Organic Mergers and Acquisitions

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Abstract

This paper examines the competition between organic and non-organic firms, their incentives to undertake a horizontal merger, and the effect of mergers on firms' market shares. We also consider an alternative setting where one firm can acquire its rival. For generality, we allow for goods to be horizontally and vertically differentiated, and cost asymmetry. Our results show that both organic and non-organic firms, despite their cost asymmetries and demand differentials, have incentives to merge under large conditions. Our paper also identifies settings in which the merger increases the organic firm's market share, which occurs when its demand is sufficiently stronger than its non-organic rival. When demand and cost differentials are significant, we identify settings under which a firm (either organic or non-organic) purchases its rival, to subsequently shut it down, and yet increase its profits.

Keywords: Horizontal integration; Merger and acquisition; Firm Reputation; Subjective beliefs.

JEL classification: G34; Q18; D11.

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1 Introduction

U.S. sales of organic products grew from $28.4 billion in 2012 to $47 billion in 2016. Importantly, this industry experienced a large amount of mergers and acquisitions since 2014, exceeding US$20 billion.[1] In most cases, an established firm producing non-organic goods acquired a relatively new firm selling organic products in the same (or close) market, which could be understood as a strategy to ameliorate competition; but in some cases the acquired firm produced goods extremely differentiated from those of the acquirer, which could be rationalized on the basis of portfolio diversification. After the acquisition, both firms remained active, but their output levels were often adjusted under the new management. Recent examples include United Natural Foods Inc. purchasing Nor-Cal Produce (a distributor of organic produce and flowers) in March 2016 and Gourmet Guru (organic and better-for-you food) in August 2016; PepsiCo acquiring KeVita (which produces coconut-based probiotic drinks) in November 2016; and Coca Cola purchasing Suja Juice (organic cold-pressed juice) in August 2015, Blue Sky Beverage Company (organic, all natural soft drinks and energy drinks) in June 2015, and minority stakes in companies such as Aloe Gloe (organic aloe-water beverages).[2] Similarly, organic firms have acquired other organic companies during this short period, including Albert's Organics purchasing Global Organic Specialty Source (organic produce distributor) in March 2016; Nature Path's Foods acquiring Country Choice Organic (organic breakfast cereals and snacks) in July 2015; and Jusu Bars Inc. purchasing Cru Juice Inc. (organic cold-pressed juice, plant-based shots, and raw meals) in September 2016.[3]

In this paper, we seek to understand the incentives that drive both organic and non-organic firms to acquire other companies in the same or different markets, how their market shares change after the acquisition, and how these results are affected by demand and cost differentials across firms. Our model considers two firms, one producing an organic good while its rival produces the non-organic good. For generality, we allow for products to be horizontally differentiated (describing the case where some consumers prefer organic to non-organic goods, while others prefer the opposite) and vertically differentiated (representing the case where consumers regard the organic product as of superior quality).[4] The model also permits for different production costs, to account for the

[1] Some of the largest operations include Danone purchasing WhiteWave in July 2016 for US$12.5 billion, TreeHouse Foods acquiring Ralcorp (from ConAgra) in November 2015 for US$2.7 billion, Hormel Foods Corporation purchasing Applegate Farms in May 2015 for US$775 million, or Coca-Cola company acquiring AdeS from Unilever in June 2016 for US$ 575 million.

[2] Other examples include Amplify Snack Brands purchasing Boundless Nutrition (an allergen-free, non-GMO, snack manufacturer) in May 2016; Preferred Popcorn acquiring K&W Popcorn (a producer of organic popcorn) in April 2016; ConAgra Foods puchasing Blake's All Natural Food (organic frozen meals) in May 2015; General Meals acquiring Annie's (organic foods and snacks) in September 2014; J.M. Smucker purchasing Sahale Snacks (gluten free and non-GMO snacks) in August 2014, and the Millstone Coffee Company (organic coffee manufacturer) in November 2008; and WhiteWave Foods acquiring So Delicious (organic and dairy-free foods and beverages) in September 2014.

[3] Other examples include SunOpta (a Canadian organic and specialty food company) acquiring Sunrise Growers (a leading producer of organic foods) and Niagara Natural Food Snacks (healthy fruit snacks) in October 2015; Natural American Foods purchasing Sweet Harvest Foods (a producer of organic peanut butter, honey, and syrups) in December 2016; and Fresca Foods acquiring Wonderfully Raw and Open Road Snacks (both firms produce organic, gluten-free and vegan snacks) in October 2015 and February 2017, respectively.

[4] Krissoff (1998) summarizes studies on consumer demand for organic food, indicating that a large proportion of consumers prefer organic foods because of taste, appearance, or personal health reasons. For other articles evaluating

fact that organic goods are often more costly to produce than non-organic varieties. We examine a two-stage game where, in the first stage, firms choose whether to merge and, in the second stage, they select their output levels (as part of the merger, or as independent firms if the merger does not occur). For completeness, we then consider an alternative first-stage setting, whereby one firm (e.g., the industry leader) chooses whether to acquire the other firm, to subsequently determine optimal production levels for both firms during the second stage.

In the second stage, we show that only the most efficient firm produces a positive output when firms are relatively asymmetric in their production costs, while both firms remain active when their costs are relatively symmetric. In the first stage, we demonstrate that the merger can be supported for large parameter conditions, but firms remain active only if their production costs are relatively symmetric. Otherwise, the most inefficient firm substantially reduces its output, relative to prior to the merger, and can even shut down its operations if its cost disadavantage is sufficiently severe.[5] We then evaluate how our results are affected by firms' degree of horizontal and vertical differentiation, as well as by their relatively cost efficiency.

Our findings provide several implications. First, we show that inefficient firms also seek to merge, even if they anticipate that their output will substantially decrease after the merger; in the extreme case, shutting it down to zero. Intuitively, this type of firm expects to share merger profits with its more efficient rival. The latter reduces its current competition since its inefficient rival produces fewer units; yielding a monopoly market when the cost advantage of the efficient firm is sufficiently strong. Therefore, both firms, despite their initial differences, have incentives to merge. A similar argument applies for acquisitions.

Second, our results help predict changes in market shares upon a merger between firms producing organic and non-organic goods. Specifically, while the former are often more costly than the latter, we find that the market share of organic (non-organic) products can increase (decrease, respectively) after the merger, but only if the demand for organic varieties is sufficiently strong. Intuitively, the merged firm, by internalizing all sales, decreases the production of the relatively less profitable product (that with the weakest demand), increasing sales of the product with the strongest demand, which yields a larger profit margin per unit of output. If demand for the organic good is sufficiently strong and its cost is not significantly larger than that of the non-organic variety, the merger could have incentives to shut down the non-organic firm, selling the organic product as a monopoly.[6] Importantly, our results apply to the opposite case, whereby the organic product has

consumer perceptions of organic product quality, see Grunert (2007) and Agyekum et al. (2015).

[5] Our paper therefore connects with the literature on mergers between firms with asymmetric costs, such as Fauli-Oller (2002), which finds that the merger chooses to close the plant exhibiting a significant cost inefficiency, thus exclusively producing in the efficient plant. Our paper finds a similar result in equilibrium, but allowing for horizontal and vertical product differentiation, and evaluates its welfare implications.

[6] Hershey Co. acquired the organic non-GMO companies Dagoba in October 2006, Krave Pure Foods in February 2015, and barkTHINS in April 2016. In addition, Hershey has been replacing sugar from sugar beets for non-GMO cane sugar, accounting for more than 75% of its sugar use in February 2016. A similar argument applies to Flower Foods, Inc. (a firm mainly selling non-organic products before 2015), which acquired two organic producers, Dave's Killer Bread in August 2015 and Alpine Valley Bread in September 2015. After these acquisitions, the acquirer, Flower Foods, Inc., significantly reduced its non-organic output while increasing the production of Dave's Killer Bread by 4 times relative to pre-acquisition levels. See Howard (2009), Gutierrez (2016), and MarketLine (2017).

a weak demand, perhaps because it is still in its infancy or consumers do not yet know about its properties, and it suffers a cost disadavantage relative to the non-organic variety. In this setting, the non-organic firm would have incentives to acquire the organic company to, essentially, shut it down thus limiting its competition.[7] We demonstrate that these results are emphasized when products are relatively homogeneous (small horizontal differentiation), where our findings can be sustained under larger parameter conditions.

Finally, we compare equilibrium output after the merger against the socially optimal output (first best). While the merger reduces output relative to pre-merger outcomes, we show that post-merger production can be socially insufficient or excessive. A socially insufficient output arises under large parameter conditions, and becomes more likely to occur when firms sell highly differentiated goods, or when their costs are sufficiently asymmetric. In this setting, mergers can be welfare reducing, leading antitrust authorities to block mergers under large conditions. We also find that, when firms sell relatively homogeneous goods and/or their costs are not extremely asymmetric, the merger produces a socially excessive output. Therefore, while output decreases because of the merger, it approaches the first-best outcome, implying that the merger is welfare improvement and should be allowed.

Related literature. Our model builds on the literature on horizontal mergers, as in Salant et al. (1983) and Farrell and Shapiro (1990), which consider homogeneous goods (no vertical or horizontal differentiation) and cost symmetry among firms. The literature was then extended to allow for product differentiation, as in Norman and Pepall (2000) and Escrihuela-Villar (2011), and both product differentiation with cost asymmetries, as in Zanchettin (2006), Kao and Menezes (2010), and Gelves (2014). Unlike our paper, Zanchettin (2006) does not examine firms' incentives to merge; Kao and Menezes (2010) XXXXXXXXXXX; and Gelves (2014) XXXXXXXXXXXXXX. Other studies consider the possibility that merging firms benefit from a cost-reducing effect; as in Norman et al. (2005).

We analyze mergers between firms selling organic and non-organic goods, allowing for cost asymmetries and for horizontal and vertical product differentiation. Allowing for both types of product differentiation separates us from most papers on this literature, which focus on one dimension alone. For instance, Norman et al. (2005) examines firms' incentives to merge as a function of the vertical (quality) differential between their goods, and shows under which conditions the merge firm chooses to discontinue some product lines. We extend the analysis allowing for horizontal product differentiation. Savorelli (2012) examines under which settings firms have incentives to collude when facing asymmetric production costs, as in our paper. However, it does not allow for horizontal or vertical product differentiation. Finally, Häckner (2000) considers goods that can be differentiated in both their horizontal and vertical dimensions, but does not analyze firms' incentives to merge or acquire their rivals.

[7] The J.M. Smucker Company (seller of non-organic products in 2008) acquired the organic firm Millstone Coffee in November 2008. The acquirer, however, discontinued Millstone Coffee in September 2016, citing lack of sustainable demand. Their organic coffee brand, therefore, disappeared since the company did not acquire another organic coffee brand, nor develop its own; as reported by The Vending Times in August 25th, 2016

Section 2 presents the model, Section 3 describes the time structure of the game, and solves for equilibrium output (second stage) and for merger and acquisition decisions (first stage). Section 4 discusses our findings.

2 Model

Consider that firm 1 produces a non-organic good, with marginal cost $c_{NO} > 0$; while firm 2 produces an organic good, with marginal cost $c_O > 0$. For generality, we allow for the organic good to be more costly, $c_O > c_{NO}$; less costly, $c_O < c_{NO}$; or equally costly, $c_O = c_{NO}$, than the non-organic product. The production of organic goods can affect the demand for non-organic products when both goods are sufficiently homogeneous. In particular, firm 1's (firm 2's) inverse demand function for the non-organic (organic) product, q_{NO} (q_O, respectively) is[8]

$$p(q_{NO}, q_O) = a_{NO} - q_{NO} - \lambda q_O \quad \text{and} \quad p(q_O, q_{NO}) = a_O - q_O - \lambda q_{NO}$$

Demand intercept a_k captures consumers' overall preference for organic and non-organic products (vertical differentiation), where $k = \{O, NO\}$. We assume that $a_O \geq a_{NO}$ thus indicating that consumers regard organic goods as (weakly) superior, i.e., if both goods had the same price, consumers would opt for the organic variety. Furthermore, $a_k > c_k$ for every firm k. In addition, parameter $\lambda \in [0, 1]$ describes the degree of horizontal product differentiation between both goods. Specifically, if $\lambda = 0$ products are completely differentiated, and sales of organic goods do not affect the demand of non-organic products. This case resembles two separate monopolies. However, when $\lambda = 1$ products are homogeneous, and firms compete as duopolists selling a good that is regarded as horizontally identical to consumers; although in this case our model would still allow for vertical differentiation to play a role if $a_O \neq a_{NO}$.

3 Equilibrium analysis

We consider the following two-stage game:

1. In the first stage, every firm decides whether or not to merge with its rival. A merger only occurs if both firms choose to merge.

2. In the second stage, if firms did not merge, they compete in output. Otherwise, they coordinate their production decisions, which may entail shutting down the operations of one firm.

For completeness, we first examine the setting in which firms, during the first stage, choose whether to merge; and then analyze an alternative scenario where one firm has the ability to acquire its rival. The game is solved by backward induction.

[8] This demand specification is, thus, similar to that of Singh and Vives (1984) for the analysis of firms' incentives to compete in either quantities or prices when they produce differentiated products.

3.1 Second-stage output

Case 1, No merger. If one or both firms chose to not merge during the first period, a merger does not occur, leading each firm to simultaneously and independently set its own output. In particular, every firm k solves

$$\pi_k^{NM} \equiv \max_{q_k} p(q_k, q_j)q_k - c_k q_k. \tag{1}$$

where $j \neq k$ indicates firm k's rival, π_k^{NM} is the value function arising from this problem (i.e., maximal profits for firm k under no merger), and superscript NM denotes "no merger." This problem yields best response function $q_k(q_j) = \frac{a_k - c_k}{2} - \frac{\lambda}{2} q_j$, which increases as products become more differentiated (lower λ).[9] Simultaneously solving for output levels q_k and q_j, we obtain

$$q_k^{NM} = \frac{2(a_k - c_k) - \lambda(a_j - c_j)}{4 - \lambda^2} \text{ for every firm } k.$$

Intuitively, when goods are completely differentiated, $\lambda = 0$, this production level converges to standard monopoly output $\frac{a_k - c_k}{2}$; but as goods become more homogeneous, this output becomes $\frac{2(a_k - c_k) - (a_j - c_j)}{3}$ when $\lambda = 1$. Furthermore, if consumers assign the same value to organic and non-organic goods, $a_k = a_j$, and both products are equally costly, $c_k = c_j$, this output level reduces to the standard result in duopoly markets with symmetric firms and homogeneous products, i.e., $\frac{a_k - c_k}{3}$.

Firm k's output under no merger is positive if its cost satisfies $c_k < c_k^{NM} \equiv \left(a_k - \frac{\lambda a_j}{2}\right) + \frac{\lambda c_j}{2}$; which collapses to the standard condition $c_k < a_k$ when firms sell completely differentiated goods, $\lambda = 0$, but becomes more restrictive as their products are more homogeneous (higher λ). A similar argument applies to firm j, which produces a positive output if only if $c_j < c_j^{NM}$.[10]

Last, we can evaluate profits emerging from problem (1), as follows

$$\pi_k^{NM} = \left[\frac{2(a_k - c_k) - \lambda(a_j - c_j)}{4 - \lambda^2}\right]^2.$$

Since this profit can be alternatively represented as $\pi_k^{NM} = \left(q_k^{NM}\right)^2$, we can extend similar comparative statics results as those for output in our above discussion.

Case 2, Merger. A merger occurs if both firms agree to merge during the first period. Therefore, firms coordinate their production decisions (choice of q_k and q_j) to maximize their joint profits, which entails either of three options: (i) produce positive units of both goods, obtaining profits $\pi^{M,Both}$, where the superscript indicates a merger where both plants are active; (ii) produce a positive amount of good k alone, yielding $\pi^{M,k}$; or (iii) produce positive units of good j alone, earning $\pi^{M,j}$. We analyze each case separately below, and subsequently compare profits.

[9] When products become completely differentiated, $\lambda = 0$, firm k produces output $q_k = \frac{a_k - c_k}{2}$, since both markets become separated monopolies.

[10] Note that both cutoffs c_k^{NM} and c_j^{NM} are less demanding than all the cutoffs we identify in subsequent sections of the paper, which implies that conditions $c_k < c_k^{NM}$ and $c_j < c_j^{NM}$ hold throughout our analysis.

Both firms are active. When both firms are active, they maximize their joint profits as follows

$$\pi^{M,Both} \equiv \max_{q_k,q_j} \; [p(q_k,q_j)q_k - c_k q_k] + [p(q_j,q_k)q_j - c_j q_j]\,. \tag{2}$$

where $\pi^{M,Both}$ denotes the overall profits for the merged firm (which explains why it does not include a firm's subscript). Differentiating with respect to q_k and q_j, and simultaneously solving, we obtain

$$q_k^{M,Both} = \frac{(a_k - c_k) - \lambda(a_j - c_j)}{2(1-\lambda^2)}.$$

Like in Case 1, where firm did not merge, output in this setting converges to monopoly output $\frac{a_k - c_k}{2}$ when firms sell completely differentiated products, $\lambda = 0$. Firm k's output under the merger is positive if its cost satisfies $c_k < c_k^M \equiv (a_k - \lambda a_j) + \lambda c_j$. The intuition behind cutoff c_k^M is similar to that behind c_k^{NM} in Case 1, but since cutoffs satisfy $c_k^M < c_k^{NM}$, the condition for both firms to be active, $c_k < c_k^M$, is more restrictive than that in the no merger case, $c_k < c_k^{NM}$. Intuitively, since the merged firm seeks to limit production in order to raise prices, costs need to be lower than prior to the merger for firm k to keep producing positive units. In other words, when costs are intermediate, i.e., $c_k^M < c_k < c_k^{NM}$, if firm k is the organic producer and faces high costs, it stops producing the non-organic product after the merger. A similar argument applies to non-organic firm j, which produces a positive output under the merger only if $c_j < c_j^M$.

Last, we can evaluate profits emerging from problem (2), as follows

$$\pi_k^{M,Both} = \frac{(a_k - c_k)\left[(a_k - c_k) - \lambda(a_j - c_j)\right]}{4\left(1-\lambda^2\right)} = \frac{(a_k - c_k)}{2} q_k^M$$

and similarly for firm j. Therefore, overall profits for the merged firms are

$$\pi^{M,Both} = \frac{(a_k - c_k)\left[(a_k - c_k) - 2\lambda(a_j - c_j)\right] + (a_j - c_j)^2}{4\left(1-\lambda^2\right)}$$

Only firm k is active. If the merged firm shuts down firm j, its profit-maximization problem becomes

$$\pi_k^{M,k} \equiv \max_{q_k} \; p(q_k,0)q_k - c_k q_k \tag{3}$$

yielding the standard monopoly output $q_k^{M,k} = \frac{a_k - c_k}{2}$, with associated profits $\pi_k^{M,k} = \frac{(a_k - c_k)^2}{4}$. A similar argument applies to the case in which the merger shuts down firm k, entailing profits of $\pi_j^{M,j} = \frac{(a_j - c_j)^2}{4}$.

Comparing the profits that the merged firm obtains from keeping producing both goods, $\pi^{M,Both}$, against those where only firm k remains active, $\pi_k^{M,k}$, we obtain the following proposition. For presentation purposes, recall that firm j's output under the merger is positive if its cost c_j satisfies $c_j < a_j - \lambda(a_k - c_k)$. For presentation purposes, we solve for c_k in this inequality to obtain $c_k < c_j^M \equiv \left(a_k - \frac{a_j}{\lambda}\right) + \frac{c_j}{\lambda}$. Graphically, cutoff c_j^M is easier to plot in the (c_j, c_k)-quadrant, and to compare against other cutoffs found above.

Proposition 1. *The following three regions can arise in the* (c_j, c_k)*-quadrant:*

1. *Region I. Only firm* k *produces positive output if* $c_k < c_j^M$*.*
2. *Region II. Both firms produce positive output if* $c_j^M \leq c_k < c_k^M$*.*
3. *Region III. Only firm* j *produces positive output if* $c_k \geq c_k^M$*.*

Figures 1 depicts cutoffs c_k^M and c_j^M, to identify the four regions identified in Proposition 1. Since $a_k > c_k$ for every firm k, we only focus on (c_j, c_k)-pairs in the lower left-hand corner of the figure. In Region I, firm k benefits from a significant cost advantage, relative to j, leading the merged firm to produce at firm k alone. A symmetric case emerges in Region III, where now firm j is the only one producing a positive output.[11] Last, when the costs of both firms are relatively low, they both remain active after the merger; as depicted in Region II.[12]

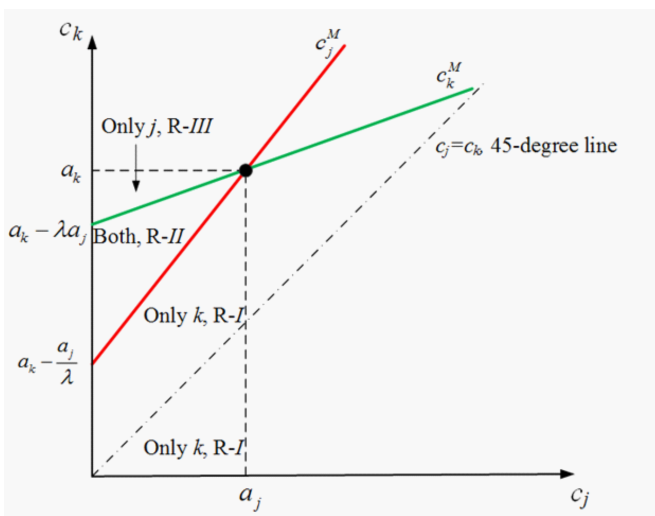

Figure 1. Output profiles.

Cutoffs c_k^M and c_j^M cross at $c_j = a_j$ and a height of $c_k = a_k$, thus lying above the 45-degree line when $a_k > a_j$, but below this line otherwise. Intuitively, when the demand for good k is stronger

[11]Comparing cutoff c_k^M against that under no mergers, c_k^{NM}, we find that $c_k^{NM} \equiv \left(a_k - \frac{\lambda}{2}a_j\right) + \frac{\lambda}{2}c_j$ originates above the vertical intercept of cutoff c_k^M, $a_k - \lambda a_j$. In addition, cutoff c_k^{NM} crosses c_k^M at $c_j = a_j$ and a height of $c_k = a_k$. Therefore, cutoff c_k^{NM} divides Region III into two areas: (1) if $c_k^M \leq c_k < c_k^{NM}$, firm k shuts down under the merger, but would produce a positive output if no merger occurs; and (2) if $c_k \geq c_k^{NM}$, firm k shuts down both when the merger occurs and when it does not. Since we have showed that a merger can be sustained in Region III, the discussion about whether firm k would have been active had the merger not occured is inconsequential. A similar argument applies to cutoff c_j^{NM}, which splits Region I into two areas.

[12]Note that cutoff c_k^M originates in the positive quadrant if $a_k - \lambda a_j \geq 0$, or $a_k \geq \lambda a_j$; while cutoff c_j^M does when $a_k - \frac{a_j}{\lambda} \geq 0$, or $a_k \geq \frac{a_j}{\lambda}$. That is, when a_k is low, $a_k < \lambda a_j$, both cutoffs originate in the negative quadrant; when a_k takes intermediate values, $\lambda a_j \leq a_k < \frac{a_j}{\lambda}$, only cutoff c_k^M originates in the positive quadrant; and when a_k is relatively high, $a_k \geq \frac{a_j}{\lambda}$, both cutoffs start at the positive quadrant.

than that of j (e.g., organic produce is highly demanded), Region I is larger than III, since the merged firm can extract a larger margin from every unit of good k. In words, the stronger demand that firm k faces justifies shutting down firm j, keeping only firm k active in three cases: (a) when firm k is more efficient than j (below the 45-degree line); (b) when they are equally efficient; and (c) even when firm k suffers a small cost disadvantage.

We can apply our result to special cases, such as a market where products are homogeneous, $\lambda = 1$. As depicted in Figure 2a, in this case both cutoffs collapse to the same line (i.e., they both originate at $a_k - a_j$, and have a slope of 1), yielding only two possible outcomes: Region I, where fim k is the only active plant, if $c_k < c_k^M = c_j^M$; or Region III, where only firm j operates, otherwise.[13]

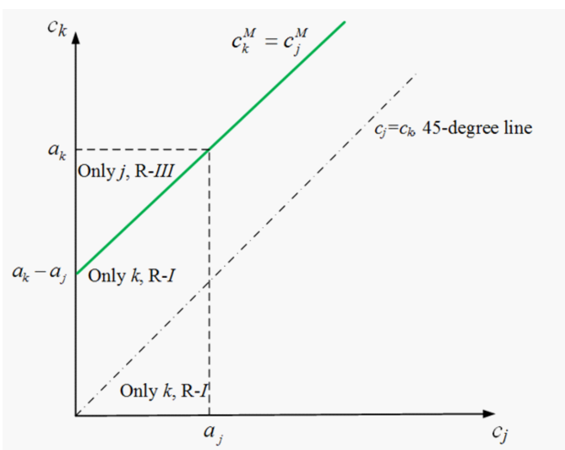

Figure 2a. $\lambda = 1$.

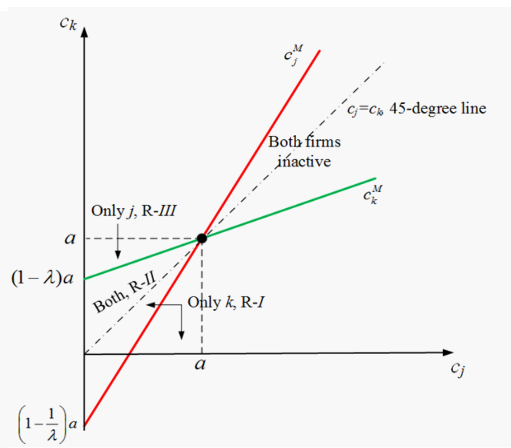

Figure 2b. $a_k = a_j = a$.

Last, Figure 2b considers the case in which both firms face the same demand, $a_k = a_j = a$. In this context, cutoff c_k^M originates at $(1 - \lambda)a$, which lies at the positive quadrant; cutoff c_j^M originates at $\left(\frac{\lambda-1}{\lambda}\right) a$, which lies on the negative quadrant; and both cutoffs cross at $c_k = c_j = a$, i.e., at the 45-degree line. Moving along the 45-degree line, it is easy to observe that both firms remain active when their common cost is relatively low, or both become inactive when such cost is high.

3.2 First stage

For each (c_j, c_k)-pair, every firm k anticipates the output profile that will emerge in the second stage of the game, i.e., Regions I-III. For completeness, we consider that during the first stage firms choose whether to merge; and subsequently examine how the results would change if, instead, one firm is allowed to acquire its rival.

[13] If, in addition, firms face the same demand, i.e., $a_k = a_j = a$, both cutoffs originate at zero, thus coinciding with the 45-degree line. In this context, when a firm enjoys even a minor cost advantage, the merged firm chooses only that plant to be active.

3.2.1 Mergers

In the first stage, every firm chooses whether to merge or not. In particular, for each region I-III, the firm compares the profits that it currently obtains as an independent firm, π_k^{NM}, against the profits it would obtain under the merger: $\frac{\pi_k^{M,k}}{2}$ in Region I, $\frac{\pi^{M,Both}}{2}$ in Region II, and $\frac{\pi_j^{M,j}}{2}$ in Region III. For simplicity, we assume that firms evenly share merger profits.[14]

Proposition 2. *During the first stage, every firm k chooses to merge as follows:*

1. *If (c_j, c_k)-pairs lie in Region I, firm k merges if and only if $c_k \in [c_1, c_2]$;*
2. *If (c_j, c_k)-pairs lie in Region II, firm k merges if and only if $c_k \in [c_3, c_4]$; and*
3. *If (c_j, c_k)-pairs lie in Region III, firm k merges if and only if $c_k \in [c_5, c_6]$.*

While the proposition allows for several patterns to emerge, in specific settings mergers may only be sustained if firms expect one of the three regions to arise during the second-period game. To understand this point, consider, for instance, parameter values $a_k = 1$, $a_j = 2/3$, $\lambda = 1/2$, and $c_j = 1/4$. As shown in the first row of Table I (benchmark set of parameters), the cutoffs identifying Regions I-III in Proposition 1 become $c_k^M = 0.79$ and $c_j^M = 0.16$. For illustration purposes, Figure 3 depicts cutoffs c_k^M and c_j^M in this setting, along with cutoffs c_1 through c_6.

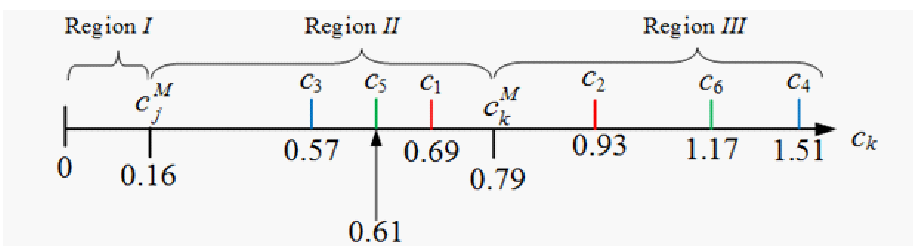

Figure 3. Cutoffs in benchmark case.

As a consequence, Region I can only be sustained for all $c_k < 0.16$; Region II can be supported for all $0.16 \leq c_k < 0.79$; and Region III for all $0.79 \leq c_k$. We can then conclude that: (1) the range of parameters $[c_1, c_2] = [0.69, 0.93]$ is incompatible with Region I, implying that this region cannot be sustained in equilibrium; (2) the the range of parameters $[c_3, c_4] = [0.57, 1.51]$ is compatible with Region II as long as $c_k \in [0.57, 0.79]$, which entails that this region can be supported in equilibrium when costs are relatively high; and (3) the range of parameters $[c_5, c_6] = [0.61, 1.17]$ is compatible for

[14] An alternative sharing rule could assign every firm a larger share of profits when it produces a larger share of output, as follows: $\frac{\pi_k^{M-k}}{q_k^{M-k}/Q^{M-k}}$ in Region I, $\frac{\pi^{M-Both}}{q_k^{M-Both}/Q^{M-Both}}$ in Region II, and $\frac{\pi_j^{M-j}}{q_j^{M-j}/Q^{M-j}}$ in Region III, where Q^{M-x} denotes aggregate output in setting $x = \{k, Both, j\}$. However, this profit sharing rule entails that firm j (firm k) would not receive any profits in Region I (III, respectively).

all values of c_k in Region III, implying that this region can be sustained in equilibrium. Overall, a merger can only be sustained in Region III and in Region II (as long as $c_k > c_3 = 0.57$). Intuitively, when firm k is relatively inefficient (in Region III and in the right-hand portion of Region II, as depicted in Figure 3), it prefers to join the merger rather than continue operating as an independent firm. In other words, the most inefficient firm seeks to ameliorate the tought competition it faces from its rival by entering the merger. If the merger is successful, this firm accepts to shut down its operations when its cost disadvantage is sufficiently large (in Region III), but continues producing a positive output level when such cost disadvantage is minor.

	c_k^M	c_j^M	c_1	c_2	c_3	c_4	c_5	c_6
Benchmark	0.79	0.16	0.69	0.93	0.57	1.51	0.61	1.17
Lower cost, $c_j = 1/10$	0.71	−0.13	0.57	0.91	0.41	1.69	0.48	1.23
Higher demand, $a_j = 1$	0.62	−0.5	0.44	0.88	0.23	1.92	0.31	1.31
Homogeneous goods, $\lambda = 1$	0.58	0.58	0.55	0.86	0.58	0.58	0.57	1.01
$\lambda = 1$ and $a_j = 1$	0.25	0.25	0.20	0.75	0.25	0.25	0.22	0.10

Table I. Cutoffs from Propositions 1 and 2.

Appendix 1 provides a detailed analysis of the regions that can/cannot be sustained in equilibrium for each row in Table I. Overall, when firm j becomes more efficient (as in the second row of the table), Region I cannot be supported, indicating that the merger does not find it profitable to produce using firm k alone (the most inefficient firm) under any parameter conditions.

3.2.2 Acquisitions

In this subsection, we consider an alternative setting for the first-stage game. We now allow firm k to make a take-it-or-leave-it offer to acquire firm j (an acquisition, rather than a merger analyzed above). Firm k might have more experience in the industry, and thus act as the leader, making an offer to firm j, who observes the offer and responds accepting it or not. If firm j accepts the offer, firm k manages both firms, seeking to maximize joint profits. If, instead, firm j rejects the offer, both firms continue to operate independently, competing in quantities.

To understand firm k's willigness to pay to acquire firm j, let us separately consider (c_j, c_k)-pairs lying in Region I, II, and III. In Region I, firm k anticipates that it will be the only firm that remains active after the acquisition, obtaining profits of $\pi^{M,k}$. (Unlike in the merger, firm k now earns all profit $\pi^{M,k}$, rather than half of it.) If this profit exceeds that from competing as an independent firm, π_k^{NM}, firm k acquires firm j, and its maximum willingness to pay is captured by profit gain $WP_I \equiv \pi^{M,k} - \pi_k^{NM}$. A similar argument applies when (c_j, c_k)-pairs lie in Region II, as in this case firm k can expect both firms remaining active after the acquisition, yielding profits of π^{Both}. Therefore, firm k is willing to pay up to $WP_{II} \equiv \pi^{Both} - \pi_k^{NM}$. Finally, when (c_j, c_k)-pairs lie in Region III, firm k anticipates that, given the substantial cost disadvantage is suffers, it will shut down its operations after the acquisition, operating the acquired firm j as a monopolist, earning profit $\pi^{M,j}$. In this context, firm k is willing to pay $WP_{III} \equiv \pi^{M,j} - \pi_k^{NM}$ to acquire firm j.

Figure 4 depicts the three regions of willingness to pay for firm k considering the same parameter values as in Table I (benchmark). Region I can be sustained for all $c_k < c_j^M = 0.16$ (left-hand side of the figure). In this region firm k has incentives to acquire firm j since curve WP_I lies in the positive quadrant. Similarly, Region II can be supported for all $0.16 \leq c_k < c_k^M = 0.79$ (intermediate values of c_k at the center of the figure). In this region, firm k chooses to acquire j given that curve WP_{II} is positive. Finally, Region III can exist for all $c_k \geq 0.79$ (right-hand side of figure), which leads firm k to acquire j since curve WP_{III} lies in the positive quadrant as well.

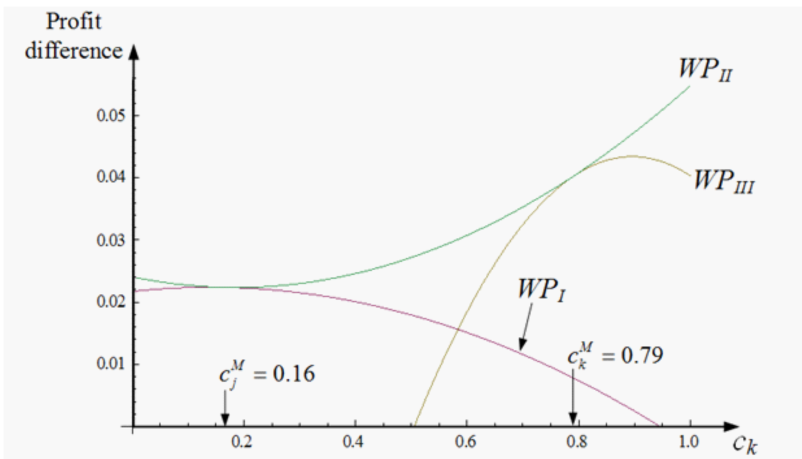

Figure 4. Profit gains from acquisition.

Not all Regions I-III necessarily emerge as equilibria of the acquisition game. For instance, when firm j's cost are lower ($c_j = 1/10$, as in the second row of Table I), Region I cannot be sustained since $c_j^M = -2/15 < 0$. Region II (III), however, can be sustained when firm k's costs are relatively low (high, respectively). A similar argument applies when the demand for good j increases ($a_j = 1$, as in the third row of Table I), whereby $c_j^M = -1/2 < 0$; but Regions II and III can still be supported.

While our above discussion analyzes the profit gain that firm k experiences from acquiring firm j, it was silent about the specific offer that firm k makes in equilibrium. In particular, firm k is willing to make an acceptable offer if its willingness to pay exceeds firm j's profits from continuing as an independent firm, π_j^{NM}. That is, if $WP_x \geq \pi_j^{NM}$ holds in Region $x = \{I, II, III\}$, firm k makes an offer of exactly π_j^{NM} to firm j. This offer yields a (weak) Pareto improvement: on one hand, it weakly compensates firm j for its foregone profits; and, on the other hand, firm k's profit gain (as captured by WP_x) exceeds the monetary outlay π_j^{NM} provided to firm j. We summarize this offer in the following corollary.

Corollary 1. *Firm k makes an offer of π_j^{NM} to acquire firm j if and only if its profit gain, WP_x, satisfies $WP_x \geq \pi_j^{NM}$ where $x = \{I, II, III\}$.*

Figure 5 depicts the results of this corollary. In Region I, the difference $WP_I - \pi_j^{NM}$ is positive, entailing that firm k has incentives to offer π_j^{NM} to firm j, and an equilibrium emerges in which only the efficient firm k keeps its operations. Similarly, in Region II, the difference $WP_{II} - \pi_j^{NM}$ is positive for all admissible c_k, which implies that firm k has incentives to offer π_j^{NM} to firm j as well. In this context, an equilibrium arises in which both firms are active. Finally, in Region III, the difference $WP_{III} - \pi_j^{NM}$ is only positive for relatively low costs, entailing that firm k has incentives to offer π_j^{NM} to firm j when the former is sufficiently efficient, but does not otherwise.

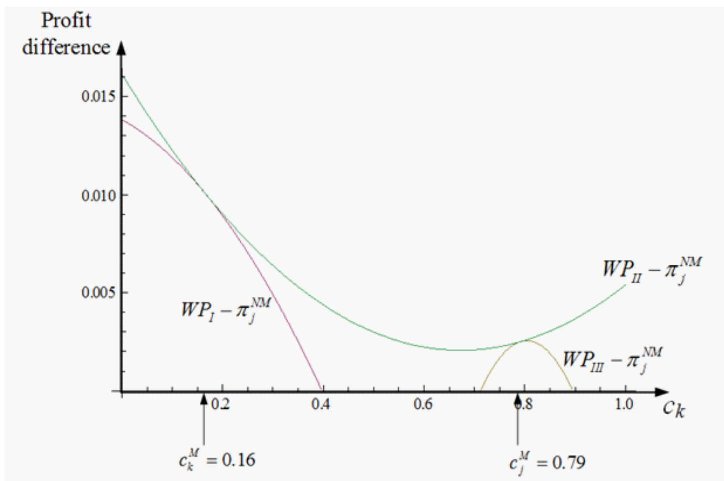

Figure 5. Difference $WP_x - \pi_j^{NM}$.

When the costs of firm j decrease to $c_j = 1/10$ (i.e., second row of Table I), Region I cannot be sustained. Region II can be supported for intermediate values of c_k, and the curve $WP_{II} - \pi_j^{NM}$ still lies on the positive quadrant, indicating that firm k has incentives to acquired firm j as prescribed in Proposition 2, and subsequently keeping both firms active. Region III can be sustained, but like in our above discussion, only leads firm k to acquire j if the former is relatiavely efficient (low values of c_k). A similar argument applies when firm j's demand increases (third row of Table I), since firm k is relatively inefficient and, upon acquiring firm j, does not find it profitable to become the only active firm in the industry.

4 Welfare analysis

The following proposition identifies the welfare-maximizing output pair. Social welfare is given by the sum of consumer and producer surplus, $W = CS + PS$, where $CS \equiv \frac{1}{2}(q_k^2 + q_j^2)$ and $PS \equiv \pi_k + \pi_j$.

Lemma 1. *The socially optimal output for firm k is $q_k^{SO} = \frac{a_k - c_k - 2\lambda(a_j - c_j)}{1-4\lambda^2}$, which is positive if and only if c_k satisfies $c_k \leq c_k^{SO} \equiv a_k - 2\lambda(a_j - c_j)$; and that of firm j is positive if and only if $c_k \leq c_j^{SO} \equiv \left(a_k - \frac{a_j}{2\lambda}\right) + \frac{c_j}{2\lambda}$. Therefore, it is socially optimal that:*

1. *only firm k produces a positive output if $c_k < \min\{c_k^{SO}, c_j^{SO}\}$;*
2. *only firm j produces a positive output if $c_k > \max\{c_k^{SO}, c_j^{SO}\}$; and*
3. *both firms produce a positive output if $\min\{c_k^{SO}, c_j^{SO}\} \leq c_k \leq \max\{c_k^{SO}, c_j^{SO}\}$.*

Graphically, Lemma 1 divides the $(c_k c_j)$-quadrant into three areas. First, when firm k's costs are low relative to those of j's, the social planner assigns a positive production level to this firm alone, leaving firm j inactive. A symmetric argument applies when firm k's costs are high relative to j's, where $q_k^{SO} = 0$ while $q_j^{SO} > 0$. Finally, when firms' costs are relatively symmetric, the social planner assigns a positive output to both firms.[15] Therefore, for every $(c_k c_j)$-pair, Lemma 1 informs us about which output profile to implement (q_k^{SO}, q_j^{SO}) to maximize social welfare. Our results are, however, silent about whether such output is higher than that emerging in equilibrium (as examined in Propositions 1 and 2), which entails that equilibrium output is socially insufficient; or whether socially optimal output is lower than that in equilibrium, thus giving rise to a socially excessive production. We analyze that below.

Proposition 3. *If λ satisfies $\lambda \geq \frac{1}{2}$, equilibrium output is socially insufficient when $c_k < c_k^{SO}$, but socially excessive otherwise. If λ satisfies $\lambda < \frac{1}{2}$, equilibrium output is socially insufficient when $c_k < c_k^A$, but socially excessive otherwise, where $c_k^A \equiv \left(a_k - \frac{3\lambda a_j}{1+2\lambda^2}\right) + \frac{3\lambda}{1+2\lambda^2} c_j$.*

Figure 6a and 6b illustrate the results in Proposition 3. When products are relatively homogeneous, $\lambda \geq \frac{1}{2}$, Figure 6a indicates that equilibrium output is lower than the social optimum when firm k's costs are relatively low, i.e., $c_k < c_k^{SO}$, which occurs in Region I and in the lower part of Region II, which only arises when $\frac{1}{2} \leq \lambda < \frac{1}{\sqrt{2}}$.[16]

[15] For a given value of λ, the ranking between cutoffs c_k^{SO} and c_j^{SO} becomes unambigous. In particular, when $\lambda < \frac{1}{2}$, cutoff c_k^{SO} satisfies $c_k^{SO} > c_j^{SO}$ for all admissible production costs; while when $\lambda \geq \frac{1}{2}$, cutoff c_k^{SO} satisfies $c_k^{SO} < c_j^{SO}$ for all admissible production costs.

[16] The frontier betwen Regions I and II, cutoff c_j^M, lies below cutoff c_k^{SO} when λ satisfies $\frac{1}{2} \leq \lambda < \frac{1}{\sqrt{2}}$, but above cutoff c_k^{SO} when $\frac{1}{\sqrt{2}} \leq \lambda$. In the first case, $c_k^{SO} > c_j^M$, which gives rise to Region II for $(c_j, c_k)-$pairs between c_k^{SO} and c_j^M, and Region I emerges below c_j^M. Therefore, socially insufficient output can be sustained in the lower part of Region II, and the entire Region I. In the second case, $c_k^{SO} < c_j^M$, which implies that Region II emerges for all c_k satisfying $c_j^M < c_k \leq c_k^M$, and Region I arises for all $c_k < c_j^M$. In this case, socially insufficient output can be supported when $c_k < c_k^{SO}$ (the lower portion of Region I), while socially excessive production occurs otherwise.

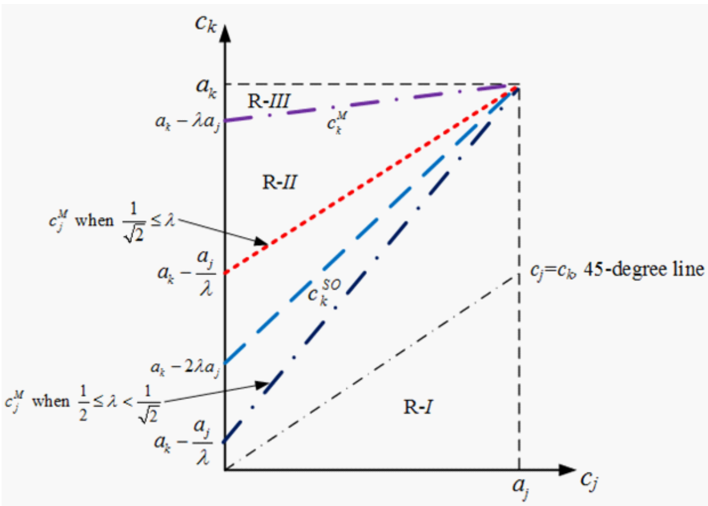

Fig. 6a. Production regions when $\lambda \geq \frac{1}{2}$.

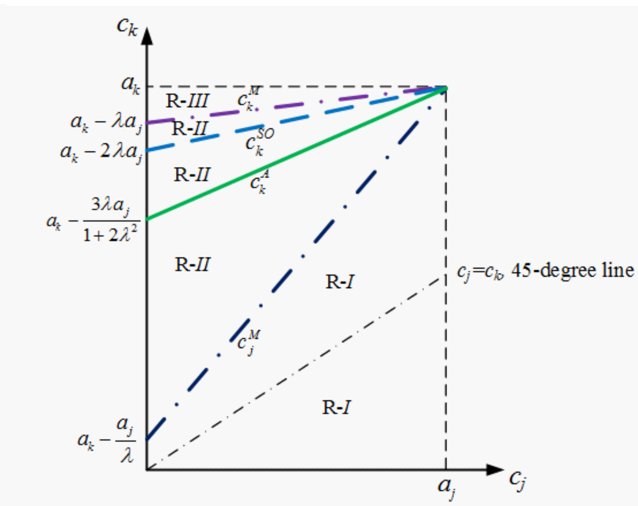

Fig. 6b. Production regions when $\lambda < \frac{1}{2}$.

Since firm k enjoys a significant cost advantage with its rival in these regions, it behaves as a monopolist (if only firm k is active after the merger, in Region I) or firms produce a smaller output than prior to the merger (if both firms are active, in Region II). In both cases, aggregate output lies below what a social planner would assign, yielding insufficient production. In contrast, equilibrium output is socially excessive in the upper area of Region II, and in the entire Region III.

Furthermore, the region of socially insufficient production expands when products become more differentiated. As depicted in Figure 6b, when $\lambda < \frac{1}{2}$ socially insufficient production occurs when $c_k < c_k^A$ (in Region I, and a large portion of Region II).[17] Intuitively, when products are more differentiated, firms' competition ameliorates, equilibrium output levels decrease, ultimately expanding the region of parameter values for which socially insufficient output can be sustained.

For illustration purposes, the next corollary identifies the regions where equilibrium output is socially insufficient or excessive in the extreme cases of completely differentiated products ($\lambda = 0$) or homogeneous goods ($\lambda = 1$).

Corollary 2. *When products are homogeneous, $\lambda = 1$, socially insufficient output arises when $c_k < c_k^{SO}$, whereas socially excessive production arises otherwise. When products are differentiated, $\lambda = 0$, only socially insufficient production can be sustained, which occurs in Region I (i.e., $c_k < c_j^M$).*

When firms sell a completely differentiated product, $\lambda = 0$, several cutoffs coincide, i.e., $c_k^M = c_j^M = c_k^{SO} = c_j^{SO}$. As a result, only Region I emerges in the (c_k, c_j)-quadrant, where only firm k

[17] The vertical intercept of cutoff c_k^A, $a_k - \frac{3\lambda a_j}{1+2\lambda^2}$, lies above that of cutoff c_k^{SO}, $a_k - 2\lambda a_j$, thus enlarging the area of Region II for which socially insufficient production can be sustained. For more details, see the proof of Proposition 3.

is active after the merger, ultimately leading a socially insufficient output level. In contrast, when firms sell homogeneous products, $\lambda = 1$, only cutoffs c_k^M and c_j^M coincide. Therefore, we can still find costs for which insufficient or excessive production occurs; as in Proposition 3. In particular, socially insufficient output exists when firm k's cost advantage is sufficiently strong, $c_k < c_k^{SO}$;[18] whereas socially excessive production emerges when c_k takes relatively high values, $c_k^{SO} \leq c_k$.

5 Discussion

Changing production profiles. Both after a merger or acquisition, our results suggest that all firms remain active only if their production costs are relatively symmetric. Otherwise, the new management (i.e., the merged firm or the acquirer) chooses to shut down the most inefficient company, only leaving the relatively efficient firm active, which operates as a monopolist. In less extreme cases, a similar result emerges, whereby the most inefficient firm is active after the merger but producing substantially fewer units than prior to the merger. In most real-world examples, we observe both firms being active after the merger, even if they alter their market shares, thus indicating that, while organic products are more costly than its non-organic rivals, their cost differentials are not extreme.

Inefficient firms also seek to merge. Our findings also highlight that companies have incentives to merge regardless of their relative efficiency. Specifically, inefficient firms seek to merge, even if they anticipate that their output will significantly decrease after the merger. When their inefficiency is sufficiently severe, this type of firm expects to shut down its operations after the merger, yet obtain a share of merger profits that exceeds its small profits when operating as an independent firm.

Larger production of more costly organic products? If the demand for good k is sufficiently strong (such as for some organic products), our results indicate that the merger chooses to increase output for this product, while reducing that of its non-organic rival. When the demand differential between organic and non-organic varieties is sufficiently large, we demonstrate that the merger might shut down the production of the non-organic variety. Importantly, the increase (decrease) in organic (non-organic) production occurs despite the organic product being more costly to produce than its non-organic rival.

Purchasing a company to shut it down? Our results also suggest that a non-organic firm, often benefiting from lower production costs than organic companies, has incentives to acquire its organic competitor. After the acquisition, we showed that both firms can coexist producing a positive output when the non-organic cost advantage is not extreme; otherwise, the acquirer would choose to shut down the organic firm. In this case, the non-organic company undergoes a costly acquisition just to shut down its organic rival immediately after the purchase. Intutively, the benefit from the acquisition, in the form of lower competition for the non-organic good which in this case becomes nil, offset the cost of the purchase.

[18] However, since $\lambda = 1$, cutoff c_k^{SO} originates at a low vertical intercept, $a_k - 2a_j$, which lies in Region I. Therefore, insufficient output can only arise if firm k's cost advantage is extremely strong.

Antimerger implications. We also show that the output reduction that arises after the merger yields underproduction relative to the socially optimal output under larger parameter conditions. This is more likely to occur when firms sell highly differentiated goods, or when their costs are sufficiently asymmetric. In this setting, antitrust authorities can have incentives to block mergers and acquisitions, as they anticipate welfare reducing outcomes. However, we also identify that, when firms sell relatively homogeneous goods and/or their costs are not extremely asymmetric, a socially excessive output can emerge after the merger. In this context, while output decreases as a result of the merger, it approaches the first-best output (q_k^{SO}, as identified in Lemma 1), indicating that the merger is welfare improvement.

6 Appendix

6.1 Appendix 1 - Numerical example

Benchmark case. Applying Proposition 1 to this parametric example yields cutoffs $c_k^M = 0.79$ and $c_j^M = 0.16$. As a consequence, Region I can only be sustained for all $c_k < 0.16$; Region II can be supported for all $0.16 \leq c_k < 0.79$; and Region III for all $0.79 \leq c_k$. From Proposition 2, we obtain cutoffs c_1 through c_6 (see first row of Table I). Figure 3 depicts all eight cutoffs to facilitate their comparison. We can then conclude that: (1) the range of parameters $[c_1, c_2] = [0.69, 0.93]$ is incompatible with Region I, and thus this region cannot be sustained in equilibrium; (2) the the range of parameters $[c_3, c_4] = [0.57, 1.51]$ is compatible with Region II as long as $c_k \in [0.57, 0.79]$, which entails that this region can be supported in equilibrium when costs are relatively high; and (3) the range of parameters $[c_5, c_6] = [0.61, 1.17]$ is compatible for all values of c_k in Region III, implying that this region can be sustained for all admissible c_k.

We next examine the previous cutoffs on rows 2-5 of Table I.

Lower cost, $c_j = 1/10$. Applying Proposition 1 to this parametric example yields cutoffs $c_k^M = 0.71$ and $c_j^M = -0.13$. Since $c_k > 0$, Region I cannot be sustained in equilibrium. Region II can be sustained for all costs $c_k < 0.71$; and Region III for all $0.71 \leq c_k$. Proposition 2 implies that: (1) the range of parameters $[c_3, c_4] = [0.41, 1.69]$ is compatible with Region II as long as $c_k \in [0.41, 0.71]$, which entails that this region can be supported in equilibrium when costs are moderately high; and (2) the range of parameters $[c_5, c_6] = [0.48, 1.23]$ is compatible for all values of c_k in Region III, entailing that this region can be sustained for all admissible c_k.

Higher demand, $a_j = 1$. Applying Proposition 1 to this parametric example yields cutoffs $c_k^M = 0.62$ and $c_j^M = -0.5$. Since cutoff $c_j^M < 0$ and costs must be positive by definition, Region I cannot be sustained in equilibrium. Region II can be sustained for all costs satisfying $c_k < 0.62$; and Region III for all remaining costs $c_k \geq 0.62$. Proposition 2 implies that: (1) the range of parameters $[c_3, c_4] = [0.23, 1.92]$ is compatible with Region II as long as $c_k \in [0.23, 0.62]$; and (3) the range of parameters $[c_5, c_6] = [0.31, 1.31]$ is compatible for all values of c_k in Region III, implying that this region can be sustained for all admissible c_k.

Homogeneous goods, $\lambda = 1$. Applying Proposition 1 to this parametric example yields cutoffs $c_k^M = c_j^M = 0.58$. As a consequence, Region I can be sustained for all $c_k < 0.58$. Region II cannot be sustained since cutoffs coincide $c_j^M = c_k = c_k^M$; and Region III can be sustained for all $0.58 \leq c_k$. Proposition 2 implies that: (1) the range of parameters $[c_1, c_2] = [0.55, 0.86]$ is compatible with Region I as long as $c_k \in [0.55, 0.58]$; and (2) the range of parameters $[c_5, c_6] = [0.57, 1.01]$ is compatible for all values of c_k in Region III, implying that this region can be sustained for all admissible c_k.

$\lambda = 1$ and $a_j = 1$. Applying Proposition 1 to this parametric example yields cutoffs $c_k^M = c_j^M = 0.25$. Therefore, Region I can be sustained for all $c_k < 0.25$; Region II cannot be sustained since cutoffs c_k^M and c_j^M coincide; and Region III can be sustained for all $c_k \geq 0.25$. Proposition 2 implies that: (1) the range of parameters $[c_1, c_2] = [0.20, 0.75]$ is compatible with Region I as long as $c_k \in [0.20, 0.25]$, which entails that this region can be supported in equilibrium when costs are relatively low; and (2) the range of parameters $[c_5, c_6] = [0.22, 0.10]$ is not compatible with Region III.

6.2 *Proof of Proposition 1*

First, note that the profit difference $\pi^{M,Both} - \pi_k^{M,k}$ yields a U-shaped curve, which becomes zero at exactly $c_k = a_k - \frac{a_j - c_j}{\lambda}$. As a consequence, $\pi^{M,Both} \geq \pi_k^{M,k}$ holds for all parameter values. For firm j, the profit difference $\pi^{M,Both} - \pi_j^{M,j}$ exhibits a similar shape, becoming zero at $c_k = c_k^M$; thus implying that $\pi^{M,Both} \geq \pi_j^{M,j}$ also holds for all parameter values. Summarizing, it is profitable to maintain both firms active, rather than shutting one of them down. However, conditions $c_k < c_k^M$ and $c_j < c_j^M$ still apply yielding different regions in the (c_k, c_j)-quadrant.

We can now compare cutoffs c_k^M and c_j^M. First, cutoff c_k^M originates above c_j^M since their vertical intercepts satisfy $a_k - \lambda a_j > a_k - \frac{a_j}{\lambda}$, which holds given that $\lambda \in [0, 1]$ by definition. Second, the positive slope of cutoff c_k^M is λ, whereas that of cutoff c_j^M is $1/\lambda$, thus indicating that cutoff c_j^M grows faster than c_k^M does. In addition, cutoffs c_k^M and c_j^M cross each other at $c_j = a_j$ and a height of $c_k = a_k$. Recalling that $a_k > c_k$ for every firm k, only three regions can be sustained in the (c_j, c_k)-quadrant: (1) when $c_k < c_j^M$, only firm k is active; (2) when $c_j^M \leq c_k < c_k^M$, both firms are active; and (3) when $c_k \geq c_k^M$, only firm j is active.

6.3 *Proof of Proposition 2*

First, consider (c_j, c_k)-pairs in Region I, i.e., $c_k < c_j^M$. In this region, only firm k operates under a merger in the second stage. Therefore, every firm k chooses to merge in the first stage if and only if its share of profits under the merger, $\frac{\pi_k^{M,k}}{2}$, exceeds the profits it would obtain as an independent firm, π_k^{NM}. Setting $\frac{\pi_k^{M,k}}{2} \geq \pi_k^{NM}$, and solving for cost c_k, we find that $\frac{\pi_k^{M,k}}{2} \geq \pi_k^{NM}$ holds for all $c_k \in [c_1, c_2]$, where

$$c_1 \equiv \frac{a(16 + 8\lambda^2 - \lambda^4) - 16\lambda(a_j - c_j) - 2\sqrt{2}(a_j - c_j)\lambda(4 - \lambda^2)}{16 + 8\lambda^2 - \lambda^4}$$

and

$$c_2 \equiv \frac{a(16+8\lambda^2-\lambda^4)-16\lambda(a_j-c_j)+2\sqrt{2}(a_j-c_j)\lambda(4-\lambda^2)}{16+8\lambda^2-\lambda^4}.$$

Second, consider (c_j, c_k)-pairs in Region II, i.e., $c_j^M \leq c_k < c_k^M$. In this region, both firms are active under a merger in the second stage. Therefore, every firm k chooses to merge in the first stage if and only if its share of profits under the merger, $\frac{\pi^{M,Both}}{2}$, exceeds the profits it would obtain as an independent firm, π_k^{NM}. Setting $\frac{\pi^{M,Both}}{2} \geq \pi_k^{NM}$, and solving for cost c_k, we find that $\frac{\pi^{M,Both}}{2} \geq \pi_k^{NM}$ holds for all $c_k \in [c_3, c_4]$, where

$$c_3 \equiv \frac{(a_j-c_j)\lambda^3(8+\lambda^2)+a_k(16-24\lambda^2-\lambda^4)+(a_j-c_j)(4-\lambda^2)\left[16-32\lambda^2+15\lambda^4+\lambda^6\right]^{1/2}}{16-24\lambda^2-\lambda^4}$$

and

$$c_4 \equiv \frac{(a_j-c_j)\lambda^3(8+\lambda^2)+a_k(16-24\lambda^2-\lambda^4)-(a_j-c_j)(4-\lambda^2)\left[16-32\lambda^2+15\lambda^4+\lambda^6\right]^{1/2}}{16-24\lambda^2-\lambda^4}.$$

Third, consider (c_j, c_k)-pairs in Region III, i.e., $c_k \geq c_k^M$. In this region, only firm j operates under a merger in the second stage. Therefore, every firm k chooses to merge in the first stage if and only if its share of profits under the merger, $\frac{\pi_j^{M,j}}{2}$, exceeds the profits it would obtain as an independent firm, π_k^{NM}. Setting $\frac{\pi_j^{M,j}}{2} \geq \pi_k^{NM}$, and solving for cost c_k, we find that $\frac{\pi_j^{M,j}}{2} \geq \pi_k^{NM}$ holds for all $c_k \in [c_5, c_6]$, where

$$c_5 \equiv \frac{4[2a_k-\lambda(a_j+c_j)]+\sqrt{2}(a_j-c_j)(4-\lambda^2)}{8}$$

and

$$c_6 \equiv \frac{4[2a_k-\lambda(a_j+c_j)]-\sqrt{2}(a_j-c_j)(4-\lambda^2)}{8}.$$

6.4 *Proof of Lemma 1*

As discussed in the main body of the paper, social welfare is given by the sum of consumer and producer surplus, $W = CS + PS$, where $CS \equiv \frac{1}{2}(q_k^2+q_j^2)$ and $PS \equiv [p(q_k,q_j)q_k - c_kq_k] + [p(q_j,q_k)q_j - c_jq_j]$. Using the inverse demands $p(q_k,q_j)$ and $p(q_j,q_k)$, the expression of producer surplus, PS, collapses to $PS = a_kq_k + q_j(a_j-c_j-q_j) - q_k(q_k+c_k+2\lambda q_j)$. Differentiating welfare W with respect to q_k, we obtain

$$a_k - c_k - q_k - 2\lambda q_j = 0$$

and a symmetric expression when we differentiate W with respect to q_j, $a_j - c_j - q_j - 2\lambda q_k = 0$. Simultaneously solving for q_k and q_j, yields $q_k^{SO} = \frac{a_k-c_k-2\lambda(a_j-c_j)}{1-4\lambda^2}$ and $q_j^{SO} = \frac{a_j-c_j-2\lambda(a_k-c_k)}{1-4\lambda^2}$.

Comparing q_k^{SO} against q_k^{M-Both}, we obtain that $q_k^{SO} \geq q_k^{M-Both}$ for all $c_k \leq c_k^A \equiv \left(a_k - \frac{3\lambda a_j}{1+2\lambda^2}\right) + \frac{3\lambda}{1+2\lambda^2}c_j$, where the term in parenthesis indicates the vertical intercept of cutoff c_k^A in the $(c_k, c_j)-$quadrant (such as that in Figure 1), while $\frac{3\lambda}{1+2\lambda^2}$ represents its positive slope. Similarly, comparing q_k^{SO} against

q_k^{M-k}, we obtain that $q_k^{SO} \geq q_k^{M-k}$ for all $c_k \leq c_k^B \equiv \left(a_k - \frac{4\lambda a_j}{1+4\lambda^2}\right) + \frac{4\lambda}{1+4\lambda^2}c_j$, where the term in parenthesis indicates the vertical intercept of cutoff c_k^B in the $(c_k, c_j)-$quadrant (such as that in Figure 1), while $\frac{4\lambda}{1+4\lambda^2}$ represents its positive slope. A similar argument for the output levels of firm j yields that $q_j^{SO} \geq q_k^{M-j}$ if and only if $c_k \leq \left(a_k - \frac{(1+4\lambda^2)a_j}{4\lambda}\right) + \frac{(1+4\lambda^2)c_j}{4\lambda} \equiv c_j^B$. We can finally compare socially optimal output against aggregate output to identify that $q_j^{SO} \geq q_k^{M-Both} + q_j^{M-Both}$ holds if and only if $c_k \leq \left(a_k - \frac{(1+2\lambda+4\lambda^2)a_j}{1+4\lambda}\right) + \frac{(1+2\lambda+4\lambda^2)c_j}{1+4\lambda} \equiv c_j^A$.

6.5 *Proof of Proposition 3*

Let us now analyze each of the regions in Figure 1. Since we are simultaneously plotting several cutoffs for c_k, their ranking depends on λ: $\lambda < \frac{1}{2}$, $\frac{1}{2} \leq \lambda < \frac{1}{\sqrt{2}}$, and $\frac{1}{\sqrt{2}} \leq \lambda$. We separately examine each case below.

Case A**,** $\lambda < \frac{1}{2}$**.** As depicted in Figure A1a, in this setting, cutoff c_k^M originates above cutoff c_k^{SO} since $a_k - \lambda a_j > a_k - 2\lambda a_j$, cutoff c_k^{SO} originates above c_k^A since $a_k - 2\lambda a_j > a_k - \frac{3\lambda a_j}{1+2\lambda^2}$, cutoff c_k^A originates above c_k^B since $a_k - \frac{3\lambda a_j}{1+2\lambda^2} > a_k - \frac{4\lambda a_j}{1+4\lambda^2}$, cutoff c_k^B originates above c_j^A since $a_k - \frac{4\lambda a_j}{1+4\lambda^2} > a_k - \frac{(1+2\lambda+4\lambda^2)a_j}{1+4\lambda}$, cutoff c_j^A originates above c_j^B since $a_k - \frac{(1+2\lambda+4\lambda^2)a_j}{1+4\lambda} > a_k - \frac{(1+4\lambda^2)a_j}{4\lambda}$, and cutoff c_j^B originates above c_j^M given that $a_k - \frac{(1+4\lambda^2)a_j}{4\lambda} > a_k - \frac{a_j}{\lambda}$. Furthermore, as depicted in Figure A1b, cutoff c_k^M originates above cutoff c_k^{SO} since $a_k - \lambda a_j > a_k - 2\lambda a_j$, cutoff c_k^{SO} originates above c_k^A since $a_k - 2\lambda a_j > a_k - \frac{3\lambda a_j}{1+2\lambda^2}$, cutoff c_k^A originates above c_j^{SO} given that $a_k - 2\lambda a_j > a_k - \frac{a_j}{2\lambda}$, and cutoff c_j^{SO} originates above c_j^M since $a_k - \frac{a_j}{2\lambda} > a_k - \frac{a_j}{\lambda}$.

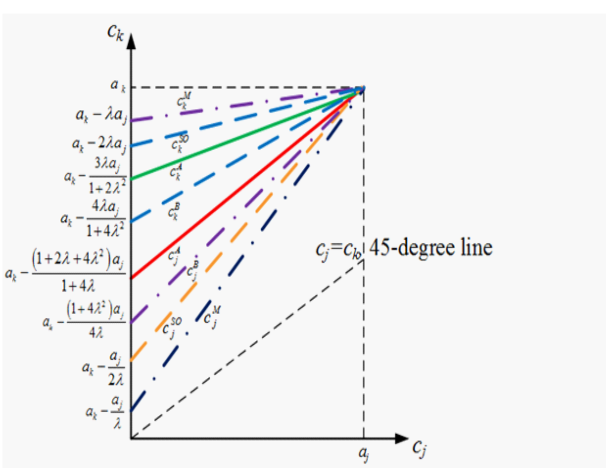

Fig. A1a. Cutoffs when $\lambda < \frac{1}{2}$.

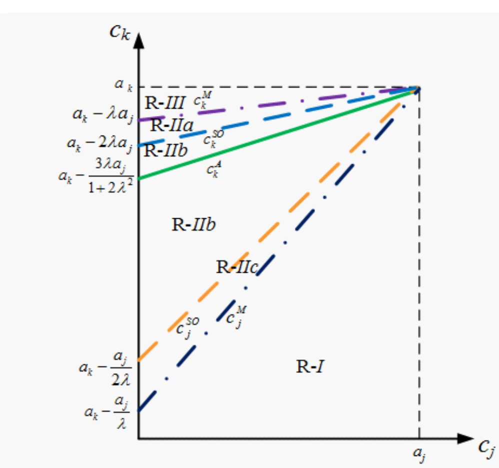

Fig. A1b. Production regions when $\lambda < \frac{1}{2}$.

Starting at Region I, where $c_k < c_j^M$, only firm k is active in equilibrium. The social planner would also have only firm k being active since in this region c_k satisfies $c_k < c_k^{SO}$ and $c_k < c_j^{SO}$.

We can then compare equilibrium and socially optimal output, q_k^{M-k} and q_k^{SO}, obtaining that $q_k^{SO} \geq q_k^{M-k}$ since Region I lies entirely below cutoff c_k^B. Therefore, a socially insufficient output emerges in Region I, relative to the social optimum.

In Region II, where $c_j^M \leq c_k < c_k^M$, both firms are active in equilibrium. The social planner, however, would only recommend that firm j is active when c_k satisfies $c_k^{SO} < c_k$; that both firms are active when $c_j^{SO} \leq c_k < c_k^{SO}$; and that only firm k is active if $c_k < c_j^{SO}$. Graphically, this entails that Region II is divided into three subregions, which we refer as regions IIa, IIb, and IIc, respectively.

- In Region IIa, only firm j produces according to the social optimum, producing q_j^{SO}, while both firms are active in equilibrium. Comparing q_j^{SO} and aggregate equilibrium output $q_k^{M-Both} + q_j^{M-Both}$, we obtain that $q_j^{SO} \geq q_k^{M-Both} + q_j^{M-Both}$ if and only if $c_k \leq c_j^A$. Since Region IIa lies above cutoff c_j^A, we find that $q_j^{SO} < q_k^{M-Both} + q_j^{M-Both}$, indicating that in this region there is an excessive production relative to the social optimum.

- In Region IIb, the social planner recommends both firms to be active, which coincides with the equilibrium result where $q_k^{M-Both}, q_j^{M-Both} > 0$. Comparing equilibrium and optimal output, we obtain that $q_k^{SO} \geq q_k^{M-Both}$ when $c_k \leq c_k^A$, but $q_k^{SO} < q_k^{M-Both}$ when $c_k^A < c_k < c_k^{SO}$ (which can hold in this case since $c_k^A < c_k^{SO}$). Therefore, Region IIb is divided into two regions: for relatively low values of c_k a socially insufficient output emerges in equilibrium, while for relatively high values fo c_k a socially excessive output can be sustained in equilibrium.

- Finally, in Region IIc only firm k is active according to the social optimum, while both firms acre active in equilibrium. Comparing equilibrium and socially optimal output, we obtain that $q_k^{SO} \geq q_k^{M-Both}$ since Region IIc lies entirely below cutoff c_k^A. As a result, a socially insufficient output emerges in Region IIc.

In Region III, only firm j is active in equilibrium, which coincides with the social optimum since $c_k > c_k^{SO}$ and $c_k > c_j^{SO}$. Comparing output levels, we find that $q_j^{SO} < q_j^{M-j}$ since Region III lies entirely above cutoff c_j^B. Therefore, a socially excessive output emerges for all costs in Region III.

Case B**,** $\frac{1}{2} \leq \lambda < \frac{1}{\sqrt{2}}$**.** As depicted in Figure A2a, in this setting, cutoff c_k^M originates above cutoff c_j^{SO} since $a_k - \lambda a_j > a_k - \frac{a_j}{2\lambda}$, cutoff c_j^{SO} originates above c_k^B since $a_k - \frac{a_j}{2\lambda} > a_k - \frac{4\lambda a_j}{1+4\lambda^2}$, cutoff c_k^B originates above c_j^B since $a_k - \frac{4\lambda a_j}{1+4\lambda^2} \geq a_k - \frac{(1+4\lambda^2)a_j}{4\lambda}$, cutoff c_j^B originates above c_k^A since $a_k - \frac{(1+4\lambda^2)a_j}{4\lambda} \geq a_k - \frac{3\lambda a_j}{1+2\lambda^2}$, cutoff c_k^A originates above c_j^A since $a_k - \frac{3\lambda a_j}{1+2\lambda^2} \geq a_k - \frac{(1+2\lambda+4\lambda^2)a_j}{1+4\lambda}$, and cutoff c_j^A originates above c_k^{SO} since $a_k - \frac{(1+2\lambda+4\lambda^2)a_j}{1+4\lambda} > a_k - 2\lambda a_j$, and cutoff c_k^{SO} originates above c_j^M given that $a_k - 2\lambda a_j > a_k - \frac{a_j}{\lambda}$. Furthermore, as depicted in Figure A2b, cutoff c_k^M originates above cutoff c_j^{SO} since $a_k - \lambda a_j > a_k - \frac{a_j}{2\lambda}$, cutoff c_j^{SO} originates above c_k^{SO} given that $a_k - \frac{a_j}{2\lambda} \geq a_k - 2\lambda a_j$, and cutoff c_k^{SO} originates above c_j^M since $a_k - 2\lambda a_j > c_k - \frac{a_j}{\lambda}$.

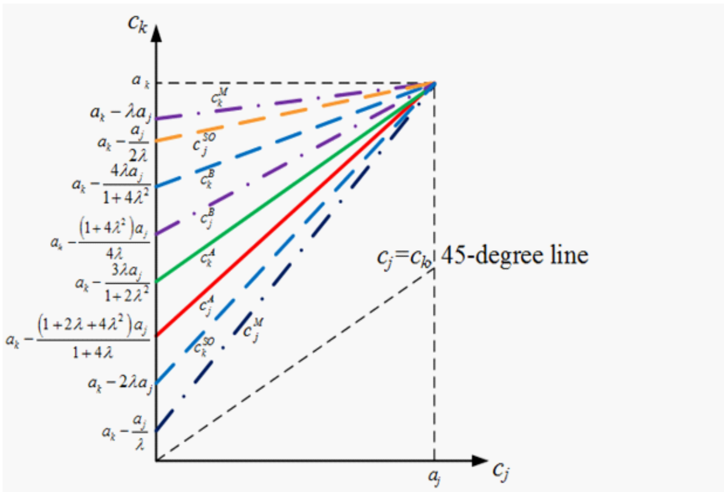

Fig. A2a. Cutoffs when $\frac{1}{2} \leq \lambda < \frac{1}{\sqrt{2}}$.

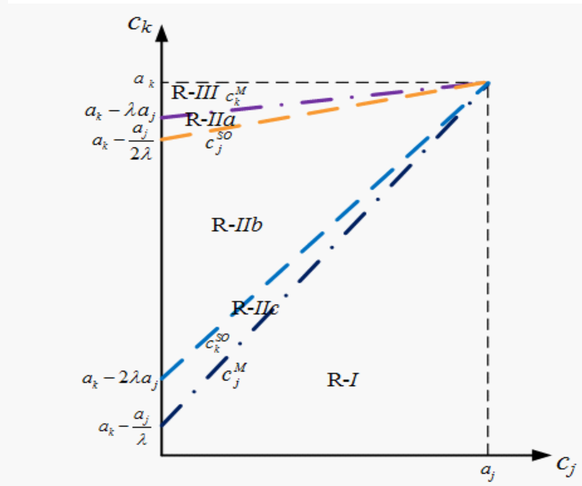

Fig A2b. Production regions when $\frac{1}{2} \leq \lambda < \frac{1}{\sqrt{2}}$.

Starting at Region I, where $c_k < c_j^M$, only firm k is active in equilibrium. The social planner would also have only firm k being active since in this region c_k satisfies $c_k < c_k^{SO}$ and $c_k < c_j^{SO}$. We can then compare equilibrium and socially optimal output, q_k^{M-k} and q_k^{SO}, obtaining that $q_k^{SO} \geq q_k^{M-k}$ since Region I lies entirely below cutoff c_k^B. Therefore, a socially insufficient output emerges in Region I, relative to the social optimum.

In Region II, where $c_j^M \leq c_k < c_k^M$, both firms are active in equilibrium. The social planner, however would only recommend that firm j is active when c_k satisfies $c_j^{SO} \leq c_k$; that no firm is active when $c_k^{SO} \leq c_k < c_j^{SO}$; and that only firm k is active if $c_k < c_k^{SO}$. Graphically, this entails that Region II is divided into three subregions, which we refer as regions IIa, IIb, and IIc, respectively.

- In Region IIa, only firm j produces according to the social optimum, producing q_j^{SO}, while both firms are active in equilibrium. Comparing q_j^{SO} and aggregate equilibrium output $q_k^{M-Both} + q_j^{M-Both}$, we obtain that $q_j^{SO} \geq q_k^{M-Both} + q_j^{M-Both}$ if and only if $c_k \leq c_j^A$. Since Region IIa lies above cutoff c_j^A, we find that $q_j^{SO} < q_k^{M-Both} + q_j^{M-Both}$, indicating that in this region there is an excessive production relative to the social optimum.

- In Region IIb, the social planner recommends no firm to be active, while both firms are active in equilibrium. Since $q_k^{SO} = q_j^{SO} = 0$ and $q_k^{M-Both} + q_j^{M-both} > 0$ there is an excessive production relative to the social optimum.

- In Region IIc, only firm k is active according to the social optimum, while both firms are active in equilibrium. Comparing equilibrium and socially optimum output, we obtain that $q_k^{SO} \geq q_k^{M-Both}$ since Region IIc lies below c_k^A. As a result, a socially insufficient output emerges in Region IIc.

In Region III, only firm j is active in equilibrium, which coincides with the social optimum since $c_k > c_k^{SO}$ and $c_k > c_j^{SO}$. Comparing output levels, we find that $q_j^{SO} < q_j^{M-j}$ since Region III lies entirely above cutoff c_j^B. Therefore, a socially excessive output emerges for all costs in Region III.

Case C**,** $\frac{1}{\sqrt{2}} \leq \lambda$**.** As depicted in Figure A3a, in this setting, cutoff c_j^{SO} originates above cutoff c_k^M since $a_k - \frac{a_j}{2\lambda} \geq a_k - \lambda a_j$, cutoff c_k^M originates above cutoff c_k^B since $a_k - \lambda a_j > a_k - \frac{4\lambda a_j}{1+4\lambda^2}$, cutoff c_k^B originates above c_k^A since $a_k - \frac{4\lambda a_j}{1+4\lambda^2} > a_k - \frac{3\lambda a_j}{1+2\lambda^2}$, cutoff c_k^A originates above c_j^B since $a_k - \frac{3\lambda a_j}{1+2\lambda^2} \geq a_k - \frac{(1+4\lambda^2)a_j}{4\lambda}$, cutoff c_j^B originates above c_j^A since $a_k - \frac{(1+4\lambda^2)a_j}{4\lambda} > a_k - \frac{(1+2\lambda+4\lambda^2)a_j}{1+4\lambda}$, cutoff c_j^A originates above c_j^M given that $a_k - \frac{(1+2\lambda+4\lambda^2)a_j}{1+4\lambda} > a_k - \frac{a_j}{\lambda}$, and cutoff c_j^M originates above cutoff c_k^{SO} given that $a_k - \frac{a_j}{\lambda} \geq a_k - 2\lambda a_j$. Furthermore, as depicted in Figure A3b, cutoff c_j^{SO} originates above cutoff c_k^M since $a_k - \frac{a_j}{2\lambda} \geq a_k - \lambda a_j$, cutoff c_k^M originates above c_j^M given that $a_k - \lambda a_j > a_k - \frac{a_j}{\lambda}$, and cuotff c_j^M originates above c_k^{SO} since $a_k - \frac{a_j}{\lambda} \geq a_k - 2\lambda a_j$.

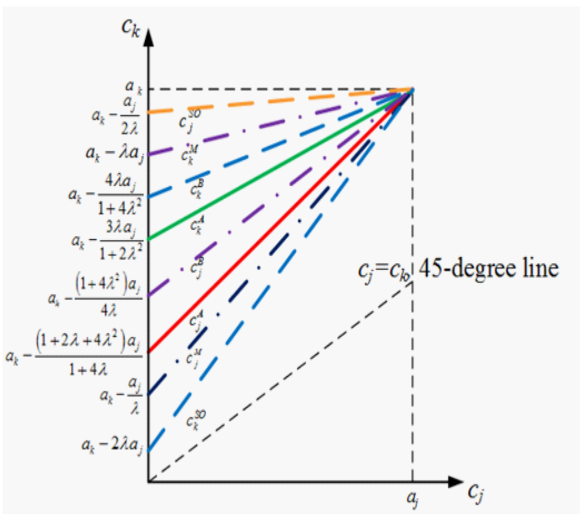

Fig. A3a. Cutoffs when $\frac{1}{\sqrt{2}} \leq \lambda$.

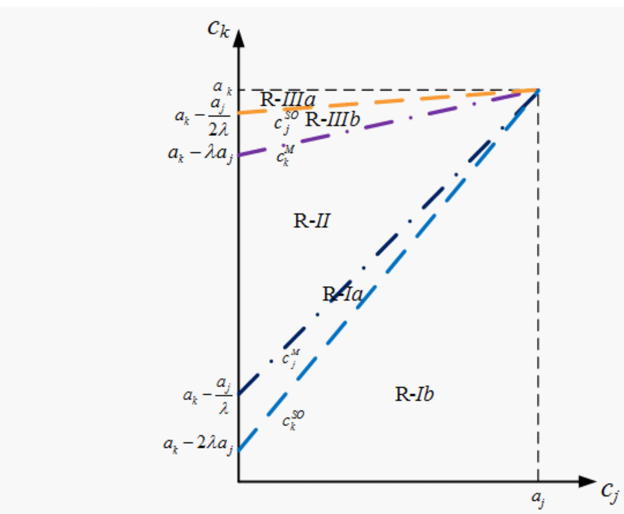

Fig. A3b. Production regions when $\frac{1}{\sqrt{2}} \leq \lambda$.

Starting at Region I, where $c_k < c_j^M$, only firm k is active in equilibrium. The social planner, however, would only recommend that firm k is active when c_k satisfies $c_k < c_k^{SO}$; and that no firm is active if $c_k^{SO} \leq c_k < c_j^M$. Graphically, this entails that Region I is divided into two subregions, which we refer as regions Ia and Ib, respectively.

- In Region Ia, the social planner recommends no firm to be active, while firm k is active in equilibrium. Since $q_k^{SO} = 0$ and $q_k^{M-k} > 0$ there is an excessive production relative to the social optimum.

- In Region Ib, only firm k is active according to the social optimum, which coincides with the equilibrium output profile. Comparing equilibrium and socially optimal output, we obtain that $q_k^{SO} \geq q_k^{M-k}$ since Region Ib lies below cutoff c_k^B. As a result, a socially insufficient output emerges in Region Ib.

In Region II, where $c_j^M \leq c_k < c_k^M$, both firms are active in equilibrium. However, no firm is active according to the social optimum. Since $q_k^{SO} = q_j^{SO} = 0$ and $q_k^{M-Both} + q_j^{Both} > 0$ there is an excessive production relative to the social optimum.

In Region III, only firm j is active in equilibrium. The social planner, however, would only recommend that firm j is active when c_k satisfies $c_j^{SO} \leq c_k$; and that no firm is active if $c_k < c_j^{SO}$. Graphically, this entails that Region III is divided into two subregions, which we refer as regions IIIa and IIIb, respectively.

- In Region IIIa, only firm j is active in according to the social optimum, which coincides with the equilibrium output profile. Comparing output levels, we find that $q_j^{SO} < q_j^{M-j}$ since Region IIIa lies above c_j^B. Therefore, a socially excessive output emerges in Region IIIa.
- In Region IIIb, the social planner recommends no firm to be active. Since $q_k^{SO} = q_j^{SO} = 0$ and $q_j^{M-j} > 0$ there is an excessive production relative to the social optimum.

We can next summarize all cases in which equilibrium output is socially insufficient, as follows:

1. Case A, $\lambda < \frac{1}{2}$: (a) Region I, where $c_k < c_j^M$; (b) Region IIb, where $c_j^{SO} \leq c_k < c_k^A$; and (c) Region IIc, where $c_j^M \leq c_k < c_j^{SO}$. However, all regions in Case A (a)-(c) can be collapsed with condition $c_k < c_k^A$.
2. Case B, $\frac{1}{2} \leq \lambda < \frac{1}{\sqrt{2}}$: (a) Region I, where $c_k < c_j^M$; and (b) Region IIc, where $c_j^M \leq c_k < c_j^{SO}$. However, regions in Case B (a)-(b) can be collapsed with condition $c_k < c_k^{SO}$.
3. Case C, $\frac{1}{\sqrt{2}} \leq \lambda$: Region Ib, where $c_k < c_k^{SO}$.

Furthermore, we can say that Cases B and C emerge when $\lambda \geq \frac{1}{2}$ and $c_k < c_k^{SO}$. In summary, socially insufficient production occurs in two cases: (a) when λ satisfies $\lambda < \frac{1}{2}$ and $c_k < c_k^A$; or (b) when λ satisfies $\lambda \geq \frac{1}{2}$ and $c_k < c_k^{SO}$.

We can now operate similarly, and list all the cases in which socially excessive production was identified:

1. Case A, $\lambda < \frac{1}{2}$: (a) Region IIa, where $c_k^{SO} \leq c_k < c_k^M$; (b) Region IIb, where $c_k^A \leq c_k < c_k^{SO}$; and (c) Region III, where $c_k^M \leq c_k$. However, regions in Case A (a)-(c) can be collapsed with condition $c_k^A \leq c_k$.
2. Case B, $\frac{1}{2} \leq \lambda < \frac{1}{\sqrt{2}}$: (a) Region IIa, where $c_j^{SO} \leq c_k < c_k^M$; (b) Region IIb, where $c_k^{SO} \leq c_k < c_j^{SO}$; and (c) Region III, where $c_k^M \leq c_k$. However, regions in Case B (a)-(c) can be collapsed with condition $c_k^{SO} \leq c_k$.

3. Case C, $\frac{1}{\sqrt{2}} \leq \lambda$: (a) Region Ia, where $c_k^{SO} \leq c_k < c_j^M$; (b) Region II, where $c_j^M \leq c_k < c_k^M$; (c) Region IIIa, where $c_j^{SO} \leq c_k$; and (d) Region IIIb, where $c_k^M \leq c_k < c_j^{SO}$. However, regions in Case C (a)-(d) can be collapsed with condition $c_k^{SO} \leq c_k$.

Furthermore, we can collapse the conditions under which Cases B and C arise to just $\lambda \geq \frac{1}{2}$ and $c_k^{SO} \leq c_k$. In summary, socially excessive production occurs in two cases: (i) when λ satisfies $\lambda < \frac{1}{2}$ and $c_k \geq c_k^A$; or (ii) when λ satisfies $\lambda \geq \frac{1}{2}$ and $c_k \geq c_k^{SO}$.

6.6 *Proof of Corollary 2*

Undifferentiated products, $\lambda = 1$. In this context, cutoffs c_k^A, c_k^M and c_j^M coincide, becoming $(a_k - a_j) + c_j$. As depicted in Figure A4a, in this setting, cutoff c_j^{SO} originates above c_k^B since $a_k - \frac{1}{2}a_j > a_k - \frac{4}{5}a_j$, cutoff c_k^B originates above c_k^A, c_k^M and c_j^M since $a_k - \frac{4}{5}a_j > a_k - a_j$, cutoffs c_k^A, c_k^M and c_j^M originate above c_j^B since $a_k - a_j > a_k - \frac{5}{4}a_j$, and cutoff c_j^B originates above c_j^A since $a_k - \frac{5}{4}a_j > a_k - \frac{7}{5}a_j$, and cutoff c_j^A originates above c_k^{SO} given that $a_k - \frac{7}{5}a_j > a_k - 2a_j$. Furthermore, as depicted in Figure A4b, cutoff c_j^{SO} originates above cutoff c_k^A, c_k^M and c_j^M since $a_k - \frac{1}{2}a_j > a_k - a_j$, and cutoffs c_k^A, c_k^M and c_j^M originate above c_k^{SO} since $a_k - a_j > a_k - 2a_j$.

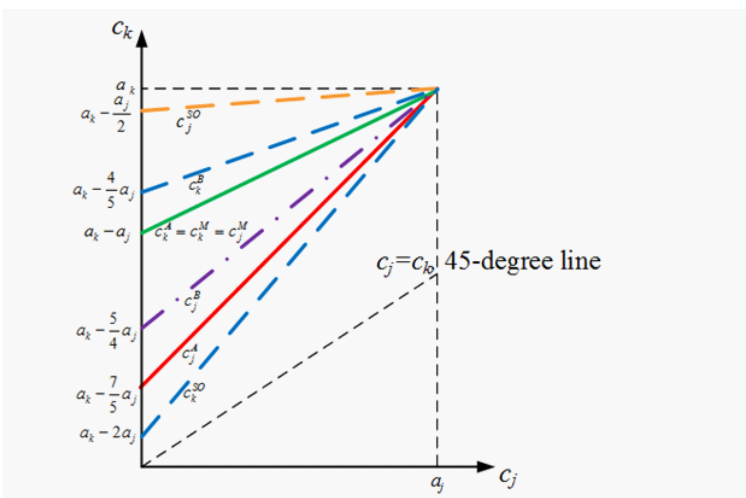

Fig. A4a. Cutoffs when $\lambda = 1$.

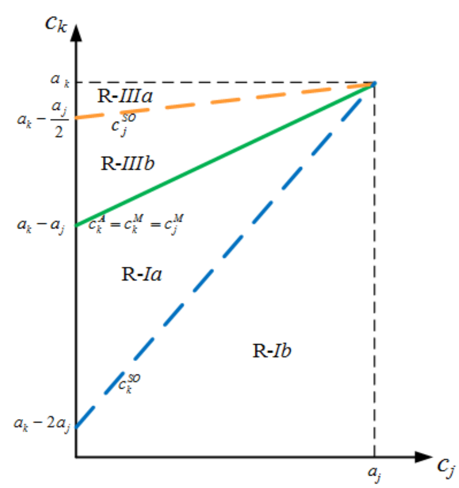

Fig. A4b. Production regions when $\lambda = 1$.

Starting at Region I, where $c_k < c_j^M$, only firm k is active in equilibrium. The social planner, however, would only recommend that no firm is active if $c_k^{SO} \leq c_k < c_j^M$; and that firm k is active when c_k satisfies $c_k < c_k^{SO}$. Graphically, this entails that Region I is divided into two subregions, which we refer as regions Ia and Ib, respectively.

- In Region Ia, the social planner recommends no firm to be active, while firm k is active in equilibrium. Since $q_k^{SO} = 0$ and $q_k^{M-k} > 0$ there is an excessive production relative to the social optimum.

- In Region Ib, only firm k is active according to the social optimum, which coincides with the equilibrium output profile. Comparing equilibrium and socially optimal output, we obtain that $q_k^{SO} \geq q_k^{M-k}$ since Region Ib lies entirely below cutoff c_k^B. As a result, a socially insufficient output emerges in Region Ib.

In Region III, only firm j is active in equilibrium. The social planner, however, would only recommend that firm j is active when c_k satisfies $c_j^{SO} \leq c_k$; and that no firm is active if $c_k < c_j^{SO}$. Graphically, this entails that Region III is divided into two subregions, which we refer as regions IIIa and IIIb, respectively.

- In Region IIIa, only firm j is active in according to the social optimum, which coincides with the equilibrium output profile. Comparing output levels, we find that $q_j^{SO} < q_j^{M-j}$ since Region IIIa lies entirely above c_j^B. Therefore, a socially excessive output emerges in Region IIIa.

- In Region IIIb, the social planner recommends no firm to be active. Since $q_k^{SO} = q_j^{SO} = 0$ and $q_j^{M-j} > 0$ there is an excessive production relative to the social optimum.

We can next summarize in which cases equilibrium output is socially insufficient or excessive. Socially insufficient production was only identified in Region Ib, where $c_k < c_k^{SO}$; while socially excessive production was identified in Region Ia, where $c_k^{SO} \leq c_k < c_j^M$; Region IIIa, where $c_j^{SO} \leq c_k$; and Region IIIb, where $c_k^M \leq c_k < c_j^{SO}$. However, these three regions of c_k can be collapsed to $c_k^{SO} \leq c_k$.

Completely differentiated products, $\lambda = 0$. As depicted in Figure A5, in this setting, all cutoffs except for c_j^A collapse to the same line (i.e., they are all horizontal line originating at a_k), yielding only one possible outcome: Region I, where firm k is the only active plant if $c_k < c_j^M$.

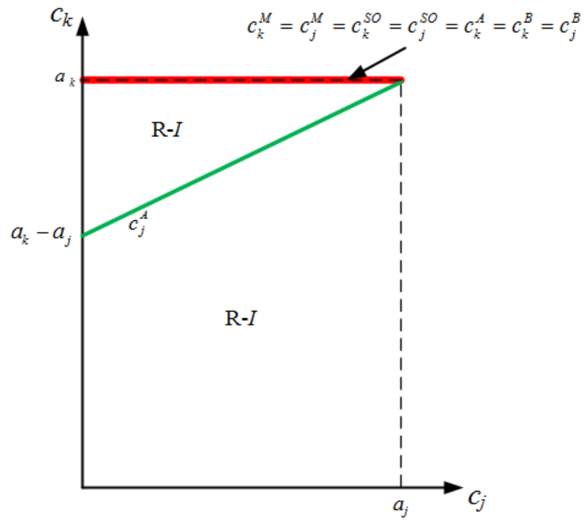

Fig. A5. Cutoffs and production regions when $\lambda = 0$.

Starting at Region I, where $c_k < c_j^M$, only firm k is active in equilibrium. The social planner would also have only firm k being active since in this region c_k satisfies $c_k < c_k^{SO}$ and $c_k < c_j^{SO}$. We can then compare equilibrium and socially optimal output, q_k^{M-k} and q_k^{SO}, obtaining that $q_k^{SO} \geq q_k^{M-k}$ since Region I lies entirely below cutoff c_k^B. Therefore, a socially insufficient output emerges in Region I, relative to the social optimum.

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