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Abstract

In this note we introduce mergers and an endogenous minimum quality standard in a Cournot triopoly with vertically differentiated quality and fixed quality costs. As in Ecchia and Lambertini (1997) we endogenize the choice of the minimum quality standard by allowing the regulator to chose the standard that maximizes social welfare. We show that, without mergers, an endogenous minimum quality standard increases differentiation by reducing the minimum quality. This implies a reduction in the consumer surplus but an increase in the industry profit. When mergers are allowed, we show that merging always result in a standard duopoly because each new entity shuts down the lowest quality. Without the minimum quality standard, mergers produce a minimum quality higher than the socially optimal level. Consumer surplus and market coverage get reduced but welfare increases. Under the minimum quality standard, although mergers remain consumer surplus reducing and social welfare increasing, the minimum quality decreases and market coverage increases. All mergers result in a lower market share, with and without regulation.

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Keywords: Mergers; Minimum quality standard; Quality differentiation; Market coverage.

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1 Introduction

Literature on minimum quality standard (MQS henceforth) has been widely extended in models with vertically differentiated quality, however a mergers analysis under endogenous MQS is still missing. This note aims at filling this gap and it shows that a MQS may increase welfare and market coverage respect to case of unregulated mergers. This issue is worth to be addressed when MQS are imposed and market coverage is an important variable in deciding whether to allow a merger. Airlines (with the introduction of low cost companies), cars (in terms of compulsory investment in safety), baby food and rail freight are examples of industries with vertically differentiated quality in which MQS are crucial and mergers usually occur.[1]

We set up a Cournot triopoly with vertically differentiated quality and fixed development costs. Following Ecchia and Lambertini (1997), we introduce a Regulator that fixes a MQS maximizing the social welfare by playing a simultaneous game with profit-maximizers competitors. We show that, without a MQS, mergers are consumer surplus and market coverage reducing but welfare increasing. Under a MQS, instead, although they reduce consumer surplus and increase social welfare even more, market coverage increases. Furthermore, all mergers result in a reduction of the market share, with and without MQS.

Without mergers, endogenous MQS increases differentiation by reducing the minimum quality. This implies a reduction in the consumer surplus but an increase in the industry profit. The only consumers benefiting from such a MQS are those that without regulation would be out of the market. The profit of the lowest quality firm decreases while the profits of medium-high quality firms increase. The reduction in the minimum quality is due to the fact that (as showed in Pezzino 2006), in a Cournot triopoly, an exogenous increase in MQS induces a reduction in industry profit that outweights the increase in consumer surplus. Thus, a MQS that maximizing also industry profit induces the Regulator to shrink the minimum quality.

When, instead, mergers occur, these always result in a standard duopoly because each new entity shuts down the lowest quality by reducing differentiation. This result holds with and without MQS. However, when mergers are unregulated, minimum quality gets higher than its socially optimal level. MQS, indeed, induces the low-quality duopolist to deliver a minimum quality lower than the level that would be produced in case of unregulated merger. This reaction leads to an increase in the market coverage. Furthermore, with and without MQS, shutting down one quality induces new entities to produce less than the quantities produced by the insiders without merger, therefore all mergers result in a lower market share.

[1] The recent paper of Pilsbury and Meaney (2009) analyzes the impact of mergers in rail freight market by discussing some recent examples: *i)* SNCF/Trenitalia/AFA in the rail freight services on the Lyon–Turin, *ii)* Arcelor/SNCF/CFL Cargo in the freight services with origination or destination in Luxembourg, *iii)* Deutsche Bahn/EWS on the routes from the northwestern European ports to northern Italy. The issue of quality requirements in the rail freight system has been recently rising in Italy after the disaster occured at Viareggio train station where a train transporting liquid gas crushed and killed 26 people.

To the best of our knowledge this is the first paper introducing mergers in a Cournot triopoly under endogenous MQS. Our result contradicts the general idea in Motta (2004) that horizontal mergers are welfare reducing because the reduction in consumer surplus overweights the increases in producer surplus. An endogenous MQS, in fact, increases market coverage and total welfare respect to the case of unregulated mergers. The only paper dealing with mergers in market with vertically differentiated quality is Barbot (2001). However, she studies the effect of horizontal mergers under Bertrand competition without MQS. In her model the lowest quality is eliminated when low-quality firms merger, whereas, if the merge involves high-quality firms, all qualities remain in the market. In particular, the merger is welfare increasing in the first scenario and welfare reducing in the second.

Previous literature strictly related to MQS has been widely extended under Cournot and Bertrand competition. Ecchia and Lambertini (1997) is the only paper to introduce an endogenous MQS whereas the rest of this literature treats MQS as a marginal increase in the lowest quality in the market. They find that, in a Bertrand duopoly, MQS reduces differentiation and increases total welfare because the gains for the low-quality firm and low-income consumers outweigh the losses for the high-quality firm and high-income consumers. Motta and Thisse (1993), instead, show that, in a Bertrand duopoly with exogenous MQS, social welfare increases with the level of the quality standard. Scarpa (1998) extends Bertrand model to three firms and finds that an exogenous MQS leads to an increase in consumer welfare that outweights the reductions in profits. Valletti (2000) shows that the effect of the MQS also depends on the nature of competition. He, in fact, finds that in a Cournot duopoly an exogenous MQS is unambiguously social welfare reducing. Pezzino (2006) finds the same result in a Cournot triopoly. Jinji and Toshimitsu (2004) show that the result in Valletti (2000) is robust if endogeneity of quality ordering and asymmetry in the fixed costs of quality are introduced.

Our result is in line with literature on MQS because we confirm that the effect of MQS (with and without mergers) depends on Regulator's utility and the nature of competition.

We can drawn two policy implications. First, an endogenous MQS may be a good policy to improve total welfare (with and without mergers) and increase market coverage that mergers usually shrink. Second, under quality differentiation, antitrust practice of allowing mergers that reduce market share may reduce consumer surplus and market coverage.[2]

The model is organized as follows. In section 2 we describe the standard triopoly. Section 3 introduces the Regulator. Section 4 and 5 study mergers respectively without and with MQS. Section 6 concludes.

[2] As Pilsbury and Meaney (2009) explain, several mergers involving rail freight companies were accepted by the European Commission because their market shares were considered sufficiently low. For example, the merger among Deutsche Bahn and Bax Global resulted in a market share not exceeding the 10%.

2 The model

Consider a triopoly market with vertically differentiated quality (q_i, with $i = 1, 2, 3$). We assume that each firm supplies only one quality, with $q_3 < q_2 < q_1$, and each consumer consumes only one product. Each firm i produces a quantity denoted by x_i. The costs depends only on quality and are given by $c_i = \frac{(q_i)^2}{2}$. As standard the profit is $\pi_i = p_i x_i - c_i$. Consumers are differentiated according to their quality preference θ that is uniformly distributed over $[0, 1]$, as usual θ also measures their marginal willingness to pay for quality. Utility of consuming product i is:

$$U = \theta q_i - p_i \tag{1}$$

As standard, the marginal consumers are:

$$\widetilde{\theta}_1 = \frac{p_1 - p_2}{q_1 - q_2}, \quad \widetilde{\theta}_2 = \frac{p_2 - p_3}{q_2 - q_3}, \quad \widetilde{\theta}_3 = \frac{p_3}{q_3} \tag{2}$$

In words, $\widetilde{\theta}_3$ is the share of consumers out of market, $\widetilde{\theta}_2 - \widetilde{\theta}_3$ buy from firm 3, $\widetilde{\theta}_1 - \widetilde{\theta}_2$ from firm 2 and $1 - \widetilde{\theta}_1$ from firm 1. By inverting the demand functions we obtain:[3]

$$p_1 = q_1 - q_1 x_1 - q_2 x_2 - q_3 x_3 \tag{3}$$

$$p_2 = q_2 - q_2 x_1 - q_2 x_2 - q_3 x_3 \tag{4}$$

$$p_3 = (1 - x_1 - x_2 - x_3)\, q_3 \tag{5}$$

The profits are:

$$\pi_1 = (q_1 - q_1 x_1 - q_2 x_2 - q_3 x_3)\, x_1 - \frac{(q_1)^2}{2} \tag{6}$$

$$\pi_2 = (q_2 - q_2 x_1 - q_2 x_2 - q_3 x_3)\, x_2 - \frac{(q_2)^2}{2} \tag{7}$$

$$\pi_3 = (1 - x_1 - x_2 - x_3)\, q_3 x_3 - \frac{(q_3)^2}{2} \tag{8}$$

As standard in this literature, we set up a two-stage game. In the first stage firms choose quality, while in the second they compete in quantity. The solution is characterized by a sub game perfect equilibrium. In what follows we firstly find the effect of a MQS in a market without merger, then we study all possible bilateral mergers with and without a MQS.

[3] Given the marginal consumers, demand functions are $x_1 = -\frac{p_1 - p_2 - q_1 + q_2}{q_1 - q_2}$, $x_2 = \frac{p_1 - p_2}{q_1 - q_2} - \frac{p_2 - p_3}{q_2 - q_3}$ and $x_3 = \frac{p_2 - p_3}{q_2 - q_3} - \frac{p_3}{q_3}$.

2.1 Triopoly without Regulator

The triopoly equilibrium in absence of Regulator is straightforward then we just give the prices and qualities:

$$q_1^* = 0.2522, \quad q_2^* = 0.08946, \quad q_3^* = 0.0261 \tag{9}$$

$$p_1^* = 0.11276, \quad p_2^* = 0.02278, \quad p_3^* = 0.00388 \tag{10}$$

with marginal consumers:

$$\widetilde{\theta}_1^* = 0.5529, \quad \widetilde{\theta}_2^* = 0.2983, \quad \widetilde{\theta}_3^* = 0.14866 \tag{11}$$

and equilibrium quantities:

$$x_1^* = 0.44711, \quad x_2^* = 0.25469, \quad x_3^* = 0.14909 \tag{12}$$

The firm delivering the highest quality obtains almost half the market. Let us define the market share of firm i and j, with $j \neq i$, as $m_{i,j}^* = \frac{x_i^* + x_j^*}{\sum_i x_i^*}$. Accordingly, we compute all possible equilibrium market shares:

$$m_{2,3}^* = 0.47452, \quad m_{1,3}^* = 0.70068, \quad m_{1,2}^* = 0.82478 \tag{13}$$

The consumer surplus is:

$$CS^* = 0.041323 \tag{14}$$

and profits:

$$\pi_1^* = 0.01862, \quad \pi_2^* = 0.0018, \quad \pi_3^* = 0.00024 \tag{15}$$

The equilibrium profit is increasing in the level of quality. Social welfare, W, is simply defined by the unweighted sum of aggregate profit and consumer surplus, then:

$$W^* = 0.061983 \tag{16}$$

3 The Regulator

We follows Ecchia and Lambertini (1997) and allow the Regulator to set the endogenous MQS by choosing the level of the minimum quality in a simultaneous game played with the other profit-maximizers firms. At the first period, the maximization problem of the Regulator writes:

$$\max_{q_3} W = CS + \sum_i \pi_i \tag{17}$$

Given the best reply of the Regulator obtained by (17) we have the first result.

Proposition 1 *The introduction of a MQS is consumer surplus reducing but market coverage and social welfare increasing.*

Denoting as $q_{i,R}$ the triopoly quality under MQS, the intuition for the result is directly provided by the equilibrium qualities:

$$q^*_{1,R} = 0.2519, \quad q^*_{2,R} = 0.0900, \quad q^*_{3,R} = 0.00313 \tag{18}$$

The introduction of an endogenous MQS reduces the minimum quality in the market. In our model an exogenous marginal increases in the MQS would reduce the social welfare,[4] therefore, despite a higher MQS would increase the consumer surplus, it reduces the aggregate profit by more. Since Regulator chooses a MQS by also caring about the aggregate profit, then she reduces the minimum quality respect to the case of no regulation in order to increase the profits. The consumer surplus is:

$$CS^*_R = 0.0403 \tag{19}$$

Denoting $\widetilde{\theta}_{i,R}$ as the marginal consumer under MQS, we have the following equilibrium values:

$$\widetilde{\theta}^*_{3,R} = 0.1386, \quad \widetilde{\theta}^*_{2,R} = 0.27743, \quad \widetilde{\theta}^*_{1,R} = 0.54951 \tag{20}$$

The minimum marginal consumer, $\widetilde{\theta}^*_{3,R}$, is lower than in case of no-regulation, therefore the endogenous MQS reduces the share of consumer out of the market. Although the reduction of the lowest quality allows more consumers to be served (consumers with preference in the range $\widetilde{\theta}^*_{3,R} \leq \theta \leq \widetilde{\theta}^*_3$), consumer surplus decreases. Under MQS, in fact, all consumers that would be served also without regulation are worse-off. In particular, consumers of good 2, with and without MQS ($\widetilde{\theta}^*_2 \leq \theta \leq \widetilde{\theta}^*_{1,R}$), pays more for a lower quality. The same result holds for those that keep consuming good 1 even under MQS ($\widetilde{\theta}^*_1 \leq \theta \leq 1$). Consumers

[4] This result is obtained in Valletti (2000), Jinji and Toshimitsu (2004) and Pezzino (2006).

of good 3, with and without MQS ($\widetilde{\theta}_3^* \leq \theta \leq \widetilde{\theta}_{2,R}^*$), pay a lower price for a too low quality. Consumers switching from good 3 to good 2 and from good 2 to good 1 ($\widetilde{\theta}_{2,R}^* \leq \theta \leq \widetilde{\theta}_2^*$ and $\widetilde{\theta}_{1,R}^* \leq \theta \leq \widetilde{\theta}_1^*$) receive a higher quality but they pay a too high price.[5]

The social welfare is:

$$W_R^* = 0.062368 \tag{21}$$

Social welfare increases because the introduction of an endogenous MQS increases the total profits. In particular, the reduction of the minimum quality reduces the profit of firm 3 while increases the profit of firm 1 and 2. Despite the reduction in q_3 drives to firm 3 a share of consumers that without regulation would be out of the market, the total demand for firm 3 gets lower. The reduction in q_3 increases the differentiation in the market, specially between firm 2 and 3. Firm 2 benefits more from the introduction of the MQS, it produces a higher quality at a higher price, whereas firm 1 reduces quality and increases its price.

4 Mergers without MQS

In this sections we allow all possible bilateral mergers involving in order 1-2, 2-3 and 1-3. When two firms merge the new entity maximizes their joint profits by choosing quantities at the second stage and quality at the first.

Let $\overline{q}$, $\underline{q}$, $\overline{p}$ and $\underline{p}$ be the highest and the minimum quality and prices after a merger. The following Lemma provides the first result in terms of mergers:

Lemma 1 *Without MQS each bilateral merger produces only one good by resulting in a lower market share and leading to a duopoly with* $\overline{q} = 0.25194$ *and* $\underline{q} = 0.090223$.

Since in this model all firms have symmetric costs only depending on quality, once two firms merge they internalize the strategic and the competitive effect on the quality of the partner, then the merged entity increases the differentiation between insiders so as to increase the price.[6] With symmetric and exogenous quality every firm prefers to produce the highest quality good, therefore once a bilateral merger occurs the new entity stops producing the lowest quality.[7] Hence, the new entity resulting from the merger of 2 and 3 would become the duopolist producing $\underline{q}$, whereas merger between 1 and 2, and 1 and 3 result in the duopolist producing $\overline{q}$.[8] The minimum quality gets extremely higher

[5] All these proofs are simply computations of consumer surplus, with and without MQS, for each range of θ.

[6] We stress that all mergers are profitable.

[7] It is possible to show that the merged entity prefers to produce only one quality even under variable costs, i.e. $c_i = x_i (q_i)^2$.

[8] The proof includes standard computation and it is in the Appendix.

than in absence of mergers therefore differentiation decreases. After a bilateral mergers, in fact, the difference between the highest and the minimum quality gets narrowed (in fact $q_1^* - q_3^* = 0.226\,1$ and $\overline{q} - \underline{q} = 0.16172$).

If we denote $\overline{\theta}$ and $\underline{\theta}$ as the highest and the lowest marginal consumer after unregulated mergers, the equilibrium price and marginal consumers are:

$$\overline{p} = 0.11358, \quad \underline{p} = 0.024774 \tag{22}$$

$$\overline{\theta} = 0.54914, \quad \underline{\theta} = 0.27459 \tag{23}$$

Let $\underline{m}$ and $\overline{m}$ denote the market share of the duopolist producing respectively $\underline{q}$ and $\overline{q}$ after the merger. Equilibrium values in (22)-(23) imply the following result:

Proposition 2 *All mergers without MQS reduce consumer surplus, market share and market coverage, but are social welfare increasing.*

This result arises from the reduction in quality differentiation. The reduction in the market coverage is due to the increase in the minimum quality that becomes too expensive for consumers with a low willingness to pay. However, after the merger, all consumers are worse-off (the consumer surplus is $CS_M = 0.040175$). In particular, some consumers that before the merger could afford good 3, after the merger are out of the market. Consumers of good 1, with and without the merger, are unambiguously worse-off because they receive a lower quality at higher price. All the other consumers, instead, receive a higher quality but a too high price.[9] The increase in the aggregate profit, due to a lower differentiation, overweights the reduction in the consumer surplus (social welfare becomes $W_M = 0.062375$). All bilateral mergers are profitable for the insiders and the outsider. The highest profit is always gained by the firm producing the highest quality, regardless whether is the new entity or not. Shutting down one quality induces the new entity to produce less than the sum of the quantities produced by the insiders without the merger, therefore the merger results in a lower market share ($\underline{m} = 0.37852$ and $\overline{m} = 0.62148$). This result mines the standard antitrust practice according to which merger should be allowed when it does not lead to an increase of the market share. Under vertically differentiated quality and fixed costs, in fact, mergers resulting in a lower market share may be consumer welfare and market coverage reducing.

[9] In particular, we have that: 1) consumers in the range $\overline{\theta} \leq \theta \leq \widetilde{\theta}_1^*$ switch from 2 to the highest post merger quality, while 2) consumers in $\widetilde{\theta}_2^* \leq \theta \leq \overline{\theta}$ and $\underline{\theta} \leq \theta \leq \widetilde{\theta}_2^*$ switch to the lowest post merger quality respectively from 2 and 3. The net consumer surplus is simply obtained by the difference between the integrals of utility over the marginal consumers pre and after MQS.

5 Mergers under MQS

The introduction of a MQS at the first stage of the game does not change the quantity decision taken at the second stage by the merging firms, that is, only the highest quality good is produced. However, at the first stage, the Regulator plays a simultaneous game with the firm producing the highest quality, and whether she acts as outsider or new entity depends on which firms merge. In particular, when the merger involves the lowest qualities firms (2 and 3) the Regulator *de fact* sets the optimal quality on behalf of the new entity, instead when the merger involves 1 and 2 or 1 and 3, since the new entity produces only the highest quality, the Regulator acts as outsider. Let $\overline{q}_R$, $\underline{q}_R$, $\overline{p}_R$ and $\underline{p}_R$ be the highest and the minimum quality and prices after a merger. In general, Regulator's maximization problem writes:

$$\max_{\underline{q}_R} W = CS + \pi_{-i} + \Pi_{i,j} \tag{24}$$

with $-i \neq i \neq j$, where π_{-i} and $\Pi_{i,j}$ are respectively the profits of the outsider and the new entity. Whether the new entity produces $\underline{q}_R$ depends on which firms are involved in the merger.

The following Lemma gives the first result in terms of MQS and mergers:

Lemma 2 *When MQS is introduced, each merger leads to a duopoly in which* $\overline{q}_R = 0.25039$ *and* $\underline{q}_R = 0.039411$.

The introduction of a MQS confirms the result of Proposition 1: all mergers shuts down the production of the lowest quality by leading to a standard duopoly. Merger involving the intermediate and low-quality firm results in the duopolist producing $\underline{q}_R$. The main difference with the case of merger without regulation is the difference in the minimum quality. Endogenous MQS, in fact, reduces the minimum quality respect to the case of unregulated mergers. This is due to fact that, under MQS, the lowest-quality firm is substituted by the Regulator that sets the minimum level in order to maximize the social welfare, whereas, without regulation, the lowest-quality firm only maximizes its profit (as new entity or outsider). Since an exogenous increase in MQS would reduce the aggregate profit, then the Regulator reduces the minimum quality in order to avoid this effect. However, since Regulator also maximizes consumer surplus, she reduces the share of consumers out of the market by shrinking the minimum quality. Let $\overline{\theta}_R$ and $\underline{\theta}_R$ denote the highest and the lowest marginal consumer when mergers are regulated. The equilibrium prices and marginal consumers become:

$$\overline{p}_R = 0.12007, \quad \underline{p}_R = 0.010256 \tag{25}$$

$$\overline{\theta}_R = 0.52050, \quad \underline{\theta}_R = 0.26023 \tag{26}$$

Let $\underline{m}_R$ and $\overline{m}_R$ denote the market share of the duopolist producing respectively $\underline{q}_R$ and $\overline{q}_R$ after the merger under MQS. The following proposition shows the effect of mergers under regulation:

Proposition 3 *Under MQS, mergers remain consumer surplus reducing and social welfare increasing, but the market coverage increases. All mergers result in a market share reduction.*

The introduction of an endogenous MQS increases differentiation by reducing the minimum quality. This higher differentiation benefits the highest-quality firm that gains more than the profit gained without regulator, whereas the profit of the lowest-quality firm is lower. The increase in the profit of the highest-quality firm overweights the loss of the other duopolist, then aggregate profit is higher when merger are regulated. Although a lower minimum quality allows more consumers to be served, consumer surplus is even lower than in case of unregulated mergers. In particular, consumers of the highest quality, before and after MQS, are unambiguously worse-off because they pays more for a lower quality. The same result holds for those that consume minimum quality with and without MQS, in fact, they end up to pay a lower price for a too low quality. Consumers switching from minimum quality, without regulation, to the highest quality, under MQS, receive a higher quality but at a too high price. However, merging under MQS is social welfare increasing because the reduction in consumer surplus is outweighted by the increase in the aggregate profit ($CS_{MR} = 0.035040$ and $W_{MR} = 0.063159$). Even under MQS the elimination of one quality drives consumer surplus and new entity's market share in the same direction because mergers always result in a lower market share ($\underline{m}_R = 0.35179$, $\overline{m}_R = 0.64821$).

6 Conclusions

In this paper we introduce an endogenous MQS, borrowed by Ecchia and Lambertini (1997), in a Cournot triopoly with vertically differentiated quality and fixed quality costs and study the effect of bilateral mergers. We find that, without mergers, such a MQS increases differentiation by reducing the minimum quality. This higher differentiation benefits only medium and high-quality firms and consumers that without regulation would be out of the market. When mergers occur, they always result in a standard duopoly because each new entity shuts down the lowest quality. Without MQS, mergers are consumer surplus and market coverage reducing but welfare increasing. However, minimum quality gets higher than its socially optimal level. Endogenous MQS, indeed, reduces the minimum quality so that market coverage increases. Such a reaction implies that consumer surplus and social welfare get respectively lower and higher than under unregulated mergers. Furthermore, all mergers result in a lower market share, with and without MQS. In terms of antitrust policy, our results show that, in market with vertically differentiated quality, mergers may be welfare improving even if consumers are worse-off. However, unregulated mergers induce an excessive minimum quality. Endogenous MQS, by reducing minimum quality, could contrast the reduction in market coverage that these mergers usu-

ally imply. This paper also suggests that, under quality differentiation, allowing mergers that reduce market share could be harmful for consumers.

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7 Appendix A

All computations are made by Maple.

Proof of Proposition 1
The consumer surplus writes:

$$CS = \int_{\theta_{3,R}}^{\theta_{2,R}} (q_{3,R}\theta - p_{3,R})\, d\theta + \int_{\theta_{2,R}}^{\theta_{1,R}} (q_{2,R}\theta - p_{2,R})\, d\theta + \int_{\theta_{1,R}}^{1} (q_{1,R}\theta - p_{1,R})\, d\theta \tag{27}$$

At the second stage, the best responses of firm 1, 2 and 3 are the same of the case without MQS:

$$x_{1,R} = \frac{2q_{2,R}^2 - 4q_{1,R}q_{2,R} + q_{1,R}q_{3,R}}{2q_{2,R}^2 - 8q_{1,R}q_{2,R} + 2q_{1,R}q_{3,R}} \tag{28}$$

$$x_{2,R} = \frac{-2q_{1,R}q_{2,R} + q_{1,R}q_{3,R}}{2q_{2,R}^2 - 8q_{1,R}q_{2,R} + 2q_{1,R}q_{3,R}} \tag{29}$$

$$x_{3,R} = -q_{1,R}\frac{q_{2,R}}{2q_{2,R}^2 - 8q_{1,R}q_{2,R} + 2q_{1,R}q_{3,R}} \tag{30}$$

By substituting for the quantities, the prices at the first stage are:

$$p_{1,R} = \frac{1}{2}q_{1,R}\frac{-2q_{2,R}^2 + 4q_{1,R}q_{2,R} - q_{1,R}q_{3,R}}{-q_{2,R}^2 + 4q_{1,R}q_{2,R} - q_{1,R}q_{3,R}} \tag{31}$$

$$p_{2,R} = \frac{1}{2}q_{1,R}q_{2,R}\frac{2q_{2,R} - q_{3,R}}{-q_{2,R}^2 + 4q_{1,R}q_{2,R} - q_{1,R}q_{3,R}} \tag{32}$$

$$p_{3,R} = \frac{1}{2}q_{3,R}q_{1,R}\frac{q_{2,R}}{-q_{2,R}^2 + 4q_{1,R}q_{2,R} - q_{1,R}q_{3,R}} \tag{33}$$

that, after substituting for the optimal quantities chosen at the second stage, consumer surplus becomes:

$$CS = \frac{1}{8}q_{1,R}\frac{4q_{1,R}q_{2,R}^3 - 4q_{2,R}^4 + 16q_{1,R}^2q_{2,R}^2 + q_{1,R}^2q_{3,R}^2 - q_{1,R}q_{2,R}q_{3,R}^2 + q_{1,R}q_{2,R}^2q_{3,R} - 8q_{1,R}^2q_{2,R}q_{3,R}}{\left(-q_{2,R}^2 + 4q_{1,R}q_{2,R} - q_{1,R}q_{3,R}\right)^2}$$

then the equilibrium qualities at the first stage are:

$$q_{1,R} = 0.2519, \quad q_{2,R} = 0.0900, \quad q_{3,R} = 0.00313 \tag{34}$$

Quantities and equilibrium prices are:

$$x_{1,R}^* = 0.450\,49, \quad x_{2,R}^* = 0.272\,35, \quad x_{3,R}^* = 0.13858 \tag{35}$$

$$p^*_{1,R} = 0.1135, \quad p^*_{2,R} = 0.024534, \quad p^*_{3,R} = 0.00043374 \tag{36}$$

marginal consumers:

$$\widetilde{\theta}^*_{1,R} = 0.54951, \ \widetilde{\theta}^*_{2,R} = 0.27743, \quad \widetilde{\theta}^*_{3,R} = 0.1386 \tag{37}$$

and profits:

$$\pi^*_{1,R} = 0.019404, \ \pi^*_{2,R} = 0.0026318, \ \pi^*_{3,R} = 0.000055204 \tag{38}$$

Proposition 2 and 3 directly come from Lemma 1 and 2 then we omit them.■

Proof of Lemma 1

1) Merger between 2 **and** 3.

Given that the new entity maximizes the joint profits of merging firms, at the second stage optimal quantities are:

$$x_1 = \frac{-2q_1 + q_2}{-4q_1 + q_2}, \quad x_2 = -\frac{q_1}{-4q_1 + q_2}, \quad x_3 = 0 \tag{39}$$

that given $q_1 > q_2$ are both positive and also do not depend on q_3, as expected since $x_3 = 0$. This result implies that the merger shuts down the production on the lowest quality by leading to a duopoly. Since we are in a duopoly, we define $q_1 = \overline{q}$ and $\underline{q} = q_2$, and by maximizing with respect to quality, we have:

$$\overline{q} = 0.25194, \quad \underline{q} = 0.090223 \tag{40}$$

with prices:

$$\overline{p} = 0.11358, \quad \underline{p} = 0.024774 \tag{41}$$

Denoting $\overline{\pi}$ and $\underline{\pi}$ as the profit of the duopolist producing respectively the highest and the minimum quality we have:[10]

$$\underline{\pi} = 0.0027324 \tag{42}$$

$$\overline{\pi} = 0.019468 \tag{43}$$

The market share of the merger entity is:

$$\overline{m} = 0.37852 \tag{44}$$

The new marginal consumers are now:

[10] In this case $\underline{\pi}$ denotes the profit of the new entity.

$$\overline{\theta} = 0.54914, \quad \underline{\theta} = 0.27459 \tag{45}$$

2) Merger between 1 **and** 2**.**

Now the maximization problem gives the following quantities:

$$x_1 = \frac{1}{2}, \quad x_2 = \frac{q_3}{-8q_2 + 2q_3}, \quad x_3 = -\frac{q_2}{-4q_2 + q_3} \tag{46}$$

that cannot be all positive under $q_3 < q_2 < q_1$, then do not exist any equilibrium qualities such that all goods are produced under $q_3 < q_2 < q_1$.

3) Merger between 1 **and** 3**.**

In this case the optimal quantities are:

$$x_1 = \frac{2q_2^2 - 4q_1q_2 + q_1q_3 + q_2q_3}{2q_2^2 - 8q_1q_2 + 2q_1q_3 + 4q_2q_3} \tag{47}$$

$$x_2 = -\frac{q_1q_2 - q_2q_3}{q_2^2 - 4q_1q_2 + q_1q_3 + 2q_2q_3} \tag{48}$$

$$x_3 = -\frac{q_2^2 - q_1q_2}{2q_2^2 - 8q_1q_2 + 2q_1q_3 + 4q_2q_3} \tag{49}$$

It is easy to see that cannot exist $x_1, x_2, x_3 > 0$ under $q_3 < q_2 < q_1$.

We then can conclude that does not exist an equilibrium in which the merger produces two different positive qualities. Each merger always results in a duopoly. This result implies that a merger of firm 1 and 2 would produce $\overline{q}$, whereas the merger involves 1 and 3 induces the new entity to produce $\overline{q}$ with $q_2 < \overline{q} = q_3 = q_1$. Given this, to compute $\overline{q}$ and $\underline{q}$ we can simply use the duopoly with the following marginal consumers:

$$\overline{\theta} = \frac{\overline{p} - \underline{p}}{\overline{q} - \underline{q}}, \ \underline{\theta} = \frac{\underline{p}}{\underline{q}} \tag{50}$$

The rest of the proof is just an application of profit maximization and it implies straightforward computation. Since all mergers lead to a standard duopoly, then for all mergers we obtain the same equilibrium values of the case 1).■

Proof of Lemma 2

The endogenous MQS implies, at the first stage, the replacement of the maximization problem of the lowest-quality firm with the maximization problem of the Regulator. Thus previous results about shutting down the lowest quality good still holds, and the best response for quantities are as in (39). After substituting for optimal quantities and prices, consumer surplus and social welfare in case of merger are:

$$CS_{MR} = \frac{1}{2}\overline{q}_R \frac{4\overline{q}_R^2 - \underline{q}_R^2 + \overline{q}_R\underline{q}_R}{\left(4\overline{q}_R - \underline{q}_R\right)^2} \tag{51}$$

$$W_{MR} = -\frac{1}{2}\frac{-\overline{q}_R\underline{q}_R^2 + 5\overline{q}_R^2\underline{q}_R - 8\overline{q}_R\underline{q}_R^3 - 8\overline{q}_R^3\underline{q}_R - 12\overline{q}_R^3 + 16\overline{q}_R^4 + \underline{q}_R^4 + 17\overline{q}_R^2\underline{q}_R^2}{\left(4\overline{q}_R - \underline{q}_R\right)^2} \tag{52}$$

The equilibrium qualities, prices and profits are:

$$\overline{q}_R = 0.25039, \quad \underline{q}_R = 0.039411 \tag{53}$$

$$\overline{p}_R = 0.12007, \quad \underline{p}_R = 0.010256 \tag{54}$$

$$\underline{\pi}_R = 0.0026691, \quad \overline{\pi}_R = 0.026228 \tag{55}$$

■