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Vertical Integration under an Optimal Tax Policy: a Consumer Surplus Detrimental Result

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Summary

It is widely believed that vertical integration in an environment without foreclosure, or more generally without any mechanism that restricts competition among firms, raises the welfare of consumers. In this paper we show that this can be overturned in a standard setting. We consider a vertical structure where each downstream firm purchases an input from its exclusive upstream supplier in the presence of a welfare maximizing government which taxes/subsidizes the product of the downstream market. We show that a single or multiple vertical integrations alter the optimal governmental policy in a way that hurts consumers: integration induces the government to reduce the optimal subsidy and, as a result, industry output and consumer welfare decline.

Keywords: Vertical Market, Integration, Tax Policy, Consumer Surplus

JEL Classification: L13, L42

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Vertical integration under an optimal tax policy: a consumer surplus detrimental result

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August 28, 2019

Abstract

It is widely believed that vertical integration in an environment without foreclosure, or more generally without any mechanism that restricts competition among firms, raises the welfare of consumers. In this paper we show that this can be overturned in a standard setting. We consider a vertical structure where each downstream firm purchases an input from its exclusive upstream supplier in the presence of a welfare maximizing government which taxes/subsidizes the product of the downstream market. We show that a single or multiple vertical integrations alter the optimal governmental policy in a way that hurts consumers: integration induces the government to reduce the optimal subsidy and, as a result, industry output and consumer welfare decline.

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1 Introduction

> *Vertical integration that fails to increase market power by eliminating competitors or raising entry barriers is unlikely to have adverse consequences for consumers.*

The above quote by Riordan (2008) seems to be well accepted in industrial economics. By reducing double marginalization in the absence of any factors that reduce market competition, integration has an unequivocal positive effect for consumers in the form of higher output at lower prices. In this paper we provide a natural framework where the above claim does not hold, namely it aims to show that vertical integration can actually *hurt* consumers in a context without foreclosure, secret contracts or any other mechanism that eliminates competition in the market. We consider a structure consisting of a downstream and an upstream market. Each downstream firm deals exclusively with its upstream supplier for the provision of an input. In exchange, the downstream firm pays a linear price (per unit of input). Input prices are publicly observed. This structure is subject to a standard government policy: the government taxes/subsidizes the final product market by choosing the tax/subsidy rate that maximizes total welfare. We show that a vertical integration by a downstream firm and its upstream supplier (or even multiple integrations by many pairs of such firms) leads surprisingly to a deterioration of market output and consumer surplus.

To describe the mechanism that drives our result, let's first see the impact of vertical integration absent any government policy. Given our foreclosure-free environment, integration simply reduces the double marginalization problem, leading to higher total output and higher consumer surplus. This is in line with the general view on the issue. Consider next vertical integration in the presence of a social welfare-maximizing government which taxes/subsidizes the production of the final product. Irrespective of the details of the market structure, the optimal policy consists of a subsidy given per unit of production of each downstream firm. Let now a downstream firm integrate with its upstream supplier (or let more than one downstream firms do so with their suppliers). Two effects stem out of this action. First, downstream output increases (as fewer firms pay a wholesale price); second, the optimal subsidy is reduced. It turns out that the latter effect is stronger as subsidy is relevant to all firms, whereas the wholesale price effect is relevant only to the integrated firm(s). As a result, total output after integration is lower than total output before integration and so is consumer surplus.

The paper adds to the literature on the competitive effects of vertical integration. As noted before, the general view in the literature is that in the absence of any barriers to competition, vertical integration benefits consumers (or, more generally, social welfare). The literature has identified a number of such barriers, such as market foreclosure and the raising of the cost of competitors (Salop and Scheffman, 1983; Hart and Tirole, 1990), secret contracts (Nocke and Rey, 2018), integration-driven collusion (Chen and Riordan, 2007; Nocke and White, 2007), etc. As our paper does not deal with such factors we don't intend to review the relevant literature. We instead refer the reader to the survey works of Rey and Tirole (2007) and Riordan (2008) for a description of how these (or other) mechanisms work. Regarding markets without foreclosure, a potential exception to the above general rule, apart from our tax/subsidy framework, is provided by a multiproduct market. As Salinger (1991) pointed out, the merging of a multiproduct monopolist with

one of his suppliers reduces the price of the good for which double marginalization is eliminated but also raises the prices of the other product(s) of the monopolist, resulting into an ambiguous net effect for consumers.

The paper is also linked -indirectly- to Dinda and Mukherjee (2014) which examines how optimal taxation in oligopoly may distort the positive impact of more competition in the market. Dinda and Mukherjee analyzed a horizontal market with efficient and inefficient firms under a welfare-maximizing tax/subsidy policy. The paper showed that a rise in the number of cost-inefficient firms reduces consumer surplus. The result is driven by the effect this change has on the optimal governmental policy.

The paper is organized as follows. Section 2 presents the model. Section 3 derives market equilibrium and section 4 describes the impact of vertical integration. The last section concludes.

2 Model

We consider a structure with a downstream and an upstream market. Each firm in the former market is exclusively dealing with a firm in the latter market. The upstream firm provides an input which is used in the production of the downstream firm. Inputs are homogeneous across firms and they are produced at zero cost. Moreover a unit of input is transformed into a unit of a production in the downstream market. If a pair of firms in the two markets, i.e., an upstream firm and its associated downstream firm, are non-integrated the latter pays the former a linear price per unit of input used (or output produced). If the two firms are integrated, the downstream firm uses the input for free.

There are n firms in the downstream market, m of which are non-integrated and $n-m$ are integrated. Denote by i a generic non-integrated firm and by j a generic integrated firm. The production cost for i, given that it produces q_i units of the final product and that it pays w_i per unit of input (output) is $C_i(q_i, w_i) = w_i q_i + q_i^2/2$, whereas the production cost of j is $C_j(q_j) = q_j^2/2$, where q_j is j's production. Namely the cost of production includes a quadratic term, which is identical to all (integrated or non-integrated) firms and implies increasing marginal costs at the downstream level (see Baake et al. 2002, among others).[1] This cost specification allows us to capture the welfare effects of subsidization which follow from vertical integration, thus avoiding the irrelevance of integration under constant marginal costs.[2] The inverse demand in the downstream market is given by $p = a - Q$, where p is the price of the final product and Q is total output.

In addition to the above there is a government which taxes/subsidizes the final product (downstream) market. In particular each firm in the downstream market is charged a tax/is subsidized by t per unit of production. The government choses the value of t by maximizing the total welfare generated by the vertical structure.

[1] Notice that integration does not alter the structure of costs.

[2] Under constant marginal costs of output production, subsidization succeeds in recovering the first best allocation regardless of whether firms are integrated or not. Indeed, assuming the same linear technology at the upstream and the downstream level allows the welfare-maximizing subsidy, by correcting the inefficiency due to imperfect competition on the downstream market, to also correct the inefficiency of double marginalization, causing the irrelevance of market structure. All relevant computations are available by the authors upon request.

The interaction among downstream firms, upstream firms and the government evolves via the following 3-stage game:

- at the first stage of the game the government decides upon the optimal tax/subsidy t;
- at the second stage the upstream firms choose the optimal input prices to charge the non-integrated downstream firms;
- at the third stage the non-integrated and the integrated firms compete choosing quantities.

In what follows we solve for the sub-game perfect equilibrium outcome of this interaction. We note that we won't endogenize the numbers m and $n-m$. The goal of the paper is to analyze the impact of variations in these numbers given the optimal tax policy.

3 Market equilibrium

For simplicity let firms $1, 2, \ldots, m$ be the non-integrated firms and $m+1, m+2, \ldots, n$ the integrated ones. Consider the third stage of the game. Non-integrated firm i choses q_i to maximize its profit $\pi_i = (p - w_i - t)\, q_i - \dfrac{q_i^2}{2} = (a - Q - w_i - t)\, q_i - \dfrac{q_i^2}{2}$. At the same stage integrated firm j choses q_j to maximize $\pi_j = (p-t)\, q_j - \frac{q_j^2}{2} = (a - Q - t)\, q_j - \dfrac{q_j^2}{2}$. Quantities are given by[3]

$$q_i^* = \frac{2\,(a-t) - w_i\,(1+n) + \sum_{k \neq i} w_k}{2\,(2+n)}, \quad i = 1, 2, \ldots, m \tag{1}$$

$$q_j^* = \frac{2\,(a-t) + \sum_{k=1}^{m} w_k}{2\,(2+n)}, \quad j = m+1, m+2, \ldots, n \tag{2}$$

We next move up to the second stage. Denote by u_i the supplier of non-integrated firm i, for $i = 1, 2, \ldots, m$, and let $\pi_{u_i} = w_i q_i^*$ be his objective function. Supplier u_i choses w_i by solving the problem $\max\limits_{w_i} \pi_{u_i}$. The optimal value of the wholesale price is

$$w_i^* = \frac{2(a-t)}{3+2n-m}, \quad i = 1, 2, \ldots, m,$$

which gives by (1)-(2) the optimal quantities of non-integrated and integrated firms

$$q_i^* = \frac{(1+n)(a-t)}{(2+n)(3+2n-m)}, \quad q_j^* = \frac{(3+2n)(a-t)}{(2+n)(3+2n-m)}$$

Consider finally the first stage, where the government chooses the value of t that maximizes social welfare. The latter is defined as the sum of consumer surplus, upstream and downstream firms' profits and tax revenues/subsidy expenditures. Denoting consumer surplus

[3] For notational simplicity, the equilibrium values in stages 3 and 2 will be denoted in the same way, in particular by a superscript *.

and welfare by CS and W we have

$$CS = (mq_i^* + (n-m)q_j^*)^2/2 \tag{3}$$

$$W = CS + m\pi_{u_i}^* + m\pi_i^* + (n-m)\pi_j^* + t(mq_i^* + (n-m)q_j^*) \tag{4}$$

The value of t that maximizes welfare is (see Lemma A1 in the Appendix for details)

$$t(m, n-m) = \frac{a(m(2+n)^2 - n(3+2n)^2)}{h(m, n-m)} \tag{5}$$

where $h(m, n-m) = m^2(2+n)^2 + n(1+n)(3+2n)^2 - m(8+22n+17n^2+4n^3)$. As we show in Lemma A1 $t(m, n-m) < 0$, so firms are subsidized. The corresponding equilibrium quantities are

$$q_i(m, n-m) = \frac{a(1+n)\big(n(3+2n) - m(2+n)\big)}{h(m, n-m)}, \quad i = 1, 2, \ldots, m$$

$$q_j(m, n-m) = \frac{a(3+2n)\big(n(3+2n) - m(2+n)\big)}{h(m, n-m)}, \quad j = m+1, m+2, \ldots, n$$

Total downstream output is $Q(m, n-m) = mq_i(m, n-m) + (n-m)q_j(m, n-m)$.

4 Effects of vertical integration

We are now ready to state our main result, which has to do with the impact of integration on the welfare of consumers. We take as benchmark case the scenario where all downstream firms are separated and we consider a single downstream firm integrating with its upstream supplier, given optimal policy (5).

Proposition 1 *Assume the government follows optimal policy (5). Then $CS(n-1, 1) < CS(n, 0)$, namely vertical integration reduces consumer surplus.*

Proof It suffices to show that $Q(n-1, 1) < Q(n, 0)$. By straightforward computations, (5) gives us $t(n-1, 1) = \frac{af_1(n)}{f_2(n)}$ and $t(n, 0) = \frac{a(5+3n)}{1+n^2}$, where $f_1(n) = 4 + 9n + 9n^2 + 3n^3$ and $f_2(n) = 12 + 19n + 13n^2 + 5n^3 + n^4$. Then we get

$$Q(n-1, 1) = \frac{a(2+2n+n^2)^2}{f_2(n)}, \quad Q(n, 0) = \frac{an}{1+n}$$

It is thus easy to verify that $Q(n-1, 1) < Q(n, 0)$. ■

Vertical integration has two opposite effects in our model. On the one hand, integration raises total downstream output as fewer firms pay a wholesale price. On the other hand, it induces the government to reduce the subsidy (in absolute terms) given to every downstream firm, namely $0 > t(n-1, n) > t(n, 0)$. It turns out that the latter effect dominates

the former, as the subsidy applies to all downstream firms, unlike the elimination of the wholesale price, and total output falls after integration.

Remark 1 We can reproduce Proposition 1 if we introduce product differentiation in the downstream market or if we assume that more than one downstream firms integrate with their upstream suppliers.[4]

The above are in sharp contrast with the impact of integration on consumers when the government does not intervene in the market. In such a case vertical integration has a positive effect on consumers, as we state in the following Proposition. For clarity all equilibrium variables in the no-taxation case will include a superscript "N".

Proposition 2 *Assume the government does not interfere in the market. Then* $CS^N(n-1,1) > CS^N(n,0)$*, namely vertical integration raises consumer surplus.*

Proof It suffices to show that $Q^N(n-1,1) > Q^N(n,0)$. By straightforward computations again we get

$$Q^N(n-1,1) = \frac{a(2+2n+n^2)}{8+6n+n^2}, \quad Q^N(n,0) = \frac{an(1+n)}{6+5n+n^2}$$

Given the above expressions, it is straightforward to show that the inequality $Q^N(n-1,1) > Q^N(n,0)$ indeed holds. ■

In the absence of the optimal governmental policy, vertical integration has only one effect, the partial elimination of the wholesale price, so it benefits consumers. We note also that Proposition 2 can also be re-produced with product differentiation or with more than one downstream firms integrating with their supplier.

A question that arises is whether a vertical integration of the form analyzed above will take place. Namely is there an incentive for integration? To answer positively we need to show that the profit of the integrated entity, i.e., the entity comprised of (i, u_i), surpasses the sum of the profits of i and u_i when the two are non-integrated. Remark 1 addresses this issue (for completeness we examine both cases of optimal policy (5) and of government abstinence from the market).

Remark 2 *The following hold:*

(i) *If the government follows optimal policy (5) then* $\pi_j(n-1,1) \geq \pi_i(n,0) + \pi_{u_i}(n,0)$ *for* $n \geq 4$.

(ii) *If the government does not interfere in the market then* $\pi_j^N(n-1,1) \geq \pi_i^N(n,0) + \pi_{u_i}^N(n,0)$ *for all* n.

Proof Appears in the Appendix. ■

Hence, irrespective of whether the government interferes or not in the market, one should expect vertical integration to occur if there are at least four downstream firms. In such a

[4]The proof of Remark 1 is available by the authors upon request.

market the coexistence of integration and optimal governmental tax/subsidy policy results in the surprising result on consumer welfare described above.

5 Conclusions

This paper identified a factor that undermines completely the positive impact of vertical integration on consumer welfare: the governmental optimal tax policy in the underlying market. This hadn't been noticed before in the literature. The paper showed that the interplay of integration and optimal government policy can -surprisingly- produce adverse effects for consumers, even in the absence of factors that restrict competition in the downstream and upstream markets.

Our analysis has been conducted within a rather simple model (linear downstream market demand, linear input pricing, complete and perfect information, etc). Relaxing some of these assumptions, and also introducing other forms of taxation, such as an ad valorem tax, will allow for robustness checks of our results and conclusions. These tasks are left as future research.

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Appendix

Lemma A1 *The following hold.*

(i) *The formula of W in (4) is given by*

$$W = \frac{a^2 g_1 + 2atg_2 - t^2 g_3}{2(2+n)^2(3+2n-m)^2}$$

(ii) *Optimal tax (5) is of negative sign.*

(iii) *Optimal welfare is* $W(m, n-m) = \frac{a^2\left(m(2+n)-n(3+2n)\right)^2}{2\left(m^2(2+n)^2+n(1+n)(3+2n)^2-m(8+22n+17n^2+4n^3)\right)}$

where $g_1 = m^2(2+n)^2 + n(3+n)(3+2n)^2 - m(16+30n+19n^2+4n^3)$, $g_2 = m(2+n)^2 - n(3+2n)^2$, $g_3 = m^2(2+n)^2 + n(1+n)(3+2n)^2 - m(8+22n+17n^2+4n^3)$.

Proof (i) By straightforward computations.

(ii) The numerator of t^* is negative as $m \leq n$. The denominator is a decreasing function of m. Hence, it takes the minimum value at $m = n$. it is easy to see that this minimum is positive. Hence, the denominator is positive and thus $t(m, n-m) < 0$.

(iii) By straightforward computations. ■

Proof of Remark 2

(i) We first note that, given optimal policy (5),

$$\pi_i(m, n-m) = \frac{3a^2(1+n)^2\big(m(2+n)-n(3+2n)\big)^2}{2\big(h(m,n-m))\big)^2}$$

$$\pi_j(m, n-m) = \frac{3a^2(3+2n)^2\big(m(2+n)-n(3+2n)\big)^2}{2\big(h(m,n-m))\big)^2}$$

$$\pi_{u_i}(m, n-m) = \frac{2a^2(1+n)(2+n)\big(m(2+n)-n(3+2n)\big)^2}{\big(h(m,n-m)\big)^2}$$

Plugging in the appropriate m each time gives $\pi_j(n-1,1) = \frac{3a^2(3+2n)^2(2+2n+n^2)^2}{2(12+19n+13n^2+5n^3+n^4)}$ and $\pi_i(n,0) + \pi_{u_i}(n,0) = \frac{a^2(11+7n)}{2(1+n)^3}$. By straightforward calculations, $\pi_j(n-1,1) \geq \pi_i(n,0) + \pi_{u_i}(n,0) \Leftrightarrow -738 - 2301n - 3169n^2 - 2480n^3 - 1136n^4 - 240n^5 + 30n^6 + 29n^7 + 5n^8 \geq 0$, which holds if $n \geq 4$.

(ii) Using straightforward computations, $\pi_j^N(n-1,1) = \frac{3a^2(3+2n^2)}{2(8+6n+n^2)^2}$ and $\pi_i^N(n,0) + \pi_{u_i}^N(n,0) = \frac{a^2(11+18n+7n^2)}{2(6+5n+n^2)^2}$. It is then easy to see that the desired inequality holds for all n. ■

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