Mergers and innovation – New theoretical insights with an application to the PSA/FCA merger case

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Abstract

To understand the effect of mergers on innovation, a literature review is conducted. There is no absolute result, the effects depend mainly on the characteristics of the industry under analysis. Afterwards, it is developed a game à la Cournot that is applied to the real case of the PSA/FCA merger in order to predict its effects on the innovation levels of the electric vehicle industry. This game is an extension of Ishida et al. (2011), where players are considered asymmetric, the product is homogeneous and there is process innovation. This type of innovation becomes particularly relevant due to the urgent need for an energy transition, to which the adoption of electric vehicles can significantly contribute. It is concluded that merging firms substantially increase their level of innovation. Firms that compete more directly with the merging firms reduce their innovation. Firms that compete less intensely increase their level of innovation (because investments in innovation are strategic substitutes) when investment in innovation is sufficiently efficient and decrease it in other cases. The observed decrease is larger than the increase, so the effect of this merger on the industry's innovation will be negative. The industry's profits increase with the merger. Due to the synergies created by the merger, this increase is higher when the investment in innovation is less efficient. The price decreases with the merger when investment in innovation is inefficient, again due to the synergies created, which provides an increase in demand-side welfare as measured by consumer surplus.

Keywords: mergers, innovation, competition, oligopoly, policy, PSA/FCA

1. Introduction

In the last 20 years, more than 790.000 mergers took place worldwide with a known value of over 57 trillion USD. In 2019 alone, there were 49.327 mergers with a total value of 3.370 billion USD. Several reasons motivate firm mergers, such as access to new intangible assets, the creation of synergies, diversification and growth. In several cases, mergers allow firms to grow faster and with more benefits than if they were to grow organically (Duksaite and Tamosiuniene, 2009), with increased market power and the possibility that consumer welfare is reduced.

Besides competition, mergers also affect innovation. It is not clear whether this influence is positive or negative. Régibeau and Rockett (2019), while analysing several perspectives about the impact of mergers on innovation, notice that authors positions differ: some defend that mergers foster innovation, while others believe it decreases innovation. The effect of mergers on innovation is such an important subject since innovation is the principal determinant of long-term productivity, competitiveness between firms and consumer welfare (Ahmad and Rao, 2001). Therefore, if the effect of mergers on innovation is negative, it may result in consumer harm (Federico et al., 2018). Hence, competition policy is concerned with ensuring that innovation is fostered (Haucap and Stiebale, 2016).

By joining expertise from two different companies, mergers can increase the ability to create new products and technologies, which leads to an increase in innovation and consumer welfare. However, acquirer firms can target similar companies to soften competition and to avoid the negative impact of rivals' innovation, which leads to a decrease in innovation in the long term and to a decrease in consumer welfare caused by price increases (Ornaghi, 2009). Federico et al. (2018) examined how horizontal mergers affect product innovation through its influence on market power. They conclude that mergers have a negative impact on innovation because competition decreases, leading to increased prices and resulting in a decrease in consumer welfare. Note that the effect of innovation efficiencies, such as knowledge spillovers and R&D coordination, was not considered in this model. The authors state that if these efficiencies are strong enough, then it is possible to overturn the decline of innovation due to market power. Based on Federico et al. (2018), Gilbert (2019) concludes that competition promotes innovation. Therefore, if a merger reduces competition, it reduces innovation. Motta and Tarantino (2017) focus their studies on cost-reduction innovation. These authors do not address product innovation like Federico et al. (2018) yet reach a similar conclusion: in the absence of efficiency gains, mergers decrease the investment in innovation and reduce consumer welfare. Motta and Tarantino (2017) also defend that mergers reduce competition and, consequently, increase prices and profit margins. Haucap et al. (2019) show the same negative effect of reduced competition on innovation. The authors find that, in a market with high research intensity before merging activity, the innovation rate declines after the merger. Since competition is softer after the merger, post-innovation profits will not be much different from pre-innovation profits. Also, similarly to Motta and Tarantino (2017), Haucap et al. (2019) defend that if mergers generate sufficient efficiency gains (mostly in the form of cost savings), they may increase innovation and, consequently, be beneficial for consumers.

Some authors believe that mergers do not necessarily have a negative effect on innovation. Hollenbeck (2020) investigates a model of a concentrated industry with differentiated products in which companies compete in prices. The author challenges an idea defended by Federico et al. (2018) and Motta and Tarantino (2017). Hollenbeck (2020) states that in a market with low competition, it is possible to foster innovation only if there are low barriers to entry and innovation is occasionally rapid and disruptive. Even though in the short-term after a merger prices rise and consumer welfare drops, these mergers may create a speculative entry, meaning that outsider firms may enter the market and start to compete with the existing firm. Kleer (2002) studied how a merger between companies that compete in quantities and invest in cost-reducing innovation would affect the overall investment in innovation. The author found that mergers increase the investment in innovation. This effect is mainly driven by the scale effect. If firms invest more in innovation, marginal costs reduce. Hence, equilibrium quantity would increase, resulting in higher profits for the company.

This article aims to further explore the relationship between mergers and innovation and to comprehensively determine the principal factors that influence it, contributing to the debate with new results. A theoretical model is developed to derive new conclusions. The framework from Ishida et al. (2011) was considered to be the most suitable. The authors consider a model in which there are two types of players: low-cost players (low marginal cost) and high-cost players (high marginal cost), that compete in a Cournot framework. Investment in R&D is cost reducing. Ishida et al. (2011) paper considers the existence of one low-cost player and N high-cost players and studies the impact of the number of high-cost firms (N) on the innovation level of all players. For this paper to contribute with new results to the existing literature on mergers and innovation, some extensions and adaptations will be made to the Ishida et. al (2011) model. In particular, we consider a generic number of low-cost players and a generic number of high-cost players. To the best of our knowledge, this extension to a more realistic model has not been made yet.

After developing a new theoretical model, this paper addresses the real-life merger between PSA and FCA groups. We use this merger to test the developed model. This can help to predict the effects of the merger on the innovation levels of both the merging companies and the rivals. The new merged entity, Stellantis, will become the fourth largest car manufacturer in the world (Forbes, 2019). One of the principal reasons leading FCA and PSA to merge was the creation of R&D synergies mainly related to electric vehicles (TIME, 2019). Furthermore, considering the current need to promote energy transition and intensify electric vehicles (EV) adoption, it is pertinent to study this merger's impact on innovation in the electric vehicle industry. Applying the theoretical model sheds light on the PSA/FCA merger case and its consequences on innovation, a crucial competition variable in this industry.

The objective of this Dissertation is to develop a new theoretical model to study the effect of this merger on 3 areas. First, we want to evaluate the effects on the investment in innovation of both merging companies and rivals. Then, we want to understand the impact on the profits of the industry. Lastly, we want to evaluate the impact on the price, in order to understand the effect on the consumers.

Energy transition may require large investments for companies to stay competitive. It is in this context that PSA and FCA decided to merge. Both companies expect that the merger will lead to more innovation, so they can develop and improve their electric fleet (Forbes, 2019). As this merger was strongly motivated by new regulations caused by the need for an energy transition, from fossil to renewable such as electricity, it is very important to analyse the actual effects of this merger on the innovation level of the EV industry. Because of the economic relevance of this case (as mentioned before, the merged entity will become the fourth largest car manufacturer in the world), the theoretical model is applied to this merger in particular. Besides that, few scientific papers evaluate the effects of mergers on innovation in the automotive industry, even less if one considers EV instead of fossil fuel vehicles. Hence, besides addressing an important case, this paper also intends to contribute to the existing literature on this subject.

The rest of the paper is organized as follows. In section 2, we present the model. In section 3. the model is applied to the EV industry. Section 4 discusses the results and section 5 concludes.

2. Model

As stated before, our model is based on Ishida et al. (2011). We consider a standardised version of Cournot competition with cost-reducing R&D investments. We consider an industry with a total number N of firms denoted by i ϵ {1, 2, …, N}, which can be high-cost firms (there are n_H of these) or low-cost firms (there are n_L of these, with $n_H+n_L=N$). To allow for both intra and extra group mergers, both n_H and n_L must be larger than or equal to 2. The model is two-stage. In the first stage, firms decide the level of cost-reducing R&D investments, which will determine the marginal cost of production. In the second stage, considering the marginal cost previously defined, firms engage in Cournot competition, choosing the quantities that they will make available in the market. Denote by x_L and x_H the investment level chosen by low-cost and high-cost firms, respectively. A unit increase in the investment level reduces the firm´s marginal cost in the same proportion. Let z_L and z_H be the ex-ante marginal cost (before innovation) of the low-cost and high-cost firms, respectively. It is important to note that $z_H>z_L$. If a firm decides to invest in innovation, its marginal cost becomes $c_L \equiv z_L–x_L$ for a low-cost firm and $c_H \equiv z_H–x_H$ for a high-cost firm. c_L and c_H are the ex-post marginal costs (after innovation). Subsequently, the total production cost is given by $(z_L–x_L)q_L$ for low-cost firms and $(z_H–x_H)q_H$ for high-cost firms, where q_H and q_L denote the production levels of these firms. When firms invest in cost-reducing innovation they incur a cost represented by γx_L^2 for low-cost firms and γx_H^2 for high-cost. Parameter γ represents the efficiency of cost-reducing R&D investment. If this investment is efficient, meaning that it is possible to innovate with fewer resources, γ is low. If the investment is not efficient, meaning that a great number of resources are needed to reduce the marginal cost, γ is high. The inverse demand function can be written as P=1–Q, where $Q=\sum_{j=1}^{nH} qj+ \sum_{k=nH+1}^{N} qk$. Total quantity can be written as $Q=n_Hq_H+ n_Lq_L$.

2.1 Subgame perfect Nash Equilibrium

As usual, we solve the game backwards. The objective of each firm is to choose its quantity to maximise own profit. The optimisation problems can be written as:

$$\mathrm{Max}_{q_L} \pi_L^E = [1 - n_H q_H^E - n_L q_L^E – (z_L–x_L)]\, q_L^E – \gamma x_L^2 \quad (1)$$

$$\text{Max}_{q_H}\pi_H^E = [1 - n_H q_H^E - n_L q_L^E - (z_H - x_H)]\, q_H^E - \gamma x_H^2$$

The superscript E henceforth denotes the equilibrium value of the variable. Assuming that interior solutions exist, the equilibrium values of the quantity variables can be written as (usual Cournot competition result, under this model specificities):

(2)

$$q_L^E = \frac{1+(n_L-1)(z_L-x_L)+n_H(z_H-x_H)-(n_H+n_L)(z_L-x_L)}{1+n_H+n_L}$$

$$q_H^E = \frac{1+n_L(z_L-x_L)+(n_H-1)(z_H-x_H)-(n_H+n_L)(z_H-x_H)}{1+n_H+n_L}$$

The expressions in (2) are a function of the investment levels, x_H and x_L. As expected, each group's quantity is increasing in its own innovative activity, and decreasing in the other group's level of x, that is $\frac{\partial q_i}{\partial x_i} > 0$ and $\frac{\partial q_i}{\partial x_j} < 0$ (i, j = L, H). Replacing the optimal quantity in the profit function, we obtain the equilibrium profit as a function of the number of firms in each group, marginal costs, investment levels and the investment efficiency.

(3)

$$\text{Max}_{x_L}\pi_L^E = \frac{[1-(z_L-x_L)+n_H((z_H-x_H)-(z_L-x_L))]^2}{(1+n_H+n_L)^2} - \gamma {x_L}^2$$

$$\text{Max}_{x_H}\pi_H^E = \frac{[1-(z_H+x_H)+n_L((z_L-x_L)-(z_H-x_H))]^2}{(1+n_H+n_L)^2} - \gamma {x_H}^2$$

The first-stage optimisation problem can be described as choosing x_L/x_H to maximise π, taking other firms' choices as given:

(4)

$$\frac{\partial \pi_L^E}{\partial x_L^E} = 0 \;\Leftrightarrow\; x_L^E = \frac{(n_H+1)(1-(n_H+1)z_L-n_H(x_H-z_H))}{\gamma(1+n_H+n_L)^2-(1+n_H)^2}$$

$$\frac{\partial \pi_H^E}{\partial x_H^E} = 0 \;\Leftrightarrow\; x_H^E = \frac{(n_L+1)(1-(n_L+1)z_H-n_L(x_L-z_L))}{\gamma(1+n_H+n_L)^2-(1+n_L)^2}$$

Solving the system of equations given in (4), we obtain the equilibrium investment levels, as a function of the number of firms, the initial marginal costs, and the efficiency level of the innovative investment.

(5)

$$x_L^E = \frac{(n_H+1)[\gamma(n_H+n_L+1)(1-z_L+n_H(z_H-z_L))-(1-z_L)(n_L+1)]}{\gamma(n_H+n_L+1)[\gamma(n_H+n_L+1)^2-(n_H+1)^2-(n_L+1)^2]+(n_L+1)(n_H+1)}$$

$$x_H^E = \frac{(n_L+1)[\gamma(n_H+n_L+1)(1-z_H-n_L(z_H-z_L))-(1-z_H)(n_H+1)]}{\gamma(n_H+n_L+1)[\gamma(n_H+n_L+1)^2-(n_H+1)^2-(n_L+1)^2]+(n_L+1)(n_H+1)}$$

Replacing the equilibrium levels of x_L and x_H into the quantities' expressions, we obtain the equilibrium quantities as functions of the number of firms in each group, the corresponding marginal costs. and the efficiency of the innovation investment.

(6)

$$q_L^E = \frac{(n_H+n_L+1)\gamma[\gamma(n_H+n_L+1)(1-z_L+n_H(z_H-z_L))-(1-z_L)(n_L+1)]}{\gamma(n_H+n_L+1)[\gamma(n_H+n_L+1)^2-(n_H+1)^2-(n_L+1)^2]+(n_L+1)(n_H+1)}$$

$$q_H^E = \frac{(n_H+n_L+1)\gamma[\gamma(n_H+n_L+1)(1-z_H-n_L(z_H-z_L))-(1-z_H)(n_H+1)]}{\gamma(n_H+n_L+1)[\gamma(n_H+n_L+1)^2-(n_H+1)^2-(n_L+1)^2]+(n_L+1)(n_H+1)}$$

2.2 Conditions for equilibrium existence

We need to establish conditions that guarantee that the innovation levels are positive, as well as quantities, and that they correspond to a maximum. Assuring that x_H, q_H>0 is enough to guarantee the same for low-cost firms. To simplify the presentation, the expression of the denominator is going to be presented as "Denominator > 0" or "Denominator > 0". These terms refer to the following solutions:

Denominator > 0: (7)

$$\gamma < \frac{2n_H+2n_L+n_H^2+n_L^2+2-\sqrt{4n_H^2+4n_H^3+n_H^4+4n_L^2+4n_L^3+n_L^4+2n_H^2n_L^2-n_Hn_L}}{2(1+n_L+n_H)^2}$$

V

$$\gamma > \frac{2n_H+2n_L+n_H^2+n_L^2+2+\sqrt{4n_H^2+4n_H^3+n_H^4+4n_L^2+4n_L^3+n_L^4+2n_H^2n_L^2-n_Hn_L}}{2(1+n_L+n_H)^2}$$

Denominator < 0: (8)

$$\gamma > \frac{2n_H+2n_L+n_H^2+n_L^2+2-\sqrt{4n_H^2+4n_H^3+n_H^4+4n_L^2+4n_L^3+n_L^4+2n_H^2n_L^2-n_Hn_L}}{2(1+n_L+n_H)^2}$$

V

$$\gamma < \frac{2n_H+2n_L+n_H^2+n_L^2+2+\sqrt{4n_H^2+4n_H^3+n_H^4+4n_L^2+4n_L^3+n_L^4+2n_H^2n_L^2-n_Hn_L}}{2(1+n_L+n_H)^2}$$

Condition 1: $\frac{\partial^2 \pi_H}{\partial x_H^2} < 0$ (9)

$$\gamma > \frac{(1+n_L)^2}{(1+n_L+n_H)^2}$$

Condition 1 is related to the satisfaction of the second-order conditions.

Condition 2: x_H^E> 0 and q_H^E> 0 (10)

$$\gamma > \frac{(1-z_H)(1+n_H)}{(n_H+n_L+1)(1-z_H-n_L(z_H-z_L))} \;\Lambda\; \text{Denominator} > 0 \quad \text{or}$$

$$\gamma < \frac{(1-z_H)(1+n_H)}{(n_H+n_L+1)(1-z_H-n_L(z_H-z_L))} \;\Lambda\; \text{Denominator} < 0$$

When solving x_H^E> 0 and q_H^E> 0 in order to γ, the results are the same since the expressions are similar. Therefore, to simplify, these two conditions are grouped into one.

Condition 3: $\frac{\partial^2 \pi_L}{\partial x_L^2} < 0$ (11)

$$\gamma > \frac{(1+n_H)^2}{(1+n_L+n_H)^2}$$

Like condition 1, condition 3 is related to the satisfaction of the SOC but focusing on the low-cost firms.

Combining all these conditions, that depend on several different variables (n_H, n_L, z_H, and z_L), we would be left with the most binding ones. Next section particularizes for the real-life merger case to be analysed.

3. A merger in the automobile industry

This section applies the model to the PSA/FCA merger case. We first define the relationship between n_H and n_L, so it becomes possible to identify the most restrictive conditions for companies' participation in the market (existence conditions). Based on the level of production of EVs in Europe, according to the Schmidt Automotive Report of December 2020 (Financial Times, 2020), let us consider n_H=9 and n_L=4.

3.1 Investment levels x_L and x_H

After defining n_L and n_H, we are left with 3 variables: z_H, z_L, and γ. Let us compute the investment levels of both types of firms:

(12)

$$x_L^E = 5\frac{126\gamma z_H-140\gamma z_L+14\gamma-5(1-z_L)}{1372\gamma^2-875\gamma+25}$$

$$x_H^E = 5\frac{-35\gamma z_H+28\gamma z_L+7\gamma-5(1-z_H)}{1372\gamma^2-875\gamma+25}$$

As outlined in section 2.2, we must ensure that the investment level of both types of companies is positive (otherwise there is no game being played). We will use γ to obtain the existence conditions. z_L will also be used, because if low-cost companies have very small costs, they may drive high-cost companies out of the market. Therefore, z_L must comply with a minimum condition relative to z_H.

If we replace n_L and n_H, we obtain the following restriction arising from the second order conditions:

(13)

$$\gamma \geq \max\{(\frac{n_H+1}{n_L+n_H+1})^2, (\frac{n_L+1}{n_L+n_H+1})^2\} = $$
$$=\max\{(\frac{9+1}{4+9+1})^2, (\frac{4+1}{4+9+1})^2\} = 0.510$$

Since the denominators of both x_L and x_H are equal, we start by analysing them:

$1372\gamma^2 - 875\gamma + 25 = 0 \Leftrightarrow \gamma = 0.030 \vee \gamma = 0.608$

The denominator is positive when γ <0.030 or γ >0.608, and it is negative when 0.030< γ <0.608. Recall that we have already established that γ > 0.510.

Looking at the x_L function, its numerator can be either positive or negative. Therefore, we need to look closely to understand its sign:

(14)

$$\frac{\partial(126\gamma z_H-140\gamma z_L+14\gamma+5z_L-5)}{\partial\gamma} =$$

$$14(9(z_H-z_L)+1-z_L) > 0, \text{since}(z_H-z_L) > 0 \text{ and}$$

$$(1-z_L) > 0$$

$$126 * 0.510z_H - 140 * 0.510z_L + 14 * 0.510 + 5z_L - 5$$

$$=64.26(z_H-z_L) + 7.14(1-z_L) - 5(1-z_L) > 0 \text{ for all } z_L, z_H$$

By taking the derivative of the x_L numerator in order to γ, expression (13), it is possible to see that it is positive, meaning that the numerator increases with γ. If we substitute the minimum γ =0.510 in the numerator of x_L, its value is positive. Since the numerator of x_L is positive in its minimum, the numerator of x_L is always positive for γ >0.510.

However, for 0.510< γ <0.608, x_L is negative because the denominator is negative. Then, to ensure that x_L>0, we must impose γ >0.608.

As it was said previously, z_L must have a minimum so high-cost firms can compete in the market. To find this minimum, we take the derivative of the numerator of x_H in order to γ:

(15)

$$\frac{\partial(-35\gamma z_H+28\gamma z_L+7\gamma+5z_H-5)}{\partial\gamma} =$$
$$-35z_H + 28z_L + 7 = -7(5z_H - 4z_L - 1) =$$
$$= 7[-4(z_H-z_L) + 1 - z_H] > 0 \Leftrightarrow z_L > \frac{5z_H-1}{4}$$

As γ >0.608, the denominator is positive. Therefore, to ensure that x_H>0, a positive condition was imposed in (15). This minimum z_L value must be respected.

After determining a minimum value for z_L, we look at the γ condition for x_H. We already know that the derivative of x_H to γ is always positive, meaning that x_H increases with γ. Therefore, we substitute γ =0.608 in the x_H numerator to know if x_H is positive in its minimum:

(16)

$$-35(0.608)z_H + 28(0.608)z_L + 7(0.608) + 5z_H - 5$$
$$= -16.28(z_H-z_L) - 0.744(1-z_L)$$

Since the x_H numerator is negative and the denominator is positive, x_H is negative. This means that γ =0.608 does not assure that high-cost firms exist. Therefore, in order to find a new value for γ, we need to ensure that the numerator is larger than 0:

(17)

$$-35\gamma z_H + 28\gamma z_L + 7\gamma + 5z_H - 5 > 0 \Leftrightarrow \gamma >$$
$$\frac{5(1-z_H)}{7(1-z_H)-28(z_H-z_L)} \; if \; 7(1-z_H) - 28(z_H-z_L) > 0 \text{ or}$$

$$\gamma < \frac{5(1-z_H)}{7(1-z_H)-28(z_H-z_L)} \; if \; 7(1-z_H) - 28(z_H-z_L) < 0$$

It can be seen that $7(1-z_H) - 28(z_H-z_L) < 0$ is not possible since $z_L > \frac{5z_H-1}{4}$.

$\gamma > \frac{5(1-z_H)}{7(1-z_H)-28(z_H-z_L)}$ guarantees that x_H and x_L>0. Therefore, from now on, γ must respect this limit as well as the previous one, γ>0.608.

3.2 Quantities q_L and q_H

Besides assuring that the investment levels are positive, the quantities produced by both types of companies must also be positive.

(18)

$$q_L = 7\gamma\frac{126\gamma z_H - 140\gamma z_L + 14\gamma + 5z_L - 5}{1372\gamma^2 - 875\gamma + 25}$$

We can observe that the difference between q_L and q_H increases with the increase of γ. This means that the dominance of low-cost firms increases, and the industry becomes more asymmetric in terms of market shares.

If $q_H > 0$, $q_L > 0$ because $q_L > q_H$. The denominator of both quantities is equal to the denominator of the investment levels, which means that we already know its sign. Therefore, we start by looking at the numerator of q_H.

Since the condition is the same as the one obtained in the previous section, the conditions of positivity for x_L, x_H also ensure that q_L, and q_H are positive, as required.

3.3 Effects of the PSA/FCA merger in the EV industry

In this subsection we assess the effects of mergers on innovation. The PSA/FCA merger case is the basis for the analysis. Recall that several authors, such as Davidson and Ferret (2007), assert that mergers may lead to synergies and R&D spillovers that contribute to the reduction of marginal costs. Therefore, it is reasonable to assume that the merger will give rise to a low-cost producer, that is, the PSA/FCA merged entity is low-cost. According to available information, the merging parties may be considered high-cost before the merger. In addition, as highlighted in section 1, the new merged entity becomes the fourth largest car manufacturer in the world (Forbes, 2019). Therefore, after this merger, the European EV market will be composed of 7 high-cost firms and 5 low-cost firms, since 2 high-cost firms merge to become 1 low-cost firm.

3.3.1 Low-cost companies after the merger

After the merger, the investment in innovation by each low-cost firm can be computed as:

$$x_L' = 8\frac{13\gamma + 6z_L + 91z_H\gamma - 104z_L\gamma - 6}{2197\gamma^2 - 1300\gamma + 48} \quad (19)$$

As before the merger, it must be positive. By performing the appropriate computations, we conclude that, for the admissible range of γ, innovation in low-cost companies after the merger is always positive.

3.3.2 High-cost companies after the merger

The new cost-reducing innovation formula for high-cost companies is the following:

$$x_H' = 6\frac{13\gamma + 8z_H - 78z_H\gamma + 65z_L\gamma - 8}{2917\gamma^2 - 1300\gamma + 48} \quad (20)$$

The denominator is equal to the low-cost firms', meaning that it is always positive. As for the numerator, we arrive at the condition

$\gamma > \frac{8(1-z_H)}{13[(1-z_H)-5(z_H-z_L)]}$. This threshold for γ decreases with z_L, which means that it is maximum for the minimum z_L, and minimum for the maximum z_L. This new condition on γ must also ensure that $x_H' > 0$. The condition for the denominator of this threshold to be positive yields:

$$(1 - z_H) - 5(z_H - z_L) > 0 \Leftrightarrow z_L > \frac{6z_H - 1}{5} \quad (21)$$

This new condition on z_L is more stringent than the first one (inequality 15) and will be used thereafter.

Before advancing, let us recall the conditions that ensure that this merger may occur:

$$\gamma > \max\{0.608, \frac{8(1-z_H)}{13[(1-z_H)-5(z_H-z_L)]}, \frac{5(1-z_H)}{7(1-z_H)-28(z_H-z_L)}\} \text{ and } z_L > \frac{6z_H-1}{5}, \text{ with } 0 < z_H < 1. \quad (22)$$

3.3.3 Merger effect on total innovation

As it was seen, after a merger both types of companies still invest in innovation. But is this investment higher or lower when compared to the pre-merger scenario?

Let us compute the total pre-merger innovation level. With 4 low-cost companies and 9 high-cost companies, total innovation is given by:

$$X = 4x_L + 9x_H \quad (23)$$

$$X = \frac{-325 + 225z_H + 100z_L + 595\gamma + 945z_H\gamma - 1540z_L\gamma}{1372\gamma^2 - 875\gamma + 25}$$

After a merger, 2 high-cost companies become 1 low-cost, hence total innovation is given by:

$$X' = 5x_L' + 7x_H' \quad (24)$$

$$X' = \frac{-576 + 336z_H + 240z_L + 1066\gamma + 364z_H\gamma - 1430z_L\gamma}{2197\gamma^2 - 1300\gamma + 48}$$

To understand if the merger increases or decreases innovation, we calculate the difference between X' and X. If it is greater than 0, this merger fosters innovation. By working on the sign of $\Delta X = X' - X$, we find out that, although the denominator is positive, it is not possible to conclude anything about the sign of the numerator of ΔX, which is a third-degree polynomial. Hence, it is not possible to conclude a priori if the FCA/PSA merger will foster or decrease innovation. Further in this paper we perform a merger simulation, where conclusions are obtained.

3.3.4 Merger effect on price

In this section we evaluate the impact of the merger on consumers. Does the price increase or decrease? This analysis is very important for competition authorities. If price increases after a merger, consumers will be worse off (since demand is linear, higher price corresponds to lower consumer surplus). Therefore, competition authorities should estimate the effect of a proposed merger on prices before allowing it.

Let us start by calculating the price before merger, P:

$$P = 1 - Q = 1 - n_L q_L - n_H q_H \quad (25)$$

$$P = \frac{25-105\gamma-630z_H\gamma-140z_L\gamma+98\gamma^2+882z_H\gamma^2+392z_L\gamma^2}{1372\gamma^2-875\gamma+25}$$

After that, we calculate the price after the merger, P':

$$P' = 1 - Q' = 1 - n_L' q_L' - n_H' q_H' \quad (26)$$

$$P' = \frac{48-182\gamma-728z_H\gamma-390z_L\gamma+169\gamma^2+1183z_H\gamma^2+845z_L\gamma^2}{2197\gamma^2-1300\gamma+48}$$

Then, we calculate the difference between the prices, P'-P. If it is greater than 0, it means that the price increases after the merger.

$$P'-P = \gamma\frac{12040z_H-194761z_H\gamma-3030z_L+161559z_L\gamma-9010+496769z_H\gamma^2-457275z_L\gamma^2}{(1372\gamma^2-875\gamma+25)(2197\gamma^2-1300\gamma+48)} + \frac{33202\gamma-39494\gamma^2+16562\gamma^3-314678z_H\gamma^3+298116z_L*\gamma^3}{(1372\gamma^2-875\gamma+25)(2197\gamma^2-1300\gamma+48)} \quad (27)$$

The denominator is always positive for the admissible range of γ. Therefore, we need to evaluate the numerator.

We conclude that the numerator surely grows when 0.227< γ <0.796. Since γ >0.608, the numerator actually grows when 0.608< γ <0.796. If the numerator is positive for γ =0.608, it will surely be positive until γ =0.796 since the numerator grows inside this interval. If we perform the calculations:

$$\gamma = 0.608 \quad (28)$$

$$\text{numerator} = 299.710(1-z_H) + 6836.960(z_H - z_L)$$

The numerator is positive for this γ range, which means that price increases after a merger if 0.608< γ <0.796. For γ >0.796, price may decrease after a merger from a certain point.

4. Discussion

In this chapter, we simulate the merger between PSA and FCA to evaluate its impact on innovation, price, and profit of the firms in the EV industry. To do this, we need to assign values to zL, zH and γ.

As established, firms were considered low or high-cost according to their level of production. Firms with higher production levels were considered low-cost, while firms with lower production levels were considered high-cost. To assign values to zL and zH, we use the market share values of Schmidt Automotive Report of December 2020 (Financial Times, 2020). If we divide the average market share of firms L by the average market share of firms H, we get 5.46. Following this reasoning, we assume that firms L produce on average 5.46 times more than firms H. We use this information to proceed backwards to establish the necessary conditions of existence for this model:

$$q_L = 5.46q_H \Leftrightarrow z_L = \frac{1240 - 1561\gamma + z_H(12705\gamma - 1365)}{11144\gamma - 125} \quad (29)$$

$$\text{If } z_H > 0.123: \max\left\{\frac{8(1-z_H)}{13[(1-z_H)-5(z_H-z_L)]}, \frac{5(1-z_H)}{7(1-z_H)-28(z_H-z_L)}, \frac{1365z_H-1240}{12705z_H-1561}, 0.794\right\} < \gamma$$

$$\text{If } z_H < 0.123: \max\left\{\frac{8(1-z_H)}{13[(1-z_H)-5(z_H-z_L)]}, \frac{5(1-z_H)}{7(1-z_H)-28(z_H-z_L)}, 0.794\right\} < \gamma < \frac{1365z_H-1240}{12705z_H-1561}$$

After determining our model conditions, we are now able to proceed to the merger simulation.

Table 1. Merger Simulation

γ	z_H	z_L	$\frac{z_L}{z_H}$	$\frac{x_L'-x_L}{x_L}$	$\frac{x_H'-x_H}{x_H}$	$\frac{x_L'-2x_H}{2x_H}$	$\frac{X'-X}{X}$	$\pi_L'-\pi_L$	$\pi_H'-\pi_H$	$\pi_L'-2\pi_H$	$\frac{\pi_T'-\pi_T}{\pi_T}$	$\frac{q_L'-q_L}{q_L}$	$\frac{q_H'-q_H}{q_H}$	$\frac{Q'-Q}{Q}$	$\frac{P'-P}{P}$	$\frac{CS'-CS}{CS}$
0.8	0.9	0.899	0.9999	-44.3%	13.2%	204%	-10.5%	-0.0001	0.0001	-0.0001	15.3%	-35.3%	85.1%	-0.74%	0.08%	-1.5%
1.0	0.9	0.897	0.9968	-32.7%	-1.3%	268%	-7.1%	-0.0001	0.0001	-0.0002	30.3%	-21.8%	34.5%	-0.26%	0.03%	-0.5%
2.0	0.9	0.892	0.9906	-22.6%	-18.8%	323%	-4.0%	-0.0002	0.0002	-0.0004	44.2%	-10.2%	-8.1%	0.37%	-0.04%	0.7%
10.0	0.9	0.887	0.9857	-18.8%	-27.0%	344%	-2.7%	-0.0003	0.0002	-0.0005	48.6%	-5.7%	-23.8%	0.77%	-0.08%	1.5%
0.8	0.7	0.699	0.9996	-44.3%	13.2%	204%	-10.5%	-0.0008	0.0005	-0.0010	15.3%	-35.3%	85.1%	-0.74%	0.31%	-1.5%
1.0	0.7	0.691	0.9875	-32.7%	-1.3%	268%	-7.1%	-0.0012	0.0010	-0.0019	30.3%	-21.8%	34.5%	-0.26%	0.11%	-0.5%
2.0	0.7	0.675	0.9636	-22.6%	-18.8%	323%	-4.0%	-0.0019	0.0016	-0.0034	44.2%	-10.2%	-8.1%	0.37%	-0.15%	0.7%
10.0	0.7	0.661	0.9447	-18.8%	-27.0%	344%	-2.7%	-0.0025	0.0022	-0.0045	48.6%	-5.7%	-23.8%	0.77%	-0.32%	1.5%
0.8	0.5	0.499	0.9990	-44.3%	13.2%	204%	-10.5%	-0.0021	0.0015	-0.0027	15.3%	-35.3%	85.1%	-0.74%	0.72%	-1.5%
1.0	0.5	0.485	0.9709	-32.7%	-1.3%	268%	-7.1%	-0.0033	0.0026	-0.0054	30.3%	-21.8%	34.5%	-0.26%	0.25%	-0.5%
1.2	0.5	0.476	0.9522	-28.2%	-8.4%	292%	-5.8%	-0.0040	0.0033	-0.0069	36.7%	-16.6%	15.3%	-0.02%	0.02%	0.0%
2.0	0.5	0.458	0.9151	-22.6%	-18.8%	323%	-4.0%	-0.0054	0.0046	-0.0095	44.2%	-10.2%	-8.1%	0.37%	-0.35%	0.7%
10.0	0.5	0.435	0.8709	-18.8%	-27.0%	344%	-2.7%	-0.0069	0.0061	-0.0125	48.6%	-5.7%	-23.8%	0.77%	-0.73%	1.5%
0.8	0.3	0.299	0.9977	-44.3%	13.2%	204%	-10.5%	-0.0041	0.0029	-0.0053	15.3%	-35.3%	85.1%	-0.74%	1.64%	-1.5%
1.0	0.3	0.280	0.9320	-32.7%	-1.3%	268%	-7.1%	-0.0065	0.0052	-0.0105	30.3%	-21.8%	34.5%	-0.26%	0.58%	-0.5%
2.0	0.3	0.241	0.8019	-22.6%	-18.8%	323%	-4.0%	-0.0105	0.0091	-0.0187	44.2%	-10.2%	-8.1%	0.37%	-0.80%	0.7%
10.0	0.3	0.210	0.6988	-18.8%	-27.0%	344%	-2.7%	-0.0134	0.0119	-0.0244	48.6%	-5.7%	-23.8%	0.77%	-1.63%	1.5%
1.0	0.1	0.074	0.7378	-32.7%	-1.3%	268%	-7.1%	-0.0108	0.0085	-0.0173	30.3%	-21.8%	34.5%	-0.26%	1.97%	-0.5%
2.0	0.1	0.024	0.2358	-22.6%	-18.8%	323%	-4.0%	-0.0173	0.0150	-0.0309	44.2%	-10.2%	-8.1%	0.37%	-2.64%	0.7%
3.0	0.1	0.007	0.0697	-20.8%	-22.6%	333%	-3.4%	-0.0194	0.0170	-0.0350	46.5%	-8.0%	-15.7%	0.54%	-3.81%	1.1%
3.7	0.1	0.001	0.0070	-20.2%	-23.9%	336%	-3.2%	-0.0202	0.0177	-0.0364	47.1%	-7.3%	-18.2%	0.61%	-4.23%	1.2%

4.1 Parameters setting

The first three columns of Table 1 refer to the variables that we control, and which will originate the experimental results. We first establish a value for z_H. Our objective is to approach several different cost scenarios, so we decrease z_H from 0.9 until 0.1. Then, we establish values for z_L and γ that respect the conditions previously derived. As we have seen before, z_L depends directly on z_H and γ. Hence it varies according to the different scenarios.

Let us start by analysing column $\frac{z_L}{z_H}$, which intends to show the difference between the marginal costs of both types of companies. As this ratio increases (decreases), companies are more symmetric (asymmetric). From the table we observe that as γ increases, $\frac{z_L}{z_H}$ decreases, which means that inefficient investment in innovation leads to more asymmetry between firms. We expected this result. If innovation is expensive (high values of γ), not all companies have the necessary resources to invest. In our case, low-cost companies may have more resources to invest than high-cost companies. Therefore, low-cost companies invest more than high-cost companies, resulting in more asymmetry between them. On the other side, as γ decreases, $\frac{z_L}{z_H}$ increases. If innovation is very efficient (low values of γ), high-cost companies may take advantage of this opportunity and invest more, reducing costs and approaching low-cost companies. Furthermore, as z_H decreases, $\frac{z_L}{z_H}$ decreases too, which means that the competitive advantage of low-cost firms is stronger when production is efficient than when it is not so efficient. Note that in this model, we have two efficiency measures: one that refers to efficiency in production, captured by the levels of z_L and z_H, and one that refers to efficiency in innovation investment, captured by γ.

4.2 Innovation results

From Table 1 we can see that that $\frac{x_L'-x_L}{x_L}$ is always negative. This can be explained by the fact that, after the merger, the competition among low-cost companies increases since there is one more company operating in the market. Hence, facing more competition, companies may have less resources to invest in innovation. Moreover, for given z_H, as γ decreases, $\frac{x_L'-x_L}{x_L}$ decreases too, becoming more negative and the percentual variation is indeed stronger in absolute value. This means that when the investment in innovation is very efficient (low γ), L firms invest even less after the merger compared to before the merger. This result is not intuitive since it is expected that efficient innovation leads to higher investment. However, competition in the L group increases. If innovation is efficient, it is available to everyone, meaning that competition can increase even more since all companies have an easy way to become more competitive. Hence, they may choose different investments that allow them to truly differentiate themselves. On the other hand, when innovation investment is not efficient (which means that γ is high or, in other words, this investment is very costly), it is likely that only a few companies have enough resources to invest on it. Hence, these companies may increase their investment considerably in order to escape competition. It is interesting to observe that the percentual adjustment in the equilibrium innovation levels only depends on γ, the innovation investment efficiency, being insensitive to production efficiency (measured by z_L and z_H). The absolute adjustment depends on z_L and z_H, as it does make sense, but not the relative one.

From Table 1 we can see that $\frac{x_H'-x_H}{x_H}$ can be either positive or negative. Furthermore, for a certain z_H, as γ decreases, $\frac{x_H'-x_H}{x_H}$ increases both in absolute terms and as a percentage of the pre-merger value. This means that very efficient innovation investment tends to favour H firms, which would be expected since these firms use innovation to decrease their high production costs and, therefore, become more competitive.

Hence, we observe that as γ decreases, the percentual reduction of x_L becomes stronger, while the percentual variation of x_H improves (becomes less negative or more positive). This means that inefficient innovation investment favours more low-cost firms, while efficient innovation investment favours more high-cost firms. If innovation investment is inefficient, it is more expensive. Therefore, since L firms have lower marginal costs, they are in a better position to innovate than H firms. On the other hand, when innovation investment is efficient, H firms may have the resources to invest and become more competitive. Even though innovation investment is efficient for both types of firms, H firms may take more advantage of it than L firms, mostly because they need more to decrease their marginal costs.

Even when the merger increases high-cost firms investment in innovation, total innovation in the industry is reduced ($\frac{X'-X}{X}$, measured as a percentage of the pre-merger innovation). This reduction may be of more than one quarter of the pre-merger innovation and is larger when innovation investment is more efficient (low γ). But why does the merger always decrease total innovation?

Column $\frac{x_L'-2x_H}{2x_H}$ allows us to understand the contribution of the merger to the innovation level of the industry. Let us recall that this merger case is between 2 high-cost companies that turn into 1 low-cost company. Hence, this column can be interpreted as the difference between the investment in innovation of the merged entity (L firm) and the merging firms before the merger (2 H firms). As it can be seen, $\frac{x_L'-2x_H}{2x_H}>0$ for every γ, which means that this merger alone contributes to innovation. Then, why is the variation of total innovation always negative? The answer can be found in the outsider firms (firms that do not participate in the merger) response. Recall that investments in innovation are strategic substitutes. This means that when one firm increases its investment in innovation, its rivals decrease. The merging firms always increase their investment in innovation, so outsiders decrease theirs. The balance of these moves is a negative effect on the total innovation of the industry.

In parallel with this strategic substitution effect, there is also a change in the level of competition, which helps to explain this negative variation of total innovation in terms of groups of firms. With the merger, 2 high-cost companies become 1 low-cost. This means that competition among low-cost firms increases (we have 1 more company), while competition among high-cost firms decreases (we have 2 fewer high-cost companies). Since competition among L firms increases after the merger, they may have fewer resources to spend on innovation, meaning that $\frac{x_L'-x_L}{x_L}$ may be negative. If the newly merged entity is an L firm that increases its investment in innovation, the L outsiders will decrease their investment in innovation because of the strategic substitution effect and, on top of that, because there is more competition. Regarding the H firms, the effect of the merger is not as simple. On the one hand, the decrease in competition increases the firms' availability to innovate. On the other hand, we have the negative strategic substitution effect that decreases the outsiders' investment in innovation. That is why we can have positive or negative values for $\frac{x'_H - x_H}{x_H}$. Therefore, we can conclude that the variation of the total innovation is explained by the strategic substitution effect and the change in competition among the 2 groups of firms.

4.3 Profits

Now, let us analyse the profits of the companies. Starting with the $\pi'_L - \pi_L$ column, we can see that L firms always decrease their profits individually after the merger. The merger increases competition among low-cost firms; therefore, their profit is expected to decrease. The percentual decrease only depends on γ and is less pronounced the lower is γ, which is not surprising

Contrarily to the low-cost firms' case, the merger always increases the profits of high-cost firms individually, as $\pi'_H - \pi_H$ is always positive, which is justified by the fact that the merger has softened competition among this group of firms. The percentual increase in profit is less pronounced the lower is γ, because if innovation investment is efficient all firms may innovate more and, consequently, competition may increase inside this firms' group.

Column $\pi'_L - 2\pi_H$ shows the profit variation of the merging companies, that is, the profitability of the merger. According to our simulations, the profits of the merging companies always decrease after the merger. This result, which may seem surprising, is common in the merger literature and is known as the "merger paradox". It was first presented by Salant et al. (1983), who analyse a Cournot model in which a merger reduces the profits of the insiders, while it increases the profits of the outsiders. The authors start by arguing that, if players can decide whether to merge or not, it is not rational to merge knowing that profits will decrease. Then, why would firms merge? Mergers can create efficiency gains through economies of scale and other cost synergies. While variable costs are considered in the derivatives, fixed costs are not since they do not depend on quantity and would be irrelevant for the interior equilibrium. This means that the merger analysis is considering the reduction in fixed costs. Hence, even though the profit of the insiders may decrease, the decrease in fixed costs may compensate and, therefore, firms may have true incentives to merge.

Our merger simulation illustrates the merger paradox. By merging, PSA and FCA may manage to create cost synergies in terms of fixed costs that offset the decrease in profit observed in Table 1. These firms only merge because they take advantage of it, otherwise they would play a different move. We can also observe that percentual merger unprofitability (disregarding fixed cost savings) only depends on γ and is lower for small γ, which means that when innovation investment is not sufficiently efficient, fixed cost savings may not be enough to cover theses losses and the merger would risk not taking place. Therefore, the fact that the merger is observed tells us that γ is not so high.

It is also interesting to link the results of columns $\pi'_L - \pi_L$ and $\pi'_H - \pi_H$ with the merger paradox. For outsiders H, the merger is beneficial since it increases profits. As we have seen, this is because of the reduction in competition. Moreover, for outsiders L the merger is harmful since it decreases profits. From here we can conclude that this merger tends to favour high-cost firms and hurt low-cost firms. Moreover, the incentive to free-ride, common in the merger literature, only occurs in our model for H firms. Since we have two groups of firms, we have two groups of outsiders too, and hence we obtain a new result, that the incentive to free ride does not hold for all outsiders.

4.4 Quantities

Let us now look at column $\frac{\pi'_T - \pi_T}{\pi_T}$, which represents the profitability of the merger for the whole industry. As is apparent, total profit always increases after the merger, which was expected since the industry becomes more concentrated. The percentual profit increase is higher for higher γ, as a result of the stronger increase in H firms' profits. Actually, when the investment in innovation is inefficient, it is more costly to innovate. Under these circumstances, only firms with enough resources may innovate. In our case, only L firms may invest significantly in innovation. This means that L firms increase their competitive advantage over H firms, increasing their profits, which explains the higher values of $\frac{\pi'_T - \pi_T}{\pi_T}$. On the other hand, when the investment in innovation is efficient, both L and H firms innovate, meaning that competition between these two groups of firms may increase. This may lead to lower profits, which explains the lower values of $\frac{\pi'_T - \pi_T}{\pi_T}$. To confirm this reasoning, let us look at columns $\frac{x'_L - x_L}{x_L}$ and $\frac{x'_H - x_H}{x_H}$. For high values of γ, L firms innovate more after the merger than H firms, increasing their cost advantage. For low values of γ, H firms innovate more after the merger, which means that they become more competitive and, therefore, the competition in the industry increases, resulting in lower total profits.

4.5 Price and Consumer Surplus

Let us now look at the quantity variation of low-cost firms, $\frac{q'_L - q_L}{q_L}$. The quantity produced by low-cost firms always decreases after the merger, as expected because we have one more L firm, and decreases especially when innovation is efficient (γ is low), because competition inside this group is fiercer. Moreover, competition among high-cost firms decreases, leading them to eventually produce more. If high-cost firms produce more, low-cost firms produce less because quantities are strategic substitutes. This decrease is maximum when innovation investment is efficient because high-cost companies can innovate more than when innovation investment is inefficient. The decrease in $\frac{q'_L - q_L}{q_L}$ is minimum when γ is high. When innovation is inefficient, high-cost firms innovate less, and their production decreases after the merger. Recalling the strategic substitute effect, if high-cost firms decrease their innovation, low-cost firms increase theirs. However, since there is more competition among low-cost firms, the strategic substitution effect is not enough to offset the competition effect, meaning that $\frac{q'_L - q_L}{q_L}$ is negative.

For high-cost firms, $\frac{q'_H - q_H}{q_H}$ only increases if γ is low enough. Even though competition decreases after the merger because there is one less company, there are still 7 high-cost companies, meaning that competition is still high. If innovation is not very efficient, the competition effect prevails over the decrease in costs (due to innovation) and the quantity produced decreases.

Let us now look at the variation of the total quantity, $\frac{Q'-Q}{Q}$. For low levels of γ, quantity always decreases after the merger, even though we have a great increase in the production of high-cost companies. But as high-cost companies produce significantly less than low-cost ones and the latter decrease production substantially when γ is low, the total effect on quantity is negative. For high γ both low-cost reduce less their production and high-cost increase, so the global effect may be positive. Actually, in the beginning of the chapter, we established that L firms produce 5.46 times more than H firms (a figure derived from the observed real quantities sold). Even though H firms increase their production by over than 85%, L firms decrease their production by more than 35%, meaning that the net effect in the total quantity produced is negative. When γ is high, even though H firms decrease their quantity by almost 24%, L firms only decrease by 6%. Since there is one more L firm after the merger, the total quantity increases.

Let us now analyse the variation of price. If γ is low (high) enough, price increases (decreases) after the merger. The variation of price is directly related with the variation of quantity: if quantity increases, price decreases, and the opposite also. When innovation is efficient, we have already seen that total investment in innovation decreases with the merger, because low-cost firms perform less cost-reducing innovation. Since low-cost firms represent most of the market production, if they innovate less after the merger, price may increase. The opposite reasoning is also correct: when innovation is inefficient, low-cost firms innovate more to escape competition. Therefore, since innovation is cost-reducing, price decreases after the merger.

If quantity decreases, price increases and, consequently, the consumer surplus also decreases. These three variables are directly related: if firms produce less, prices increase, meaning that customers are worse off (decrease in consumer surplus). From Table 1 it is possible to see that this merger is only beneficial for consumers if γ is high enough. Before the simulation, one could think that low levels of γ would benefit the consumers, because firms would innovate more. However, we have seen that this does not happen. When γ is low, even though H firms innovate more, L firms do not. Since L firms produce much more than H firms, the effect on consumer surplus is mostly controlled by these firms. The same is verified regarding total innovation: the variation is always negative because low-cost firms always decrease their investment in innovation after the merger. The quantification of the consumer surplus variation shows that the possible loss of welfare (which occurs for γ <1.2) does not surpass 1.5% of the departing figure, and that the possible welfare increase also does not exceed 1.5% of the initial consumer surplus. These figures are associated with an expected small price change, lower than 0.1% upwards or downwards. Hence, the loss of consumer surplus, being so small, is likely to be compensated, in social terms, by fixed costs savings that are not explicitly modelled here, so the merger could be quietly authorized by antitrust authorities.

5. Conclusion

The effect of mergers on innovation is a topic that does not generate consensus among the scientific community. As highlighted in the literature review, this effect can be either positive, negative, or ambiguous, depending on several factors. Competition Authorities have the power to disapprove mergers that may harm consumers.

In this article, we proposed to evaluate the impact of the PSA/FCA merger on innovation in the EV industry. This merger was considered very relevant to analyse because of the impact it may have on the environment, especially regarding innovation concerning EVs production and EVs price (or accessibility for customers), towards energy transition (changing from non-renewable sources of energy to renewable ones, such as electricity). If the newly created merged entity, Stellantis, contributes to the shift of conventional automobiles to electric vehicles, it may help to achieve the energy transition. The PSA and FCA merger intended to create a new company that would be more competitive in the EV industry, through cost synergies, so the production of accessible EVs is expected to increase. The merger was carefully evaluated by the EC and ended up being approved. It finally took place officially in January 2021.

The Ishida et al. (2011) model was selected as the most promising environment to address the EVs industry merger cases, in particular the important PSA/FCA merger. The model was adjusted according to the characteristics expressed before, to better fit the industry in question, and in this way also filling a gap in the literature that has to do with the more realistic approach of considering a generic number of low-cost firms and high-cost firms in the Ishida et al. (2011) setup, instead of a generic number of high-cost and just one low-cost.

Then, we analyzed the levels of production of EV producers in Europe. Based on the quantities, we observed that in the pre-merger situation there are 4 low-cost companies and 9 high-cost companies, being both PSA and FCA high-cost players. However, by joining resources and expertise, we assumed that the merged entity would become a low-cost firm, meaning that the market would then have 5 low-cost companies and 7 high-cost ones. Our model was developed based on this important assumption.

After developing the model, we performed several simulations to understand the impact of this merger on innovation, profits, quantities, price, and consumer surplus. Regarding innovation, we have seen that this merger decreases total innovation investment in the industry. Low-cost firms always decrease their investment because, after the merger, competition increases among these groups (2 high-cost firms become one low-cost). Also, the newly merged entity is a low-cost firm that increases its investment. Therefore, because of the strategic substitution effect, the other L firms decrease their investment in innovation. Relatively to high-cost firms, innovation investment may increase or decrease, depending on its efficiency. On the one hand, competition inside this group decreases. On the other hand, we have the strategic substitution effect (caused by the investment increase of the newly merged entity). Nevertheless, since merging companies increase their investment in innovation, the decrease in total innovation is due to the response of outsiders. The decrease in total innovation investment is lower (higher) when the investment in innovation is less (more) efficient.

After the merger, the profits of H firms always increase because there is less competition in the industry. In contrast, the profits of L firms decrease because competition increases inside this group. Nevertheless, the total profits of the industry increase after the merger. It is interesting to note that the variation of profits of the merging companies is negative (merger paradox). However, they still decide to merge because efficiency gains are not considered in our model, such as the reduction of fixed costs. It is also interesting to see that this merger benefits high-cost companies, while it harms low-cost ones.

We also wanted to understand the effect of the merger on quantity, price, and consumer surplus. The quantity produced by L firms always decreases after the merger. Since competition increases (one more L firm after the merger), firms produce less. Also, when H firms increase their production, the strategic substitution effect contributes to the decrease of the L firms' quantity. Regarding H firms, the quantity output only increases if the investment in innovation is sufficiently efficient. Even though competition decreases (one firm less), there are still 7 companies, meaning that competition is still high. In terms of total quantity produced, it only increases if the investment in innovation is not very efficient. Even though H firms increase their production if γ is low enough, L firms decrease because of the strategic substitution effect. Since L firms produce 5.46 times more on average, total quantity only increases when the decrease in the production of L firms is minimum, which occurs for inefficient investment in innovation (high γ). By decreasing the price, this merger may contribute to two important events: first, an increase in the welfare of consumers; second, if the price drops quantity increases, meaning that the adoption of EV increases, and we approach green energy transition. Actually, if γ is high (low) enough, price decreases (increases). So, in terms of consumer welfare, this merger is only desirable if the investment in innovation is inefficient (high γ), which may be a surprising result, but derives from the fact that high γ mitigates the quantity adjustment by low-cost producers after the merger, especially due to stronger synergy effects that drive a more pronounced increase in the quantity of the newly created low-cost firm as compared with the sum of the pre-merger productions of the two former high-cost firms. Also, if prices decrease, the rate of adoption of EVs increase, which is a desirable effect towards green energy transition. This is very important since the energy transition is highly beneficial for society.

The practical application of our model has some limitations related to the data used. First, market segments may be difficult to identify in the EV market. Second, as stated in chapter 6., we use sales data regarding all the industry, even though our model is applied to market segments individually. Due to the lack of data we had to consider this option. Furthermore, despite some brands producing more units for the European market, we did not consider the total production of each brand. One brand may produce only a few units for Europe but have a very high production for countries outside Europe that generates scale economies, which means that our classification of low-cost and high-cost brands may not be fully correct.

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