline{\theta}} \in \left]\frac{8}{5}, \frac{40s_2 - s_1}{25(s_2 - s_1)}\right[$, and its upper bound is larger than 2 for $s_1 > \frac{10}{49}s_2$. In this case $\overline{s}_1 = \frac{s_2(193\ \overline{\theta} - 184\ \underline{\theta})(5\overline{\theta} - 8\underline{\theta})}{965\ \overline{\theta}^2 - 1450\ \overline{\theta}\underline{\theta} + 458\ \underline{\theta}^2}$. Therefore for all $\frac{\overline{\theta}}{\underline{\theta}} \in \left]\frac{8}{5}, 2\right[$, integration in the high-quality chain reduces the consumer surplus for $s_1 \in [\widetilde{s}_1, s_2]$ with $\widetilde{s}_1 \equiv \max\left[\frac{s_2(193\ \overline{\theta} - 184\ \underline{\theta})(5\overline{\theta} - 8\underline{\theta})}{965\ \overline{\theta}^2 - 1450\ \overline{\theta}\underline{\theta} + 458\ \underline{\theta}^2}, \frac{10}{49}s_2\right]$.

E Proof of Section 4.2.2

i) The subgame-perfect Nash equilibrium partition is as follows. For $\frac{\overline{\theta}}{\underline{\theta}} \in \left]\frac{16s_2^2 - 12s_2s_1 + s_1^2}{4s_2(s_2 - s_1)}, \infty\right[$ the market is uncovered. For $\frac{\overline{\theta}}{\underline{\theta}} \in \left[\frac{6s_2 - s_1}{4(s_2 - s_1)}, \frac{16s_2^2 - 12s_2s_1 + s_1^2}{4s_2(s_2 - s_1)}\right]$ the market is covered with a corner solution. For $\frac{\overline{\theta}}{\underline{\theta}} \in \left]\frac{3}{2}, \frac{6s_2 - s_1}{4(s_2 - s_1)}\right[$ the market is covered with an interior solution. For $\frac{\overline{\theta}}{\underline{\theta}} \in]1, 3/2]$ only the high-quality product has a positive demand.

ii) Let $SC^{tpt} \equiv \frac{1}{(\overline{\theta} - \underline{\theta})}\left[\int_{\underline{\theta}}^{\theta_{12}^{tpt}} (\theta s_1 - p_1^{tpt})\mathrm{d}\theta + \int_{\theta_{12}^{tpt}}^{\overline{\theta}} (\theta s_2 - p_2^{tpt})\mathrm{d}\theta\right]$ be the consumer surplus in the non-integrated environment, where $\theta_{12}^{tpt} \equiv \frac{p_2^{tpt} - p_1^{tpt}}{s_2 - s_1}$ is the equilibrium marginal consumer, and let $SC^I \equiv \frac{1}{(\overline{\theta} - \underline{\theta})}\left[\int_{\underline{\theta}}^{\overline{\theta}} (\theta s_2 - p_2^I)\mathrm{d}\theta\right]$ be the consumers' surplus in the integrated environment. Direct comparison reveals that $SC^{tpt} > SC^I$ for $s_1 \in [\overline{s}_1^{tpt}, s_2]$; with $\overline{s}_1^{tpt} \equiv \frac{s_2(28\ \overline{\theta} - 27\ \underline{\theta})(2\overline{\theta} - 3\underline{\theta})}{56\ \overline{\theta}^2 - 88\ \overline{\theta}\underline{\theta} + 31\ \underline{\theta}^2}$.

It remains to prove that the restriction $s_1 > \overline{s}_1^{tpt}$ is compatible with upper bound of the covered market condition rearranged as $s_1 > \overline{\overline{s}}_1^{tpt} \equiv \frac{s_2(4\overline{\theta} - 6\underline{\theta})}{4\overline{\theta} - \underline{\theta}}$. It is a matter of algebra to prove that $\overline{s}_1^{tpt} > \overline{\overline{s}}_1^{tpt}$ for all $\frac{\overline{\theta}}{\underline{\theta}} > \frac{3}{2}$. Finally, it may be easily ascertained that the condition $\frac{6s_2 - s_1}{4(s_2 - s_1)} > 2$ (which guarantees that the set $]3/2, 2]$ given by (21) is included in the set $\left]\frac{3}{2}, \frac{6s_2 - s_1}{4(s_2 - s_1)}\right[$) may be rearranged as $s_1 > \frac{2s_2}{7} \equiv \dot{s}_1^{tpt}$. The comparison between $\overline{s}_1^{tpt}$ and $\dot{s}_1^{tpt}$ depends on the parameter values. Thus, we may conclude that for all $\frac{\overline{\theta}}{\underline{\theta}} \in \left]\frac{3}{2}, 2\right]$, $SC^{tpt} > SC^i$ for $s_1 \in [\tilde{s}_1^{tpt}, s_2]$ with $\tilde{s}_1^{tpt} \equiv \max\left[\overline{s}_1^{tpt}, \dot{s}_1^{tpt}\right]$.

At last, it may be easily shown that, for both $\frac{\overline{\theta}}{\underline{\theta}} \in \left]\frac{3}{2}, 2\right]$ and $s_1 \in [\tilde{s}_1^{tpt}, s_2]$, the inequality $\pi_2^I > \pi_2^{tpt} + \Pi_2^{tpt} = \frac{2(s_2 - s_1)(3\overline{\theta} - 2\underline{\theta})^2}{25(\overline{\theta} - \underline{\theta})}$ always holds, which implies that integration in the high-quality chain increases the profits of the whole chain.

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