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Competition among vortex firms: Marketing, R & D or pricing strategy

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ABSTRACT

The mathematical model determines how firms can leverage their advantages to increase their market share. Represented as vortex, firms increase their market scope using: marketing expenses strategy, R & D expenditure strategy or price reduction strategy. For an overpriced good, the R & D strategy is required if sector marketing velocity growth is low otherwise the pricing strategy is suited. Conversely, for an underpriced good, the R & D strategy is used when sector marketing velocity growth is high, but when it is low, the pricing strategy is followed. Distance between firms, competitor marketing velocity and related services share contribute or limit these strategies.

1. Introduction

Firms may determine the best position for their products to better compete. However, this positioning depends first on product characteristics and second on perceptual attributes by consumers. Indeed, in product positioning and design, product characteristics affect perceptual attributes (Kaul & Rao, 1995). "Product attributes are abstract dimensions that characterize the perceptions that consumers have on a product" (Hadjinicola & Charalambous, 2013, p. 432) also referred as "wants satisfiers" (Shocker & Srinivasan, 1974). The price has also an impact on the perception of the attributes (Hauser & Simmie, 1981).

In product design, they analyze marketing and engineering functions by distinguishing horizontal attributes from vertical attributes. Consumer "taste" like color and shape are considered as horizontal attributes while product performance or "quality" is reflected in the vertical attributes (Lacourbe, Loch, & Kavadias, 2009). So, product characteristics reflect product technological aspects while marketing transforms these product characteristics into product attributes to influence consumer decision (Kaul & Rao, 1995). Indeed, they proposed to link marketing to R & D for successful innovations and products (Cordon-Pozo, Garcia-Morales, & Aragon-Correa, 2006; Fain, Schoormans, & Duhovnik, 2011).

It is important to be able to represent the good through its marketing, technological and price characteristics, in order to be able to determine when the marketing expenses strategy is efficient, when the R & D expenditure strategy is efficient or when the price reduction is efficient.

Determining the optimal price is also considered in product competitive positioning. Product pricing is analyzed from the standpoint of economies of scale (Hadjinicola, 1999), of competition in a multi-segmented market, (Choi, DeSarbo, & Harker, 1990,

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1992), with market entry, and fixed and variable costs (Rhim & Cooper, 2005).

In product design, the price depends on the attributes selected in order to satisfy consumers. The optimal combination of attributes allows offering a product at the right price to attract consumers (Belloni, Freund, Selove, & Simester, 2008; Chen & Hausman, 2000; Michalek, Ebbes, Adiguzel, Feinberg, & Papalambros, 2011) by considering multi-segmented market (Schon, 2010).

Multi-segmented market are studied because consumers have not the same preference for quality but also not the same level of income (Gabszewicz & Thisse, 1979; Guseo & Guidolin, 2015). However, models become more complex as they focus on product portfolio (Cantner, Krüger, & Söllner, 2012; van der Vooren, Alkemade, & Hekkert, 2013) in order to offer different levels of the same characteristics (Saviotti & Pyka, 1995).

This is why in our study we associate the firm with a good rather than a portfolio of goods. The complexity of the study is reduced but our approach allows laying the foundations for an analysis concerning the relationship between price and the technology offered. Indeed, the firm positioning depends on the price of the good: the good is either overpriced (a high price compared to the technology offered) or underpriced (a low price compared to the technology offered).

To increase the (perceived) quality of a product, firms compete in price, advertising and R & D (Haverila, 2013; Matraves & Rondi, 2007). Moreover, the technical modification of existing products leads companies to reposition their products by other non-technical elements like marketing or pricing (Chanda & Aggarwal, 2014; Urbaniak, 2001). Controllable factors (Kaul & Rao, 1995) or "actionable" attributes (Shocker & Srinivasan, 1974) that allow repositioning are the result of R & D expenditure, marketing expenses and price. Which strategy should be then pursued to offer for sale a successful product based on firm assets?

To determine the right strategy, the profit maximization should be the logical objective criterion but models opt for sales, revenue and market share since it is easier to gather data (Chanda & Das, 2015; Kaul & Rao, 1995). Indeed, to use profit maximization, costs of various product have to be assessed, both variable and fixed costs but also costs linked to product characteristics (Kaul & Rao, 1995). In this sense, the increase in the market share of the firm was retained as the objective pursued by the firm, reflecting the effectiveness of marketing, R & D and pricing strategies.

Another difficulty faced by firms is that perception and preferences are different among consumers. In a multiattributed perceptual space, an ideal point characterizes the most preferred combination of attributes (Carroll, 1972) while a vector characterizes various preferred combination of attributes (Carroll, 1980). Besides, these preferences are difficult to obtain since information concerning consumers distribution is imperfect and costly (Bonein & Turolla, 2009) and laborious to assess a priori by firms (Anderson, De Palma, & Thisse, 1992).

In product positioning, many authors have assumed a uniform distribution of consumers in one or in multiple dimensions (D'Aspremont, Gabszewicz, & Thisse, 1979; De Palma, Ginsberg, Papageorgiou, & Thisse, 1985; Eaton & Lipsey, 1975; Economides, 1984; Hotelling, 1929; Shaked & Sutton, 1982). In these models of spatial competition (Hotelling, 1929), consumer location indicates consumer preferred attributes. The consumer will then buy the product for which the distance between the perceptual attributes and preferred attributes is the lowest. It is this last assumption of consumer location that we have made in our model in order to represent consumers preferences.

However, products position on the space of characteristics change over time. To relax price competition, products have to be located sufficiently far from each other, that is maximum differentiation (D'Aspremont et al., 1979; Shaked & Sutton, 1982). Differentiating their products, firms reduce competition by searching for market niches but limit their market share (Bassi, Pagnozzi, & Piccolo, 2015).

While generally in these models, firms locate first their products and then compete simultaneously on price (Economides, Howell, & Meza, 2002; Götz, 2005; Lambertini, 2002; Neven, 1987), few have tried to analyze a successive product positioning and price changes (Anderson, 1987; Fleckinger & Lafay, 2010; Lambertini, 1997; Prescott & Visscher, 1977). Indeed, "the design of the product is far less flexible than its price" (Fleckinger & Lafay, 2010).

Also, through the R & D expenditure, firms not only improve their good but move away from their competitors and thus reduce the competition. In this way, as a result of their R & D efforts and the reduction of competition, they are less competing on price.

To gain market share, firms make advertising and/or R & D expenditure (Matraves & Rondi, 2007). Product repositioning is possible thanks to the introduction of a new characteristic (Anderson et al., 1992). Entrants move their position while incumbents reinforce their position (Fontana & Nesta, 2006).

Two alternative R & D strategies can be developed, either "escalation" by investing in few technologies or "proliferation" by investing in a wide range of technologies (Matraves & Rondi, 2007). Escalation is chosen when products are close substitutes leading to more concentration (Matraves, 1999; Sutton, 1998).

Firms introduce successful products thanks to the experience and the capabilities from R & D (Mitchell, 1989; Teece, 1986) but also from marketing (King & Tucci, 2002; Klepper & Simons, 2000) since advertising can expand the demand or change customer preferences between products (Bloch & Manceau, 1999).

Indeed, by representing firms as vortex, they can widen their vortex thanks to marketing expenses and catch more customers. However, this enlargement will be robust enough to withstand competition if the knowledge core resulting from R & D is broad.

Besides, network effects concern many industries if not all. The benefit in using a good or a service increases as it is more and more purchased or used by other consumers generating network externalities (Farrell & Saloner, 1985; Katz & Shapiro, 1985). In the global economy, platform markets that benefit from network effects are for instance container shipping, credit cards, travel reservation systems, video games (Eisenmann, Parker, & Van Alstyne, 2011) but also computers, cell phone services and video-game consoles (Tseng & Wang, 2011).

A broad range of businesses has been reconfigured as platforms (Parker & Van Alstyne, 2000; Rochet & Tirole, 2003;

Wonglimpiyarat, 2012). At least half of the revenue of the 60 of the world's 100 largest companies comes from platform markets (Eisenmann, 2007).

Because of the presence of network effects, the marketing expenses previously made have effects that are maintained over time. And, the related services developed for the main good reinforce the network effects in our model.

From evolutionary theories (Nelson & Winter, 1982), it is crucial for firms to make their model fit the present demand in order to survive (Metcalfe, 1994; Nelson & Winter, 1982; Silverberg, Dosi, & Orsenigo, 1988). The introduction or the improvement of a characteristic enabled by innovation allows escaping competition (Saviotti & Pyka, 2008; Swann, 2009). In the meantime, it generates changes in the environment and intensifies competition (van der Vooren et al., 2013).

Nevertheless, firms are constraint by their previous knowledge and routines (Nelson & Winter, 1982; Teece, Pisano, & Shuen, 1997). This path dependency limits firm competencies (Breschi, Lissoni, & Malerba, 2003; Teece, Rumelt, Dosi, & Winter, 1994) and so its capacity to develop new unrelated characteristics for their products. This can be summarized as follows: “firms make what they can rather than making what they want” (Fontana & Nesta, 2006, p. 47).

So, in firm positioning strategy, our aim is to determine the best suited strategy based on the firm and its competitors competencies and the level of competition.

Moreover, there is a need in both product positioning and product design to analyze the relationship between product characteristics and product attributes, in particular the transformation (Kaul & Rao, 1995). More precisely, in product positioning, decision-making tools are necessary for managers “to help define the competitive frame and generate general zones of interest” (Dodson & Brodsky, 1987, p. 203) instead of perfect mathematical and algorithmic models (Hadjinicola & Charalambous, 2013).

The aim of this paper consists of determining the best suited strategy to increase market share. It implies considering the sector and competitors. Besides, firms have their own strategic orientation either technology or market oriented. The strategy to implement depends also on the network effects that exist for their main good. The marketing strategy, the R & D strategy and the pricing strategy are analyzed taking into account network effects, sector technology intensity, competitor marketing velocity and the distance between firms.

This study analyzes a model of duopoly. The firms are represented as vortex or whirpool. And the customers are caught in firms competing vortex or whirlpool. To catch more customers, we show that the firm must choose between the R & D expenditure strategy and the price reduction strategy. To determine which of these two strategies is the efficient strategy and if they should also use the marketing strategy, the firm must take into account not only its positioning but also the marketing dynamic of the sector.

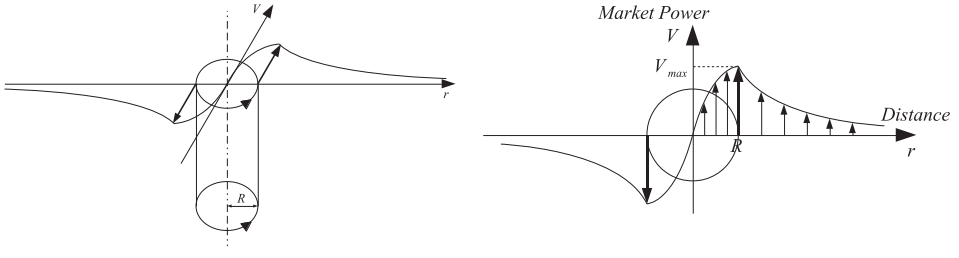
First, the firm positioning depends on the price of the good: the good is either overpriced (a high price compared to the technology offered) or underpriced (a low price compared to the technology offered). Second, the marketing dynamic of the sector is influenced by both firms operating in this sector. The firm that has an underpriced good should exhibits this advantage through marketing expenses. And the firm with more network effects must take advantage of it to hinder the marketing strategy of its competitor. Other factors are also addressed as they reinforce or limit these strategies.

The first section concerns the development of the mathematical model that represents firms as vortex. The objective is also to determine how firms can compete in turbulent environment in developing related services (network effects) to increase their marketing velocity. The second section identifies situations where marketing strategy, R & D strategy and pricing strategy are more efficient. The third section explains how firms can benefit from each strategy to expand their market share. And the last section concludes.

2. The model

A model has been developed with two network firms producing the same main good, a product or a service. Firms market power is represented as a vortex. A vortex is characterized by its core and its velocity. The core of the vortex has a size or a radius R: the distance between vortex center and maximum market power velocity V_{max} (Fig. 1). Then, vortex velocity decreases with the distance. This vortex market power V depends on firm technological velocity and marketing velocity. Firms can expand their market share by increasing their market power V.

Market shares are determined based on the consistency between prices and technological velocities. When the technological



a) The market power velocity b) The market power decrease with the distance

Fig. 1. The market power velocity.

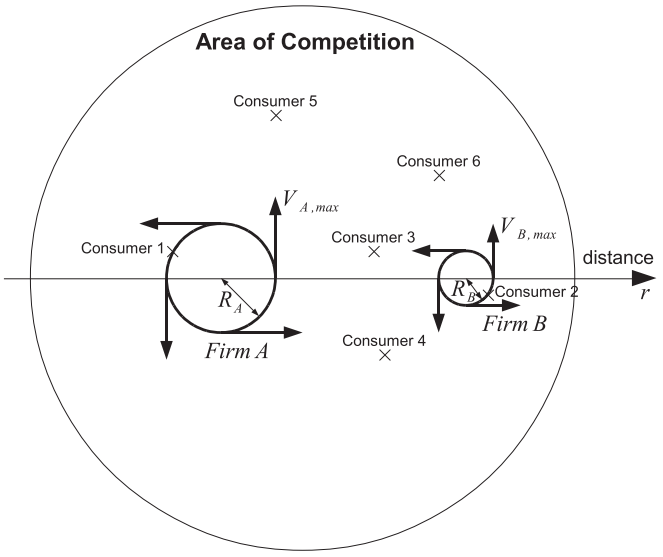


Fig. 2. The competition area for firm goods.

velocity overcomes the price, goods are underpriced, but when the price overcomes the technological velocity, goods are overpriced.

The marketing strategy serves at enhancing the marketing velocity. The related services surrounding the main good are developed in order to act as network effects. This inertia arisen from related services is included in the marketing velocity. Firms can then gain more easily market power.

2.1. The market power

In this vortex representation, through their market power, firm A and firm B compete to capture consumers. The market power V results from the interaction between technological velocity and marketing velocity. Firm circle depicts firm knowledge core (Fig. 2). Firm A knowledge core is larger than firm B knowledge core which means that firm A has made more R & D expenditure than firm B for the last years (so radius $R_A > R_B$). Assuming the knowledge core corresponds to the last 5 years level of R & D expenditures, a firm i knowledge core radius R_{it} is:

$$R_{it} = \sqrt{\frac{1}{\pi}\sum_{t=-4}^{0} \ln(1 + \text{R\&D Expenditures}_{t-1})} \tag{1}$$

Assume consumers are homogeneously distributed throughout the competition area. As in Hotelling location model, consumers choose the firm good closest to them. Consumers will choose a good if the technology proposed corresponds to their need and if marketing makes the good known and well-suited to them. So, their satisfaction depends on firm technological and marketing velocities. Consumer satisfaction evolves with firm market power.

At the firm knowledge core, consumers receive the maximum satisfaction which is also the maximum market power ($V_{A,\max}$ and $V_{B,\max}$ in Fig. 2). For instance, Consumer 1 benefits from the maximum satisfaction of Firm A good (Fig. 2).

The maximum market power or maximum consumer satisfaction is exactly equal to firm technological velocity ($V_{A,\max} = T_A$ and $V_{B,\max} = T_B$). Consumers are highly satisfied with the good characteristics. Market power or consumer satisfaction decreases as consumers are far from firm knowledge core. Consumer 6 is less satisfied by firm A good than Consumer 3, and Consumer 3 is less

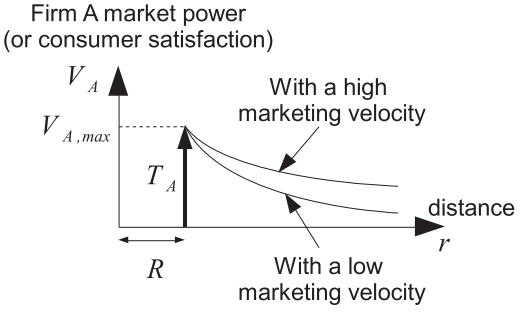


Fig. 3. The marketing velocity benefit.

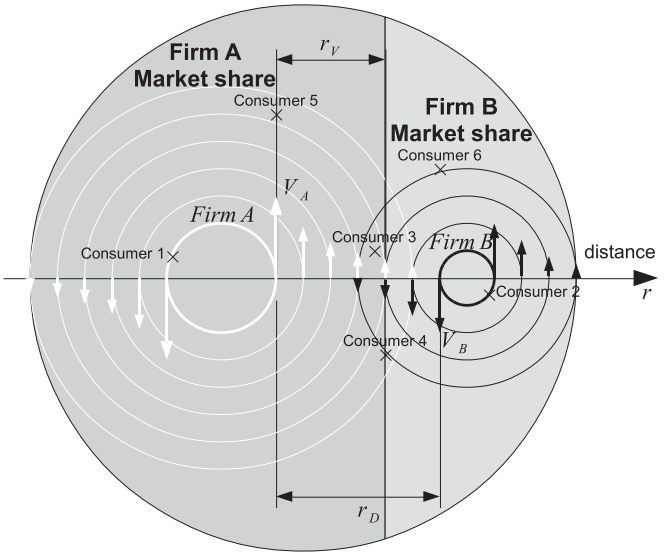


Fig. 4. The market share in a duopoly.

satisfied than Consumer 1. To limit this consumer satisfaction fall, firms make marketing expenses (Fig. 3).

The aim is to adapt as much as possible the good to consumer needs to satisfy the vast majority of consumers. So, for a firm i, exceeding the distance R_{it}, the market power velocity V_{it} diminishes either rapidly or slowly according to its level of marketing velocity M_{it}:

$$V_{it} = \frac{T_{it}}{e^{\frac{r_i}{M_{it}}}} \text{ for } r_i \geq R_{it} \tag{2}$$

Consequently to catch consumers in their vortex, firms require, first, a high technological velocity in order to have the greatest maximum market power, and second, a high market velocity to maintain the market power as high as possible. Firms market power velocities, represented by white arrows for firm A and black arrows for firm B, shrink as consumers are far from their knowledge core (Fig. 4).

The vertical line shows consumers that are indifferent between Firm A good and Firm B good. Consumers are indifferent because for them firms A and B have the same market power. Indeed, taking into account technological and marketing aspects, consumer satisfactions are the same for both goods.

All consumers in the left area (Consumers 1, 3 and 5) choose Firm A good since its market power is the highest while consumers 2 and 6 prefer Firm B good. For consumer 4, both goods are identical in terms of satisfaction. Firm A market share and Firm B market share are represented, respectively, by the dark grey area and the light grey area.

Besides, the distance r_V is the distance between Firm A maximum market power and the vertical line of indifference, the line where both market powers are equal ($V_A = V_B$). Concerning the distance r_D, it is the distance between firms maximum market power or knowledge core.

Through their R & D efforts, firms increase their previous technological velocity. They make their R & D expenditure interact with firm technological network which is expressed as a part η_{it} of the previous technological velocity T_{it-1}.

Besides, firms in low-tech industries benefit more from their previous R & D efforts than high-tech industries in which innovations are more frequent and disruptive. The previous period technological velocity is then divided by the technological intensity of the sector κ indicating that the firm can either rely a lot or a little on previous R & D efforts.

So, the technological velocity T_{it} results from R & D expenditure and previous technological velocity T_{it-1}.

$$T_{it} = \eta_{it} T_{iTt-1} + \frac{1}{\kappa} T_{iTt-1} = \left(\eta_{it} + \frac{1}{\kappa}\right) T_{iTt-1} \tag{3}$$

Depending on the level of competition, firms consider the necessity to make marketing. Regarding the interaction between marketing expenses and marketing network, a factor β_{it} reflects this new marketing effort compared to the previous marketing velocity.

Moreover, firms provide different or similar related services. For each firm, the share of related services is its related services divided by the related services of all firms. Firms with higher share of related services ($\alpha_{it} \in [0;1]$) have an advantage: they can rely more on their previous marketing velocity. The previous market velocity is taken into account by multiplying it by the firm related services share written α_{it} (its network effects).

The market velocity M_{it} is assessed based on marketing expenses and previous marketing velocity M_{it-1}.

$$M_{it} = \beta_{it} M_{iMt-1} + \alpha_{it} M_{iMt-1} = (\beta_{it} + \alpha_{it}) M_{iMt-1} = \gamma_{it} M_{iMt-1} \quad \text{with } \alpha_{it} \in [0;1] \tag{4}$$

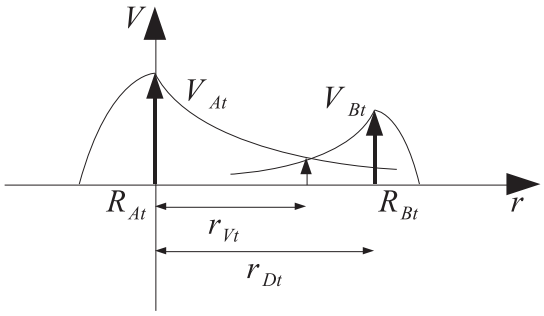


Fig. 5. The market power velocity in a duopoly.

Depending on marketing velocity M_{it}, firm market power decreases quicker or slower. If network effects α_{it} are high, the firm has to make less effort to increase its marketing velocity. The coefficient β_{it} of marketing effort can then be low.

2.2. The market share

In the case of a duopoly, two network firms, firm A and its competitor firm B, compete (Fig. 5).

The distance r_{Dt} represents the distance between their maximum market power. And at the distance r_{Vt}, both market powers are equal ($V_{At} = V_{Bt}$). This distance $r_{Vt}$is called market scope because it determines firm market share (Appendix A1). So, firm A market power velocity and firm B market power velocity are as follows:

$$V_{At} = \frac{T_{At}}{e^{\frac{r_{Vt}}{M_{At}}}} \text{ and } V_{Bt} = \frac{T_{Bt}}{e^{\frac{r_{Dt}-r_{Vt}}{M_{Bt}}}}$$

If their knowledge core is large, they are far from each other because investing in R & D is more relevant to avoid competition. The distance r_{Dt} between firms results from the knowledge core developed by both firms:

$$r_{Dt} = \kappa(R_A + R_B) \tag{5}$$

Thus, this distance is a product of sector technological intensity and the sum of firms knowledge core size.

Firm A market boundary is at the distance r_{Vt} where consumers are indifferent and where both firm market powers are equal ($V_{At} = V_{Bt}$). At this market scope r_{Vt}, there is an equilibrium (Appendix A2).

$$r_{Vt} = \frac{M_{At}}{M_{At} + M_{Bt}}\left[r_{Dt} + M_{Bt}\ln\left(\frac{T_{At}}{T_{Bt}}\right)\right] \tag{6}$$

If firms have the same technological velocity ($T_{At} = T_{Bt}$), the market scope is equal to the ratio between firm marketing velocity

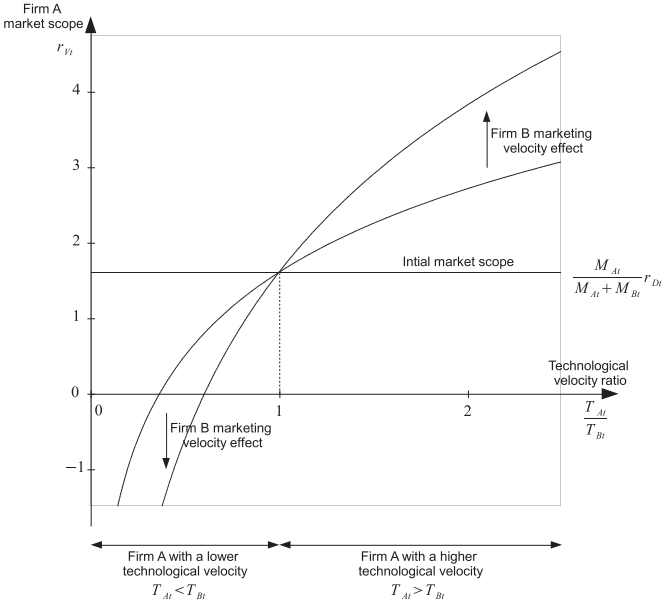


Fig. 6. Firm A market scope r_{Vt} in a duopoly.

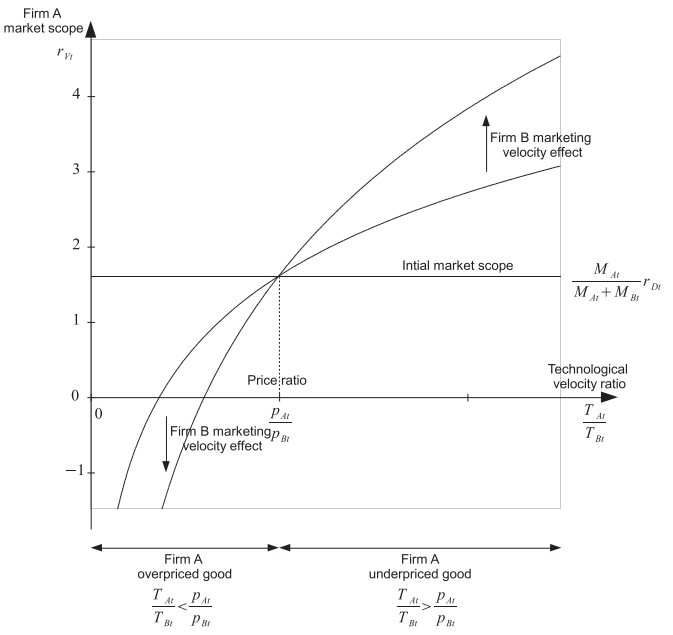


Fig. 7. Firm A market scope r_{Vt} in the case of an overpriced or an underpriced good.

and sector total marketing velocity (Fig. 6). This market scope decreases if firm A technological velocity is lower than competitor technological velocity ($T_{At} < T_{Bt}$). Otherwise, firm A market scope increases ($T_{At} > T_{Bt}$).

This decrease or increase of the market scope is accentuated by competitor marketing velocity (M_{Bt}). Competitor marketing velocity contributes to firm A market share gain only if the firm has a better technological velocity. Conversely, in case firm A has a weaker technological velocity, competitor marketing velocity contributes to firm market share loss.

2.3. The price effect

In order to estimate price effect, prices are introduced in the equation. Firm B consumers accept to pay p_{Bt} for the satisfaction V_{Bt} and firm A consumers accept to pay p_{At} for the satisfaction V_{At}. To respect the condition of indifference for consumers, satisfaction for firm B good should be twice as much as firm A good if firm B good price is two times higher than firm A good price. Thus, the ratios between prices and satisfactions should be the same:

$$\frac{p_{At}}{V_{At}} = \frac{p_{Bt}}{V_{Bt}} \tag{7}$$

By taking into account prices, the new equilibrium equation for the market scope is (Appendix A3):

$$r_{Vt} = \frac{M_{At}}{M_{At}+M_{Bt}}\left[r_{Dt} + M_{Bt}\ln\left(\frac{T_{At}}{T_{Bt}}\frac{p_{Bt}}{p_{At}}\right)\right] \tag{8}$$

Comparisons have been made based on firm A and firm B technological velocities but now it concerns the balance between technological velocities and prices (Fig. 7). The firm A market scope increases if it has an underpriced good. The good is underpriced when the technological velocity ratio is higher than the price ratio. It does not mean that the good is necessarily at a lower price. Firm A simply offer a price lower than firm B in accordance with their technological velocities.

As firm A good is overpriced, the market scope decreases and more sharply if competitor marketing velocity is high. Indeed, by making marketing expenses, firm B revealed to the market an advantageous underpriced good.

2.4. The network effects

Thanks to network effects, firms can rely more on previous marketing expenses. To assess this advantage on market scope, both firms characteristics are initially assumed identical: the same technological velocity ($T_{At} = T_{Bt}$) and price ($p_{At} = p_{Bt}$). Initial market velocities ($M_{A0} = M_{B0}$) are also the same, then, at each period, they are making similar marketing expenses ($\beta_{At}M_{At-1} = \beta_{Bt}M_{Bt-1}$).

Nevertheless, firm A develops new related services while firm B keeps the same number of related services. Through periods, firm A increases its related services share or network effects by a percentage δ: $\alpha_{At} = (1+\delta)\ \alpha_{At-1}$.

It makes increase firm A marketing velocity. Consequently, firm A market scope is (Appendix A4):

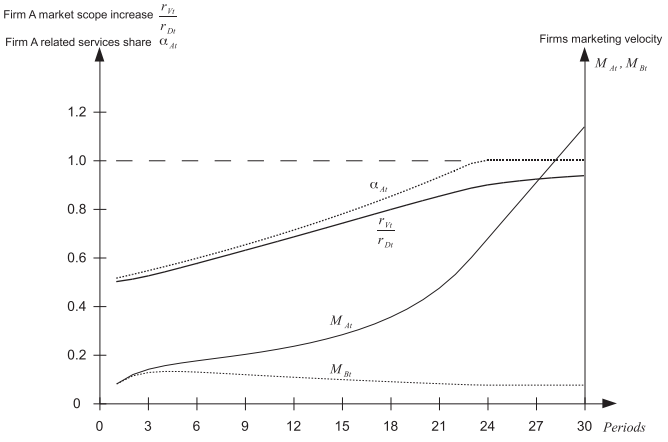


Fig. 8. The network effects on the market scope.

$$r_{Vt} = \frac{1}{1 + \frac{\beta_{At} M_{At-1} + (1-(1+\delta)\ \alpha_{At}) M_{Bt-1}}{\beta_{At} M_{At-1} + (1+\delta)\ \alpha_{At} M_{At-1}}} r_{Dt} \tag{9}$$

Beginning with the same initial situation, only firm A by increasing its related services share α_{At} improves period to period its marketing velocity and so extends its scope (Fig. 8). Firm B and firm A marketing expenses are the same. But with a lower related services share, Firm B previous marketing velocity has less impact on its new marketing velocity. Consequently, firm A increases its market scope until a certain limit because firm B still continues to make marketing expenses. So, firm A can reduce its marketing expenses since it benefits from its previous velocity through its related services share.

Thanks to its related services share, or network effects, the firm can make less marketing expenses and invest more in R & D or reduce its good price. It can also developed more and more related services in order to enhance its market power through its marketing velocity.

3. The analysis of different strategies

R & D, marketing and pricing strategies are efficient if they increase the market scope. Different contexts are analyzed in order to distinguish between relevant and irrelevant strategies.

The aim is to determine the effort to make in each strategy to reach a certain percentage λ of market scope growth:

$$\frac{r_{Vt} - r_{Vt-1}}{r_{Vt-1}} = \frac{r_{Vt}}{r_{Vt-1}} - 1 = \lambda \quad \text{or} \quad \frac{r_{Vt}}{r_{Vt-1}} = 1 + \lambda \tag{10}$$

By replacing in the basic Eq. (8), the equation becomes:

$$\frac{r_{Vt}}{r_{Vt-1}} = 1 + \lambda = \frac{\frac{M_{At}}{M_{At} + M_{Bt}}}{\frac{M_{At-1}}{M_{At-1} + M_{Bt-1}}} \times \frac{r_{Dt} + M_{Bt} \ln\left(\frac{T_{At}}{T_{Bt}} \frac{p_{Bt}}{p_{At}}\right)}{r_{Dt-1} + M_{Bt-1} \ln\left(\frac{T_{At-1}}{T_{Bt-1}} \frac{p_{Bt-1}}{p_{At-1}}\right)} \tag{11}$$

As stated before, firm A technological velocity T_{At} is expressed in function of previous technological velocity ($T_{At} = (\eta_{At} + 1/\kappa)\ T_{At-1}$ from Eq. (3)) while firm A new price is $p_{At} = (1 - \nu_{At}) p_{At-1}$ meaning that its price decreases by ν_{At} percent. Concerning the competitor, firm B, it is assumed that its technological velocity and its price remain the same for all periods ($T_{Bt} = T_{Bt-1}$ and $p_{Bt} = p_{Bt-1}$).

For both firms, marketing velocity is related to the previous marketing velocity ($M_{it} = \gamma_{it} M_{it-1}$ from Eq. (4)). The distance between firms is supposed to be fixed ($r_{Dt} = r_{Dt-1}$). So Eq. (11) is modified to assess the efficiency of different strategies (Appendix B1):

$$\frac{\eta_{At} + \frac{1}{\kappa}}{1 - \nu_{At}} = e^{\frac{r_{Dt-1}}{M_{Bt-1}} \times \frac{\lambda}{\gamma_t}} \left(\frac{T_{At-1}}{T_{Bt-1}} \frac{p_{Bt-1}}{p_{At-1}}\right)^{\frac{1+\lambda-\gamma_t}{\gamma_t}} \tag{12}$$

with $\gamma_t = \frac{\gamma_{At}\gamma_{Bt}(M_{At-1} + M_{Bt-1})}{\gamma_{At} M_{At-1} + \gamma_{Bt} M_{Bt-1}} = \frac{\frac{M_{At-1}}{M_{Bt-1}} + 1}{\frac{M_{At-1}}{M_{Bt-1}} + \frac{\gamma_{Bt}}{\gamma_{At}}} \gamma_{Bt}$, that is the sector marketing velocity growth.

3.1. Marketing strategy

Improving its marketing velocity M_{At-1} by γ_{At} in making marketing expenses, firm A increases its market scope by a percentage λ. It uses neither R & D expenditure strategy nor pricing strategy. With these assumptions, Eq. (12) becomes an equation expressing firm

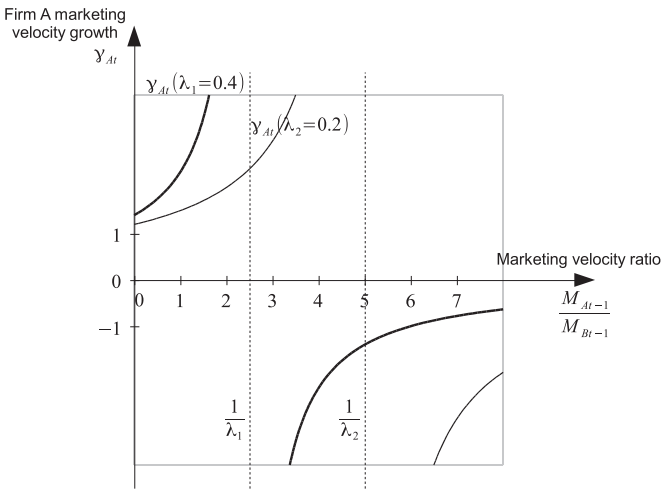


Fig. 9. The marketing velocity growth for a specific market scope growth.

A marketing velocity growth as a function of market scope growth λ (Appendix B2):

$$\gamma_{At} = \frac{1+\lambda}{\frac{1}{\lambda} - \frac{M_{At-1}}{M_{Bt-1}}} \tag{13}$$

The marketing velocity ratio $\frac{M_{At-1}}{M_{Bt-1}}$ indicates how many times firm A marketing velocity is higher than firm B marketing velocity. If firm A marketing velocity is much larger than firm B marketing velocity that it overcomes the inverse of the market scope growth, the market velocity growth is negative. Thus, the inverse of the market scope growth constitutes a limit (Fig. 9).

For instance, if firm A marketing velocity is 2.5 times higher than firm B marketing velocity, firm A cannot increase its market scope by more than 40% (since it is the inverse of 2.5). But, if firm A marketing velocity is 5 times higher than firm B marketing velocity, firm A cannot increase its market scope by more than 20% (since it is the inverse of 5). The lower is the marketing velocity, the larger is the market scope growth due to marketing expenses.

The marketing strategy is efficient when the marketing velocity is low (Table 1). If firm marketing velocity is low compare to its competitor, it becomes easier to increase the market scope by making marketing expenses. Indeed, the link is somehow exponential. With a higher marketing velocity, the firm has to make much more marketing expenses to reach the same market scope growth. Thus, it is less efficient for firm A to increase its marketing velocity when its marketing velocity is higher than firm B.

When the marketing velocity ratio is high, it is better to maintain a small growth of marketing velocity. Firms that have a high marketing velocity compared to their competitors can increase just a little their marketing velocity. In the opposite situation, firms should opt for a high marketing velocity growth.

If firm A benefits from network effects α_{At}, a higher share of related service, firm A can even make a lower marketing velocity effort β_{At}.

$$\beta_{At} = \gamma_{At} - \alpha_{At} = \frac{1+\lambda}{1-\lambda\frac{M_{At-1}}{M_{Bt-1}}} - \alpha_{At} \tag{14}$$

3.2. R & D strategy

The R & D expenditure strategy consists only of increasing the technological velocity. It is then assumed that both firms have the same marketing velocity growth ($\gamma_t = \gamma_{At} = \gamma_{Bt}$). Consequently, from Eq. (12), the technological velocity growth for a specific market scope growth λ is (Appendix B3):

$$\eta_{At} = e^{\frac{r_{Dt-1}}{M_{Bt-1}} \times \frac{\lambda}{\gamma_t}} \left(\frac{T_{At-1}/T_{Bt-1}}{p_{At-1}/p_{Bt-1}} \right)^{\frac{1+\lambda-\gamma_t}{\gamma_t}} - \frac{1}{\kappa} \tag{15}$$

Table 1
The context of an efficient marketing strategy.

Marketing velocity	
Lower than competitor	Efficient marketing strategy
Higher than competitor	Inefficient marketing strategy

Table 2a
The context of an efficient R & D strategy.

	Sector marketing velocity growth	
	Low	High
Underpriced good	Inefficient R & D strategy	Efficient R & D strategy
Overpriced good	Efficient R & D strategy	Inefficient R & D strategy

To have an efficient R & D strategy, the technological velocity growth should be as low as possible for a specific market scope growth.

Thus, the following item should be lower than one. The analysis necessitates comparing sector marketing velocity growth and firm market scope growth present in the power of the item studied. The fact that the good is underpriced or overpriced is also of concern (Table 2a and Fig. 10).

$$\left(\frac{T_{At-1}/T_{Bt-1}}{p_{At-1}/p_{Bt-1}}\right)^{\frac{1+\lambda-\gamma_t}{\eta}} < 1$$

For an underpriced good, a high sector marketing velocity growth is preferable, that is superior to market scope growth $(1+\lambda)$. Indeed, R & D expenditure with high sector marketing velocity displays the advantages of this underpriced good in terms of technology and price.

In the case the good is overpriced, the opposite situation is advantageous. Sector marketing velocity growth should be sufficiently low, inferior to market scope growth $(1+\lambda)$, to avoid bringing to light this difference between technology and price. Otherwise, firm A will have to make huge efforts in R & D to make the technology more consistent with the price offered.

Assuming that the item studied is lower than one, the technological velocity growth is lower than the following inequality:

$$\eta_{At} < e^{\frac{rDt-1}{M_{Bt-1}}\times\frac{\lambda}{\gamma_t}} - \frac{1}{\kappa}$$

Competitor marketing velocity, the distance and the sector technological intensity are also important factors because they specify the cut-off at which the R & D strategy becomes less efficient (Table 2b and Fig. 10).

First, the R & D strategy is less efficient when the distance between firms is high. Second, this factor is offset by the competitor marketing velocity. If the competitor relies heavily on the marketing strategy to compete then the R & D strategy appears as more efficient to gain market share. Third, the technological intensity annihilates R & D efforts, namely the firm may invest much more in R & D to increase its market scope if the sector is characterized by a high technological intensity. But, this is similar to all firms of the sector.

The tables summarize the two situations described as favorable to the R & D strategy (Table 2a) and how these last factors affect this kind of strategy (Table 2b).

The technological velocity growth is low for the two situations represented by the grey area (Fig. 10): sector marketing velocity

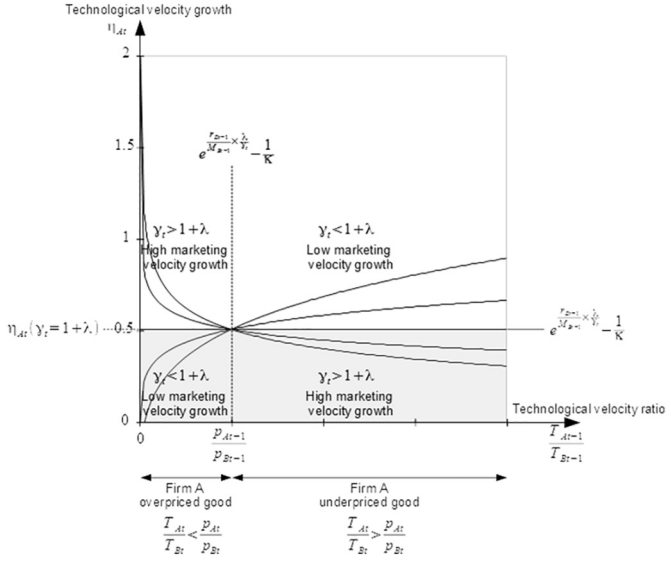


Fig. 10. The technological velocity growth for a specific market scope growth.

Table 2b
The contributing and limiting factors to an efficient R & D strategy.

Contributing factor	Limiting factors
Competitor marketing velocity	Distance Sector technological intensity

growth is high and the firm has an underpriced good, or sector marketing velocity growth is low and the firm has an overpriced good.

A firm that has an underpriced good, a price lower than the technological level (comparatively to its competitor), should ensure that the sector marketing velocity growth is as high as possible. Thanks to the marketing strategy, technological effort will be beneficial because of the underestimated good price.

For a firm characterized by an overpriced good, a price higher than the technological level (comparatively to its competitor), there is a preference for a low sector marketing velocity growth. Since the product is sold at a higher price (comparatively to its technological velocity), a high level of marketing competition is harmful to the R & D strategy efficiency since it brings to light the inadequacy between price and technology.

3.3. Pricing strategy

The pricing strategy consists of decreasing the price. From Eq. (12), suppose both firms have the same marketing velocity growth ($\gamma_t = \gamma_{At} = \gamma_{Bt}$) the price decrease can be expressed in function of market scope growth λ (Appendix B4):

$$\nu_{At} = 1 - \frac{1}{e^{\frac{r_{Dt-1}}{M_{Bt-1}} \times \frac{\lambda}{\eta}} \left(\frac{T_{At-1}/T_{Bt-1}}{p_{At-1}/p_{Bt-1}} \right)^{\frac{1+\lambda-\gamma_t}{\eta}}} \tag{16}$$

The pricing strategy is efficient if the price decreases a little for a specific market scope growth.

Contrary to the R & D strategy, the next item should be higher than one. As previously, looking at the power of the item studied, sector marketing velocity growth is compared to firm market scope growth. The pricing strategy depends also on the good feature: underpriced or overpriced (Table 3a and Fig. 11).

$$\left(\frac{T_{At-1}/T_{Bt-1}}{p_{At-1}/p_{Bt-1}} \right)^{\frac{1+\lambda-\gamma_t}{\eta}} > 1$$

If the good is overpriced, sector marketing velocity growth should be higher than market scope growth $(1 + \lambda)$ in order to make the pricing strategy efficient. The pricing strategy is suited with a high sector marketing velocity growth since it brings more in light this overpriced good sold at a decreased price.

For an underpriced good, a low sector marketing velocity growth is preferable, lower than market scope growth $(1 + \lambda)$.This underpriced good is viewed as an affordable good for which decreasing the price is harmful in the context of high sector marketing velocity.

Since the item studied exceeds one, the price decrease can even be lower than zero ($\nu_{At} < 0$) that is a price increase.

$$\nu_{At} < 1 - \frac{1}{e^{\frac{r_{Dt-1}}{M_{Bt-1}} \times \frac{\lambda}{\eta}}}$$

A price increase still leads to an increase of the market scope. So, the market scope growth will be much higher with a price decrease. Besides, competitor marketing velocity and the distance are also important factors because they specify the cut-off at which the pricing strategy becomes less efficient (Table 3b and Fig. 11).

So, the price reduction strategy is more efficient when the distance between competitors is high. Nevertheless, the competitor marketing velocity restrains this. If the competitor leverages its marketing strategy to compete, then the pricing strategy will be less efficient to gain market share.

The table describes the two situations in favor to the pricing strategy (Table 3a).

The price decrease is low, even negative, for the two situations represented by the grey area (Fig. 11): sector marketing velocity

Table 3a
The context of an efficient pricing strategy.

	Sector marketing velocity growth	
	Low	High
Underpriced good	Efficient pricing strategy	Inefficient pricing strategy
Overpriced good	Inefficient pricing strategy	Efficient pricing strategy

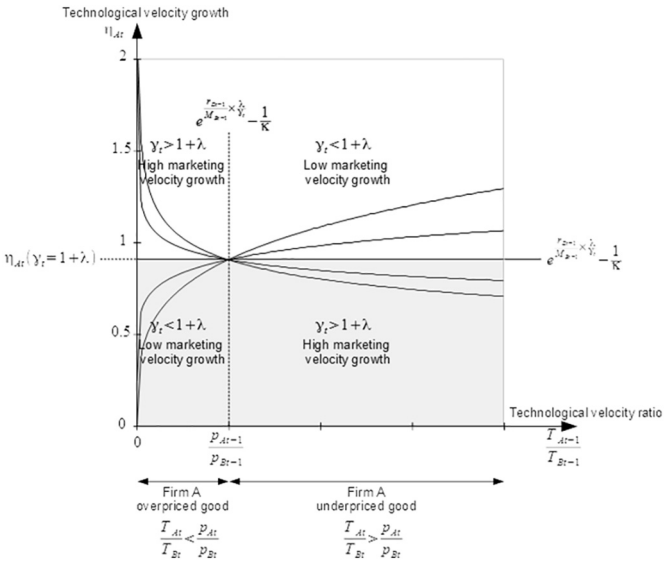


Fig. 11. The price decrease for a specific market scope growth.

growth is low and the firm has an underpriced good, or sector marketing velocity growth is high and the firm has an overpriced good.

A firm that has an underpriced good, a price lower than the technological level (comparatively to the competitor), should ensure that the sector marketing velocity growth is as small as possible. Its underpriced good reflects its inability to use properly marketing expenses in conjunction with price reduction.

For a firm characterized by an overpriced good, a price higher than the technological level (comparatively to the competitor), a high sector marketing velocity growth is requested. A high competition in marketing is beneficial to the efficiency of a strategy based on the price because the firm is more capable to sell its good at a higher price comparatively to the technology provided.

4. Managerial implications

By analyzing firms as vortex, many aspects are of concern to gain new market share. Let firm D sell an underpriced good and its competitor V an overpriced good.

If firms D and V compete largely by increasing their marketing expenses, sector marketing velocity growth will be high. Firm V will choose the pricing strategy while firm D will prefer the R & D strategy (Table 4).

The large distance profits to the overpriced good (Firm V) with its pricing strategy (Table 5). Nevertheless, a high competitor marketing velocity benefits to the underpriced good (Firm D) to take advantage of the R & D strategy.

Consequently, when sector marketing competition is high, firm D with an underpriced good attempts to increase its disequilibrium (to be more underpriced) by being focused on the technology development without changing its price. Its strategy is also associated with an increase of marketing expenses. Thus, the R & D strategy is used in conjunction with the marketing strategy. The firm is all the more beneficial that the competitor raises its marketing expenses.

Concerning the competitor, firm V, the pricing strategy is the only available strategy to respond to the marketing expenses of its competitor which reveals firm V inconsistency between its technology and price. Firm V, with its overpriced good, will try to reduce this disequilibrium by decreasing its price. Thus, the pricing strategy is used in conjunction with the marketing strategy.

However, if marketing competition is low, firm V chooses the R & D strategy to reduce its disequilibrium (Table 4). An advantageous situation if the competitor has a high marketing velocity (Table 5).

Competitor firm D choice is the pricing strategy. This strategy consists of heightening the underpriced effect so that firm D stands by its position against the R & D strategy of firm V. The marketing strategy is not efficient for them except if one of them wants to switch over the situation described previously by increasing the marketing competition.

On one hand, firm D tries to keep its good underpriced either by reducing its price (when sector marketing velocity growth is low) or by increasing its technological velocity (when sector marketing velocity growth is high).

On the other hand, firm V tries to adapt its good price to its technological velocity because its good is overpriced. Firm V increases

Table 3b
The contributing and limiting factors to an efficient pricing strategy.

Contributing factor	Limiting factors
Distance	Competitor marketing velocity

Table 4
The pricing and R & D strategies for an overpriced and underpriced good.

	Sector marketing velocity growth	
	Low	High
Underpriced good	Pricing strategy	R & D strategy
Overpriced good	R & D strategy	Pricing strategy

its technological velocity (when sector marketing velocity growth is low) or decreases its price (when sector marketing velocity growth is high).

It seems that firm D seeks to move away from the consistency while firm V wants to approach it. In reality, if firm V tries to get closer to the equilibrium with the R & D strategy, it is to be able to increase its price and to maintain its good overpriced in an offensive manner. However, for firm V, the pricing strategy is realized in a defensive position because the sector intensive marketing strategy reveals the unbalance between its price and technology.

Regarding firm D, its offensive strategy consists of increasing the technology when sector intensive marketing strategy highlights its competitor disequilibrium. The defensive position is reflected by the price reduction in order to make its technology affordable because the marketing competition is low.

Nonetheless, a firm can influence sector marketing velocity growth (Eq. (12)). To decrease or increase sector marketing velocity growth, a firm A should respectively reduce or enhance its own marketing velocity growth. Nonetheless, the higher its marketing velocity is, the less it can change sector marketing velocity growth (Fig. 12). Sector marketing velocity growth will be then closed to firm B marketing velocity growth.

When firms V and D follow different strategies, one the pricing and the other the R & D, they both look for the same sector marketing velocity growth, either high or low. However, by pursuing the same strategy, both the pricing or both the R & D, they seek different sector marketing velocity growth. One tries to increase it while the other wants to reduce it.

Sector marketing velocity is more influenced by the firm with the lowest marketing velocity. Moreover, from the context of an efficient marketing strategy, the firm with the highest marketing velocity prefers a low increase of the marketing velocity.

The marketing strategy should be pursued aggressively by the firm with the lowest marketing velocity. The firm with the lowest marketing velocity is always in a better position to determine sector marketing velocity growth depending on its need.

On the other hand, by developing related services, firms reach high network effects, and can then easily increase their marketing velocity growth. Nevertheless, high network effects prevent them to reduce easily their marketing velocity growth. So, firms that benefit from important network effects will choose strategies that require high sector marketing velocity growth: pricing strategy for an overpriced good and R & D strategy for an underpriced good.

Consequently, the firm with the lowest marketing velocity affects more the sector marketing velocity growth. This firm will obviously choose the R & D strategy. Then, according to its low or high network effects, it will set the price to obtain respectively an overpriced or an underpriced good.

The competitor can only choose the pricing strategy except if it reduces significantly its marketing expenses to be able to choose between the pricing strategy or the R & D strategy. After all, the possibility of the competitor is limited to the pricing strategy if it has high network effects because it cannot restrain the sector marketing velocity growth.

5. Conclusion

The strategy chosen depends mainly on the sector marketing velocity growth and on the balance between the price and the technology of the good. An overpriced good associated with a low sector marketing velocity growth is favorable to the R & D strategy. For the same low sector marketing velocity growth, the pricing strategy is suited for an underpriced good. As the sector marketing velocity growth becomes high, there is a shift in strategies, the pricing strategy for the overpriced good and the R & D strategy for the underpriced good.

It appears that firms with an underpriced good try to keep the inconsistency between price and technology while firms with an overpriced good attempt to achieve a balance between price and technology. Indeed, enlightening an underpriced good is beneficial. However, with an overpriced good, firms will shift their strategy from R & D expenditure to price reduction as the sector marketing velocity grows.

Using their marketing strategy, firms will try to affect sector marketing velocity growth. The firm that can affect the more the

Table 5
Contributing and limiting factors for the pricing and R & D strategies.

	Contributing factors	Limiting factors
R & D strategy	Competitor marketing velocity	Distance Technological intensity
Pricing strategy	Distance	Competitor marketing velocity

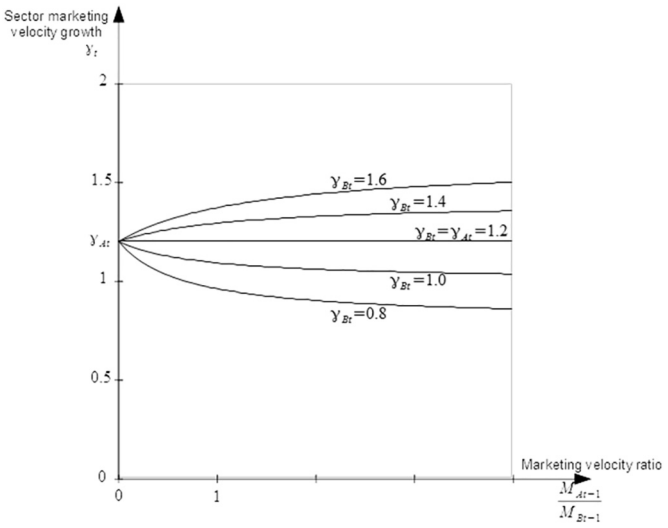


Fig. 12. Firm marketing velocity growth to increase or decrease sector velocity growth.

sector marketing velocity growth is the firm with the lowest marketing velocity. If this firm has also the highest share of related services, it can nevertheless enhance much more its marketing velocity. Nevertheless, as shown, all firms should make some marketing expenses at least to keep their market scope.

Firms can use many strategies to compete such as investing more in R & D or making more marketing expenses. They can enter into new alliances to obtain resources needed to improve their main product or service or to reach highest marketing capabilities. Despite collaboration is useful to reduce competition, costs are associated to it like administrative, coordination and information costs (Singh & Mitchell, 2005). So, costs constitute a limit in our model because they are not assessed and they can restrict price reduction.

Since resources are limited, the strategy chosen should be the one which is the more profitable (Danneels, 2007). In addition, to limit competition, firms can increase the distance between them by making more R & D expenditures. In fact, firms prefer maximum differentiation in the absence of network externalities (D'Aspremont et al., 1979) and so markets locate at the periphery (maximum differentiation) (Serfes & Zacharias, 2012).

Nevertheless, for stronger externalities, one market will be at the center while the other will be at the periphery, trying to escape from competition (Serfes & Zacharias, 2012). The model shows that the related services share serves firms mainly if competitor has a higher marketing velocity. It appears that firms can use competitor strengths to their own advantage: competitor higher marketing velocity, competitor higher related services share, competitor overpriced good.

The results indicate that the marketing strategy is important. But for those that have high marketing velocity, they should be cautious in using the marketing strategy. Besides, the strategy adopted is linked to the balance between price and technology. Firms can also try to affect sector marketing velocity growth in order to be able to choose the strategy that allows them to take advantage of firms distance, related services share and competitor marketing velocity. Taking all these factors into account, firms increase their market share or at least limit competitor offensive strategy.

The contribution of this research lies in representing the market share as a vortex or whirlpool. The proposed model can be extended in five different complementary directions.

First, the vortex approach takes into account the marketing, the technology and the price. So, the vortex approach of the firm can be used in the existing models to represent the market share of the firm.

Second, for managers, building market share is a key concern. Indeed, the market share is a key indicator of market competitiveness. The vortex approach can help to anticipate the evolution of market shares, by analyzing the impact of managers' actions on market shares. The market share in the vortex approach is directly linked to marketing variables, technological variables and the price. Thus, it would be interesting to use real data in this model to derive market share elasticities for different markets and sectors: by how much the firm or the competitor market share increases or decreases if a marketing variable, a technological variable or the price changes?

Third, the model represents a duopoly, but it is possible to consider an oligopoly or even another situation of competition with this same basic model. Simulations may allow us to adapt our findings to other competitive situations so that firms opt for the most efficient strategies.

Fourth, instead of having each firm selling one good, several firms can sell a portfolio of goods in the same market. Each firm will have a specific vortex for each of its goods. Thus, the vortex of some products will be wide and other smaller according to their specific marketing expenses, R & D expenditure and price. Moreover, consumers can be heterogeneously distributed with different densities. The model can be developed to study complex situations.

Fifth, given that competition is increasingly based on network effects, this model can be useful because the network effects are taken into account by introducing the related services share. And developing new related services for the main good will maintain the

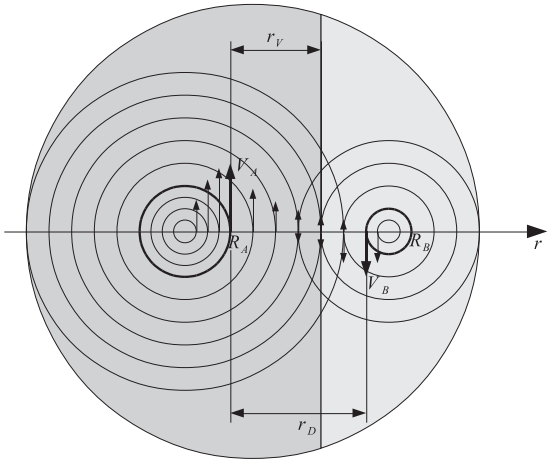


Fig. 13. The circular market share in a duopoly.

marketing expenses effects over the longer term. Models can then use related services share to represent network effects.

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Appendix A

Appendix A1

Using the circular segment equation (Fig. 13), it is possible to determine the market share S_{Bt} for firm B: $S_{Bt} = \frac{1}{2}R_{mt}^2(\theta_{Bt} - \sin\theta_{Bt})$where $R_{mt} = R_{At} + R_{Bt} + r_{Dt}$ and $\theta_{Bt} = 2Arc\ \cos\left(1 - \frac{D_{Bt}}{R_{mt}}\right)$ with $D_{Bt} = 2R_{Bt} + 2(r_{Dt} - r_{Vt})$

Consequently, the market share S_{At} for firm A is:

$$S_{At} = \pi R_{mt}^2 - S_{Bt}$$

where $R_{mt} = \frac{1}{2}(2R_{At} + 2R_{Bt} + 2r_{Dt}) = R_{At} + R_{Bt} + r_{Dt}$

and $\theta_{Bt} = 2Arc\ \cos\left(1 - \frac{D_{Bt}}{R_{mt}}\right)$ with $D_{Bt} = 2R_{Bt} + 2r_{Bt} = 2R_{Bt} + 2(r_{Dt} - r_{Vt})$

Assuming rectangular surfaces for market shares (Fig. 14), respective market shares are:

$$S_{At} = 2R_{mt}D_{At}$$

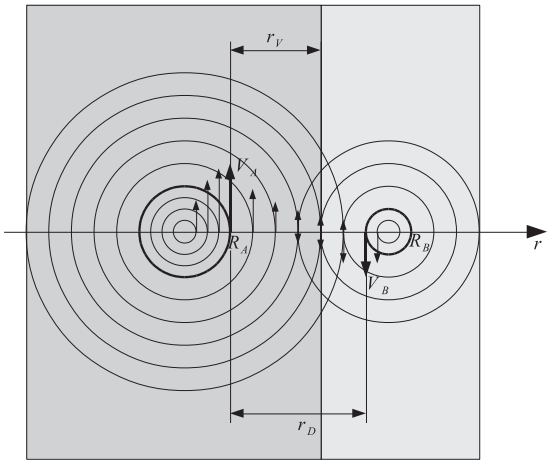

Fig. 14. The rectangular market share in a duopoly

$$S_{Bt} = 2R_{mt}D_{Bt}$$

Appendix A2

Where consumers are indifferent, both market vortexes are equal that is $V_{At} = V_{Bt}$. Each market vortex is replaced by the Eq. (2) to obtain the following expression $\frac{T_{At}}{e^{\frac{r_{Vt}}{M_{At}}}} = \frac{T_{Bt}}{e^{\frac{r_{Dt}-r_{Vt}}{M_{Bt}}}}$. By developing it, it becomes $\frac{M_{At}+M_{Bt}}{M_{At}M_{Bt}}r_{Vt} = \frac{r_{Dt}}{M_{Bt}} - \ln\left(\frac{T_{Bt}}{T_{At}}\right)$ and so the market scope Eq. (6) is obtained: $r_{Vt} = \frac{M_{At}}{M_{At}+M_{Bt}}\left[r_{Dt} - M_{Bt}\ln\left(\frac{T_{Bt}}{T_{At}}\right)\right]$.

Appendix A3

Where consumers are indifferent, both ratio between prices and market vortex (or satisfaction) should be the same $\frac{p_{At}}{V_{At}} = \frac{p_{Bt}}{V_{Bt}}$. Each market vortex is replaced by the Eq. (2) to obtain the following expression $p_{At}\frac{T_{Bt}}{e^{\frac{r_{Dt}-r_{Vt}}{M_{Bt}}}} = p_{Bt}\frac{T_{At}}{e^{\frac{r_{Vt}}{M_{At}}}}$. By developing it, it becomes $\frac{M_{At}+M_{Bt}}{M_{At}M_{Bt}}r_{Vt} = \frac{r_{Dt}}{M_{Bt}} - \ln\left(\frac{T_{Bt}}{T_{At}}\frac{p_{At}}{p_{Bt}}\right)$ and so the market scope Eq. (8) is obtained: $r_{Vt} = \frac{M_{At}}{M_{At}+M_{Bt}}\left[r_{Dt} - M_{Bt}\ln\left(\frac{T_{Bt}}{T_{At}}\frac{p_{At}}{p_{Bt}}\right)\right]$.

Appendix A4

The market scope Eq. (8), $r_{Vt} = \frac{M_{At}}{M_{At}+M_{Bt}}\left[r_{Dt} + M_{Bt}\ln\left(\frac{T_{At}}{T_{Bt}}\frac{p_{Bt}}{p_{At}}\right)\right]$, is transformed to take into account that both firms characteristics are initially exactly the same. It becomes $r_{Vt} = \frac{1}{1+\frac{M_{Bt}}{M_{At}}}r_{Dt}$ and marketing velocities are replaced by its Eq. (4). Since they are making similar marketing expenses ($\beta_{At}M_{At-1} = \beta_{Bt}M_{Bt-1}$), so the market scope Eq. (9) is $r_{Vt} = \frac{1}{1+\frac{\beta_{At}M_{At-1}+(1-(1+\delta)\ \alpha_{At})M_{Bt-1}}{\beta_{At}M_{At-1}+(1+\delta)\ \alpha_{At}M_{At-1}}}r_{Dt}$.

Appendix B

Appendix B1

From Eq. (10), $\frac{r_{Vt}}{r_{Vt-1}} = 1+\lambda$, the market scope is replaced by its Eq. (8) to obtain $\frac{r_{Vt}}{r_{Vt-1}} = \frac{\frac{M_{At}}{M_{At}+M_{Bt}}}{\frac{M_{At-1}}{M_{At-1}+M_{Bt-1}}} \times \frac{r_{Dt}+M_{Bt}\ln\left(\frac{T_{At}}{T_{Bt}}\frac{p_{Bt}}{p_{At}}\right)}{r_{Dt-1}+M_{Bt-1}\ln\left(\frac{T_{At-1}}{T_{Bt-1}}\frac{p_{Bt-1}}{p_{At-1}}\right)}$. Since the aim is to asses marketing, R & D and pricing strategies, Eq. (4) of marketing velocities $M_{it} = \gamma_{it}M_{it-1}$, Eq. (3) of firm A new technological velocity $T_{At} = (\eta_{At}+1/\kappa)\ T_{At-1}$ and firm A new price $p_{At} = (1-\nu_{At})p_{At-1}$ are introduced:

$$1+\lambda = \frac{\frac{\gamma_{At}M_{At-1}}{\gamma_{At}M_{At-1}+\gamma_{Bt}M_{Bt-1}}}{\frac{M_{At-1}}{M_{At-1}+M_{Bt-1}}} \times \frac{r_{Dt-1}+\gamma_{Bt}M_{Bt-1}\ln\left(\frac{\left(\eta_{At}+\frac{1}{\kappa}\right)T_{At-1}}{T_{Bt-1}}\frac{p_{Bt-1}}{(1-\nu_{At})p_{At-1}}\right)}{r_{Dt-1}+M_{Bt-1}\ln\left(\frac{T_{At-1}}{T_{Bt-1}}\frac{p_{Bt-1}}{p_{At-1}}\right)}$$

The next step gives the following equation:

$$\ln\left(\frac{\eta_{At}+\frac{1}{\kappa}}{1-\nu_{At}}\right) = \left[(1+\lambda)\frac{\gamma_{At}M_{At-1}+\gamma_{Bt}M_{Bt-1}}{\gamma_{At}(M_{At-1}+M_{Bt-1})} - 1\right]\frac{r_{Dt-1}}{\gamma_{Bt}M_{Bt-1}} + \left[(1+\lambda)\frac{\gamma_{At}M_{At-1}+\gamma_{Bt}M_{Bt-1}}{\gamma_{At}\gamma_{Bt}(M_{At-1}+M_{Bt-1})} - 1\right]\ln\left(\frac{T_{At-1}}{T_{Bt-1}}\frac{p_{Bt-1}}{p_{At-1}}\right)$$

Finally, the Eq. (12) to assess different strategies can be written as followed:

$$\frac{\eta_{At}+\frac{1}{\kappa}}{1-\nu_{At}} = e^{\frac{r_{Dt-1}}{M_{Bt-1}}\times\frac{\lambda}{\gamma_t}}\left(\frac{T_{At-1}}{T_{Bt-1}}\frac{p_{Bt-1}}{p_{At-1}}\right)^{\frac{1+\lambda-\gamma_t}{\gamma_t}}$$

with $\gamma_t = \frac{\gamma_{At}\gamma_{Bt}(M_{At-1}+M_{Bt-1})}{\gamma_{At}M_{At-1}+\gamma_{Bt}M_{Bt-1}} = \frac{\frac{M_{At-1}}{M_{Bt-1}}+1}{\frac{M_{At-1}}{M_{Bt-1}}+\frac{\gamma_{Bt}}{\gamma_{At}}}\gamma_{Bt}$, the sector marketing velocity growth

Appendix B2

From Eq. (11), if technogical velocities and prices do not change, then:

$$\frac{r_{Vt}}{r_{Vt-1}} = \frac{\frac{M_{At}}{M_{At}+M_{Bt-1}}}{\frac{M_{At-1}}{M_{At-1}+M_{Bt-1}}} \times \frac{r_{Dt-1}+M_{Bt-1}\ln\left(\frac{T_{At-1}}{T_{Bt-1}}\frac{p_{Bt-1}}{p_{At-1}}\right)}{r_{Dt-1}+M_{Bt-1}\ln\left(\frac{T_{At-1}}{T_{Bt-1}}\frac{p_{Bt-1}}{p_{At-1}}\right)} = \frac{\frac{\gamma_{At}M_{At-1}}{\gamma_{At}M_{At-1}+M_{Bt-1}}}{\frac{M_{At-1}}{M_{At-1}+M_{Bt-1}}}$$

By replacing $\frac{r_{Vt}}{r_{Vt-1}}$ by $1+\lambda$, the equation becomes $(1+\lambda)M_{Bt-1} = \gamma_{At}(M_{Bt-1} - \lambda M_{At-1})$.
It is equivalent to $\gamma_{At} = \frac{M_{Bt-1}+\lambda M_{Bt-1}}{M_{Bt-1}-\lambda M_{At-1}} = \frac{1+\lambda}{1-\lambda\frac{M_{At-1}}{M_{Bt-1}}}$ corresponding to Eq. (13).

Appendix B3

The Eq. (12) which is $\frac{\eta_{At}+\frac{1}{\kappa}}{1-\nu_{At}} = e^{\frac{rDt-1}{MBt-1}\times\frac{\lambda}{\gamma_t}}\left(\frac{T_{At-1}}{T_{Bt-1}}\frac{p_{Bt-1}}{p_{At-1}}\right)^{\frac{1+\lambda-\gamma_t}{\gamma_t}}$ in the case of no price change $\nu_{At}=0$ becomes Eq. (15): $\eta_{At} = e^{\frac{rDt-1}{MBt-1}\times\frac{\lambda}{\gamma_t}}\left(\frac{T_{At-1}/T_{Bt-1}}{p_{At-1}/p_{Bt-1}}\right)^{\frac{1+\lambda-\gamma_t}{\gamma_t}} - \frac{1}{\kappa}$.

Appendix B4

The Eq. (12) which is $\frac{\eta_{At}+\frac{1}{\kappa}}{1-\nu_{At}} = e^{\frac{rDt-1}{MBt-1}\times\frac{\lambda}{\gamma_t}}\left(\frac{T_{At-1}}{T_{Bt-1}}\frac{p_{Bt-1}}{p_{At-1}}\right)^{\frac{1+\lambda-\gamma_t}{\gamma_t}}$ in the case of no technological velocity change $\eta_{At}+\frac{1}{\kappa}=1$ becomes Eq. (16): $\nu_{At} = 1 - \frac{1}{e^{\frac{rDt-1}{MBt-1}\times\frac{\lambda}{\gamma_t}}\left(\frac{T_{At-1}/T_{Bt-1}}{p_{At-1}/p_{Bt-1}}\right)^{\frac{1+\lambda-\gamma_t}{\gamma_t}}}$.

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