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Pricing in Innovation Diffusion among Competitors

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ABSTRACT

Pricing is analyzed with a system dynamics approach in the context of a dynamic competition among two competitors, one of them offers a product that appears first in the market (the leader), intended to be an innovation, the other (the follower), offers a similar product but enters into the market with a certain lag; price sensitivity, brand equity, lag's length, quality of the products and consumers response are considered. The leader´s strategy stands on price and revenue performance where else the follower´s on market share. The dynamics is modeled, simulations are made and conclusions are driven. Simulated experiments are used to compute dynamic price elasticity and the hypothesis that the absolute value of price elasticity increases with time is questioned and different shapes reported from empirical data are confirmed associated to pricing strategies. The hypothesis that price reduction increases market share and profitability is also analyzed finding scenarios where it is confirmed and refuted according to price sensitivity of the market.

KEYWORDS: Innovation diffusion; stage structure; price strategy; competition; quality; brand equity; dynamic price elasticity.

Introduction

In order that a new product breaks through the market price performance has a very important role. Price is one of the main drivers in any supply chain. Pricing becomes strategic in many ways such as increasing market share, improving profit, revenue management policies or innovation diffusion. In this paper it is assumed that a leader enterprise, provider of a new product, intends to turn it into an innovation. Another enterprise, called the follower, after a certain lag, will offer a similar product and will start a competition with the former one, determined to increase its market share. An interesting and difficult problem that both enterprises cannot avoid is to find effective strategies in order to succeed in their pursuit of their purposes. Various aspects are taken into consideration as competitors' brand equity, the response of the consumers in relation to each product and the judgment that experts have about both products; pricing policies correspondent to those aspects and market share and revenue performance are used in that pursuit.

The modeling of diffusion of innovations on a market has been studied extensively since the celebrated paper by Bass (1969), which is a milestone in the field. Different techniques have been used for different purposes like in Yu, Wang, & Zhang (2003) where the theory of competitive and cooperative systems, developed by M. W. Hirsch, is applied to analyze global stable equilibrium in the diffusion of three competing products. In Wang W., Fergola, Lombardo, & Mulone (2006) a stage structure diffusion model is studied and equilibrium is also analyzed; stages are adapted from Rogers (2003). Price elasticity dynamics along the innovation diffusion process has also been a matter of concern, in Parker (1992) the hypotheses that the price elasticity will be increasing in the product adoption cycle (Simon, 1979) is confirmed. Optimal control techniques have been applied for optimal pricing and some interesting results have been reported in Bass & Bultez (1982), Krishnan, Bass, & Jain (1999) and Lin (2008) using them; in Gupta & Di Benedetto (2007) one can find an account in the literature of different optimal pricing and advertising policies, in that particular paper a joint price and advertising policy is optimized when price elasticity equals marginal revenue product of advertising. For innovation diffusion and forecasting a thorough review of the state of the art up to 2005 is given in Mead & Islam (2006). System dynamics (Forrester, 1961) (Sterman, 2000), has also been applied; in Otto (2008) a bottom up decision support system, used in the decision process of launching of a new product, is built in conjunction with a team of marketing managers to improve confidence in its use. In Groessler, Löpsinger, Stotz, & Wörner (2008) an interesting case in the capital goods industry is presented where lowering price in order to increase market share, and hence increase profitability (Buzzel, Gale, & Sultan, 1975), is questioned and proved not be right in general.

The present work is framed in a system dynamic approach where stages in the adoption of the innovation are similar to the ones considered in Wang W., Fergola, Lombardo, & Mulone (2006) and adapted from Rogers (2003), but price and competition are not considered in the former paper. This adaptation is as follows; the process of innovation adoption starts with "awareness", it is assumed that "knowledge-persuasion" diffuses in the market; here this diffusion is modeled in the same fashion as Bass modeled diffusion of innovation, in the context of this paper this stage is named *recognition of quality improvement* (in Roger's words: "forming an attitude towards innovation"). Once someone has recognized improvement in quality she or he evaluates the possibility of buying (decision stage). Different price sensitivity sectors of the market will consider their expectation of price decrease before buying; in addition, they will consider the *evaluation of fair price*, which corresponds to the main element that judicious buyers use.

Analyzing the market behavior according to time the early adopters are crucial in this process because they are very influential, decide cautiously, and belong to a class called "early knowers" (in Rogers terms) "who have higher social status, more education, more exposure to mass media and interpersonal channels of communication, and more social participation" so their opinion influences the adoption process, they decide carefully and "their decision is esteemed by their peers" and to preserve this esteem "he or she must make judicious innovation decisions". Due to this, its influence on the rest of the market is high. In the context of this paper early adopters decide according to the *evaluation of fair price* function (see equation 3). Acknowledging that the other classes of adopters, early majority, late majority and laggards are influenced by early adopters, the evaluation of the fair price function (and their price expectation sensitivity according to the sector of the market they belong), directly or indirectly, determines the decision of buying or not (adopting or not) the innovation. In this case the last stage in the diffusion adoption process is simply buying. In a few words, the consumers first recognize the quality of the products available, compare, judge the fairness of the price either by themselves or by their peers, check how much the price differs from their expectations and buy or not.

Since price role is so important in the process, pricing strategies become essential, see Nagle & Holden (2002) for a reference; in the present paper consumers' evaluation of fair price, relative selling rates between leader and competitor and proportion of high income consumers are key factors in the leader´s decision of the trend the price should take; the strategy is dynamic and assumes that market responds first by innovators which will be inclined to buy in spite of the high fashion bonus that is charged on the new product's introduction in the market. The price is intended to descend to a level assumed to be the fair price plus the product bonus[1], in order not to jeopardize loyalty to the brand and brand equity. The next group to enter are early adopters which definitely will decide according to the price performance of the new product particularly on the follower´s product entrance into the market; that evaluation comprises a comparison among, quality of features/ functions, price and product's recognition rate. It is assumed that for the products considered here, technical information is available, and early majority will follow what early adopters do. In spite of the original leader´s intention, response to an aggressive competitor strategy will need dynamical adjustments that may be different according to the stress on a differentiated product strategy or a pure cost leadership strategy; different scenarios will be produced and compared according to the corresponding stress assumed. The competitor's price strategy is based on the difference in volume share of the market, maximal accepted loss, minimal accepted price and considerations of relative price in relation to relative quality of both products, they will be used to increase or decrease price according to particular values of those elements; the precise way in which that happens will be explained in the section where the model is detailed below. It is important to remark that, in spite of the competition, both contenders profit from a high price of the opponent, we can frame this competition as a differential game like in (Rahmandad & Sibdari, 2012), and the equilibrium for piecewise differential games. Dynamic pricing in an innovation process, among other considerations, has been treated in (Miling, 1996) and by Milling and Maier, in particular (Maier, 1998). Nevertheless, the approach is different and the consumer's evaluation of fair price is not consider as it is in this paper. It is important to observe that both, skimming or penetration strategies can be obtained by suitable choice of parameters.

The organization of this paper is as follows: First some concepts that are needed in order to formulate the model are given, and then precise definitions and notation are introduced with the purpose of formulating the mathematical model. Causal loops will be presented to clarify the system dynamics approach; the outcomes of different simulations will be discussed and finally a short conclusions section is presented. Simulated experiments will be used to compute dynamic price elasticity along the diffusion process and scenarios related to the "profitability follows market share" hypothesis will be given.

Some Concepts Needed for the Model

When a new product is introduced into the market some of its features/functions characterize the product as it will be perceived by the consumers. Some examples of these features, in the case of information technology products, are intuitiveness, easiness in its use, plug & play and availability of compatible software applications; other set of features

[1] Precise definitions are given below

may be chosen for other type of products Rogers considers relative advantage, compatibility, complexity, trialability and observability as examples of the perceived characteristics of the innovation at the persuasion stage. In Robertson (1971) the "dimensions of newness" are characterized in a functional sense, a technical sense and a stylistic sense. Consumers need to recognize them and compare them to the same or similar characteristics that are observed in products intended for the same or similar purposes. With respect to a suitable set of these features/functions one can define quality. It will be assumed that the *quality standard* is determined by the leader and the follower's quality will be compared to that standard, typically it will be lower but that assumption may not necessarily hold since the follower may offer an improved product.

In order that a new product becomes an innovation it needs to be accepted by the consumers as a better option for the purpose the previous product was intended to; in this work the concept of *consumers' recognition of the quality improvement (CRQI)* of a product is considered as one way in which consumers respond towards a new product; ideally consumers that have experienced a product (not necessarily bought it) will agree it has the features declared by the supplier, nevertheless this may not be the case but in some proportion that is not necessarily one. In the case the consumers' recognition exceeds the suppliers standard, *CRQI* may even be greater than one. When that proportion is high enough one can say that the consumer has already recognized the quality improvement, and, the part of the market that has recognized quality improvement, diffuses in the same fashion Bass modeled diffusion of adoption.

In principle, each supplier has an expected profit in some time horizon which depends on how fast the recognition of quality improvement diffuses in the market, and it is determined when a fixed proportion has already recognized that improvement. A supplier can assign what is called the *fair price* of the product according to its *return on investment (ROI)* expectations that considers market share, production facilities, payment, production and distribution flows, R&D investment, cost of capital and advertisement; with this expected profit the fair price determined. Since innovators correspond to a higher economic and social status they will be able to buy at a higher price and hence the initial price will be the fair price plus a *fashion bonus*. The brand equity allows the supplier to add a proportion of the *brand bonus BB* to the fair price called the *product bonus B*; its value is determined according to the respective bonus of other products of the same supplier and may vary within a certain range. In this context it is assumed that when a high proportion of the market has already recognized the improvement of quality (time horizon), a certain proportion of them have bought the product. The expected total revenue corresponds to the one obtained by selling each unit, from the introduction of the product up to the specified horizon, at the fair price plus the product bonus. A price strategy will be *successful* if that expectation holds or it is surpassed.

The fair price, from the point of view of the consumers, is something different than the one from the point of view of the suppliers. It is critical to compare both points of view, the concept of *consumer's evaluation of fair price (CEFP)* is introduced; it is a tool used to decide whether a price may still increase, must go down or may be kept as it is. In order to get a useful definition, it is assumed that if someone will pay more for a particular good which, in general terms, offers similar benefits as another with lower price, some factors must be present that compensate that increase. The factors considered in this paper are quality of both products, fair prices according to suppliers' expectations of ROI, the brand equity of each one, as well as the recognition of improvement of quality by the consumers.

Price sensitivity of different sectors of the market (associated to time based adopter categorization found in Rogers) is also very important in the decision part of the process since it will increase as time passes. It is assumed that the market will expect a final price (*expected final price*) which is a factor of the initial price of the product called the *price reduction factor* and an *expected price* which changes in time according to the final expected price and a diffusion rate. Price sensitivity response of the market as well as price reduction factor is assumed to be different for each of the competitor's product. According to price sensitivity a *buying price sensitivity factor* is introduced whose role, in addition to the consumer's evaluation of fair price, is to make the final decision.

In the next section the concepts above will be precisely defined in order to be mathematically modeled, some parameters are introduced in order to make the model more flexible and to determine policies that may lead to better performance for any of the competitors.

Precise Definitions and Statement of the Model

In order to normalize it is assumed that the leader's product *quality standard* q_L is one hundred as well as its *fair price* FP_L, the precise way to determine it is given below in this section. Both follower's quality q_F and fair price FP_F are compared with respect to one hundred in a similar way as it is done in a percentage context. It is assumed that a group of experts certifies that quality coincides with the one claimed by the respective suppliers, and that that information can be obtained by the consumers from a public source.

Consumer's recognition of the quality improvement is a quantity which changes in time according to the differential equation that is described in what follows. Let $i = L\ or\ F$, where L stands for leader and F for follower, and $x_i\,(t)$ be the people in the market at time t that already accept that the new i^{th} product improves, in some specific features, a previous product intended for the same purpose[2]. Let us fix the market population as M people[3] and subdivide this market into those who already accept the improvement and those who still have not, these correspond to $y_i\,(t) = M - x_i\,(t)$.

Some of the $x_i\,(t)$ population will be willing to talk positively about the corresponding product, the parameters $0 \le \alpha_i \le 1$ stand for the proportion of the $x_i\,(t)$ part of the market that will do so. Other parameters that matter are the proportion of encounters β_i among the populations $x_i\,(t)$ and $y_i\,(t)$; and the effectiveness ε_i of those encounters, i.e., the proportion that, after the encounter, attains recognition of the corresponding improvement; in what follows $\alpha_i\beta_i$ will be considered as the proportion of effective encounters. When encounters among $x_L\,(t)$ and $y_F\,(t)$ take place their influence may diminish the diffusion of the recognition of the follower´s improvement of quality in some proportion $\gamma_{FL}\,(t)$[4]. The innovation coefficient ι_i stands for those which start the recognition process regardless of previous adopters (innovators). Finally let τ be the lag between the time in which the leader´s product enters into the market and the time at which the follower's product does so[5].

Now we are in the position to introduce the differential equations; let $\bar{x}_F\,(t-\tau) = x_F(t)$, then

$$x'_L\,(t) = \left(\iota_L + \alpha_L\beta_L\varepsilon_L x_L\,(t)\right)y_L(t)$$

Equation 1

$$\boldsymbol{x'_F(t) = \bar{x}'_F}(t-\tau) =$$
$$\begin{cases}[\iota_F + \alpha_F\beta_F\varepsilon_F\bar{x}_F\,(t-\tau) - \gamma_{FL}\,x_L\,(t)]\bar{y}_F\,(t-\tau) & \text{when } t \ge \tau \\ \boldsymbol{\bar{x}'_F}(t-\tau) = 0 & \text{when } t < \tau\end{cases}$$

Equation 2

Both are the classical diffusion equation but one starts τ units of time later, and the variable $\bar{x}_F$ is just an auxiliary one to make computations easier, it is important to remark that there is a lag or delay involved.

Let ES_i be the *expected size* of the market that each competitor determines, beforehand, that at time h_i, the *ROI horizon*, the quality improvement of the product has been recognized, in other words

$$x_i(h_i) = ES_i$$

In addition each supplier has an expectation of the proportion of ES_i that may have bought its product at the *ROI horizon*, this proportion will be denoted as $E(sh_i)$. If $E(sh_i)ES_i$ products are sold, there is an expected profit and, according to the expenses discussed in last section, an expected revenue for that horizon, $ER(h_i)$, can be determined; hence the precise definition of the fair price is given implicitly by $E(sh_i)ES_i(FP_i + B_i) = ER(h_i)$. Hence $FP_i = \frac{ER(h_i)}{E(sh_i)ES_i} - B_i$.

In order to fixed ideas the leader's fair price is normalized to be 100. The causal loop to determine this is depicted in Figure 4.

Consumer's evaluation of fair price basically represents a way to evaluate price performance, since there is a lag between the appearance of the follower, there are two stages, one before and the other after its appearance. In the first stage the market is assumed to compare the leader´s product to another one which used to be popular but whose quality is improved by the new product, let q_o stand for the quality of the old product, p_o its price and let ω be the proportion of the market that still recognizes the old product quality. Once the follower´s product appear, the market with only compare the price between those last products

$$v(t) = \begin{cases}\left(\frac{\bar{p}_F(t)}{\bar{p}_L(t)}\right)\left(\frac{1+x_L(t)}{1+x_F(t)}\right)\left(\frac{1+B_L}{1+B_F}\right)\left(\frac{q_L}{q_F}\right) & if\ t \ge \tau \\ \left(\frac{\bar{p}_o(t)}{\bar{p}_L(t)}\right)\left(\frac{1+x_L(t)}{\omega M}\right)\left(\frac{q_L}{q_o}\right) & if\ t < \tau\end{cases}$$

Equation 3

Here $\bar{p}_i(t), B_i, q_i$ stand for the corresponding price, product bonus and quality of each competitor respectively.

In this definition the parenthesis, though some of them are unnecessary, emphasize the role of the supplier's position, the market response, the brand reputation and historical performance in the market, and the expert's opinion respectively. As mentioned before, there must be a reason to pay more for something that may be considered as equal, and the last three factors enclose that reason. It has already been assumed that $q_L = 100$ but the symbol is written in the formula to stress its role.

The situation to be modeled assumes that the leader enters into the market with $\bar{p}(0) = FP_L + FB$ which is the fair price plus an extra bonus FB, named *fashion bonus*, corresponding to the fact that the innovators are willing to pay more in order to experience the new product in the market. The leader´s intention is to skim the market and stabilize its price in the fair price plus de product bonus. Nevertheless, the appearance in the market of a competitor may impose adjustments according to the impact of the follower's strategy.

The follower's product is assumed to enter with a lag and with a pricing strategy intended to gain market share in spite of the leader's advantage. The initial follower's price may be considerably smaller than the leader's one since less

[2] Those features have to be characterized and a questionnaire produced and answered in a sample in order to decide whether an improvement is perceived or not.
[3] In the simulations performed M is assumed to be 1000000 people
[4] This parameter will be relatively small and in fact there is no example given in this work where it is not zero, nevertheless is kept in the model since its influence may be crucial in the competition outcome.
[5] The values of all these parameters can be estimated and will be determined in the simulations below.

R&D expenses have been done and a portion of the, market is already aware of the benefits of the new product, hence advertisement expenses can be also reduced. The follower's pricing strategy is based on the volume share[6] difference, price will constantly decrease whenever the volume share difference disfavors the follower´s product, the accumulative loss must not surpass the maximal accepted loss and the price has to be above the minimal accepted one. Both quantities, depicted as $MALossF$ and $MinAPrF$ respectively, are determined beforehand. If one of those three conditions does not hold the price will constantly increase as long as the selling rate is positive and $\frac{q_F}{q_L} > \frac{p_F}{p_L}$, otherwise the price will remain equal.

As mentioned above, the leader´s pricing strategy is searching to stabilize the price $\bar{p}_L(t)$ at its highest possible value $P^U{}_L = FP_L + r_U B_L$, but the market behavior may change with the entrance of the follower, and the lowest price at which the leader accepts to sell the product $P^D{}_L = FP_L + r_D B_L$, needs to be considered. Both r_U, r_D are proportions, but the latter can be negative since the lowest accepted price may be less than FP_L at least for some period of time.

Before defining the precise way in which the leader's price will be changing in time, it is necessary to introduce the buying price sensitivity index for both competitors since sales will depend on them. Selling rates will in turn influence both leader's and follower's response. Let $EFP_i = \frac{\bar{p}(0)}{\rho_i}$ denote the expected final price by the market for each product, where ρ_i is greater or equal than one, to establish the fact that the initial price will be greater or equal than the expected final one for each product. With this in hand, the expected price at time t is defined by the differential equation

$$EP_i'(t) = \lambda_i(EFP_i - EP_i)$$

Equation 4

This implies that the final expected price is asymptotically approached at a rate depending on λ_i.

Once someone intends to buy, a comparison will be made among the actual price and the expected one, let $0 \le s_i \le 1$ be a constant, here named price sensitivity response, then

$$bps_i(t) = \begin{cases} 1 & if\ \bar{p}_i(t) \le EP_i(t) \\ e^{s_i(EP_i(t) - \bar{p}_i(t))} & otherwise \end{cases}$$

Equation 5

is defined as the *buying price sensitivity factor* which becomes, together with the leader´s fair price evaluation factor defined as $LEF(t) = 1 - e^{\ln\left(\frac{1}{2}\right)v(t)}$, where $v(t)$ was defined in Equation 3, as the essential elements in the buying process. Selling (marginal sales of both suppliers) is supposed to occur according to

$$se_L(t) = LEF(t) bps_L(t) x_L(t) \text{ and } se_F(t) = (1 - LEF(t)) bps_F(t) x_F(t)$$

Equation 6

Note that $0 \le LEF(t) \le 1$ tends to 1 as $v(t)$ increases, tends to 0 when $v(t)$ approaches 0 and equals $\frac{1}{2}$ when $v(t) = 1$, hence, once someone has recognized quality improvement, 1 is the critical value for $v(t)$, above 1 people feel more inclined to buy the leader's product and the other way round below 1; when $v(t) = 1$ the market may chooses any product with the same probability.

In relation to $bps_i(t)$, it follows that when the price is similar to the one expected, more chances are to buy that particular product, and the more different they are, chances get reduced. It is also important to remark that price sensitivity increases as time goes by and the price does not decrease as expected. Finally consider the unitary step function

$$u_\tau = \begin{cases} 0 & if\ t < \tau \\ 1 & otherwise \end{cases}$$

The adjusting of the leader's price is as follows:

Fix the positive small real numbers δ, called tolerance, κ_U, a reaction index towards $P^U{}_L$ and ,κ_D, a reaction index towards $P^D{}_L$, these constants will be determined according to the particular policies chosen by the leader.

1. Let H be the high income size of the market, the price will remain unchanged if the fashion bonus is at least twice bigger than product bonus and total sales are less than H and $t < \tau$
2. If $v(t)u_\tau(t)\frac{1+se_L}{1+se_F} > 1 + \delta$ it means that the leader is in a good position to pursuit it's desired final price and it will be ruled by $\bar{p}'_L(t) = \kappa_U(P^U{}_L - \bar{p}_L(t))$
3. If $1 - \delta < v(t)u_\tau(t)\frac{1+se_L}{1+se_F} < 1 + \delta$ occurs, there is a dubious transition stage where it is better to leave the price as it is and hence $\bar{p}'_L(t) = 0$
4. If $v(t)u_\tau(t)\frac{1+se_L}{1+se_F} < 1 - \delta$ the price will move down, always above $P^U{}_L$, in order to improve the fair price evaluation and expecting to improve sales, according to $\bar{p}'_L(t) = \kappa_D(P^D{}_L - \bar{p}_L(t))$

Closed Loop Diagrams and Program Structure

Now some of the main Causal Loop Diagrams will be depicted as well as the structure of the program that is used to do the simulations mentioned. It is interesting to observe that the CLD in Figure 2 helps to understand that the increase in the leader´s price may help to improve the price performance of the follower, something that is confirmed in Figure .

[6] Volume share represents the units each supplier has sold in relation to the number of units that both suppliers have sold.

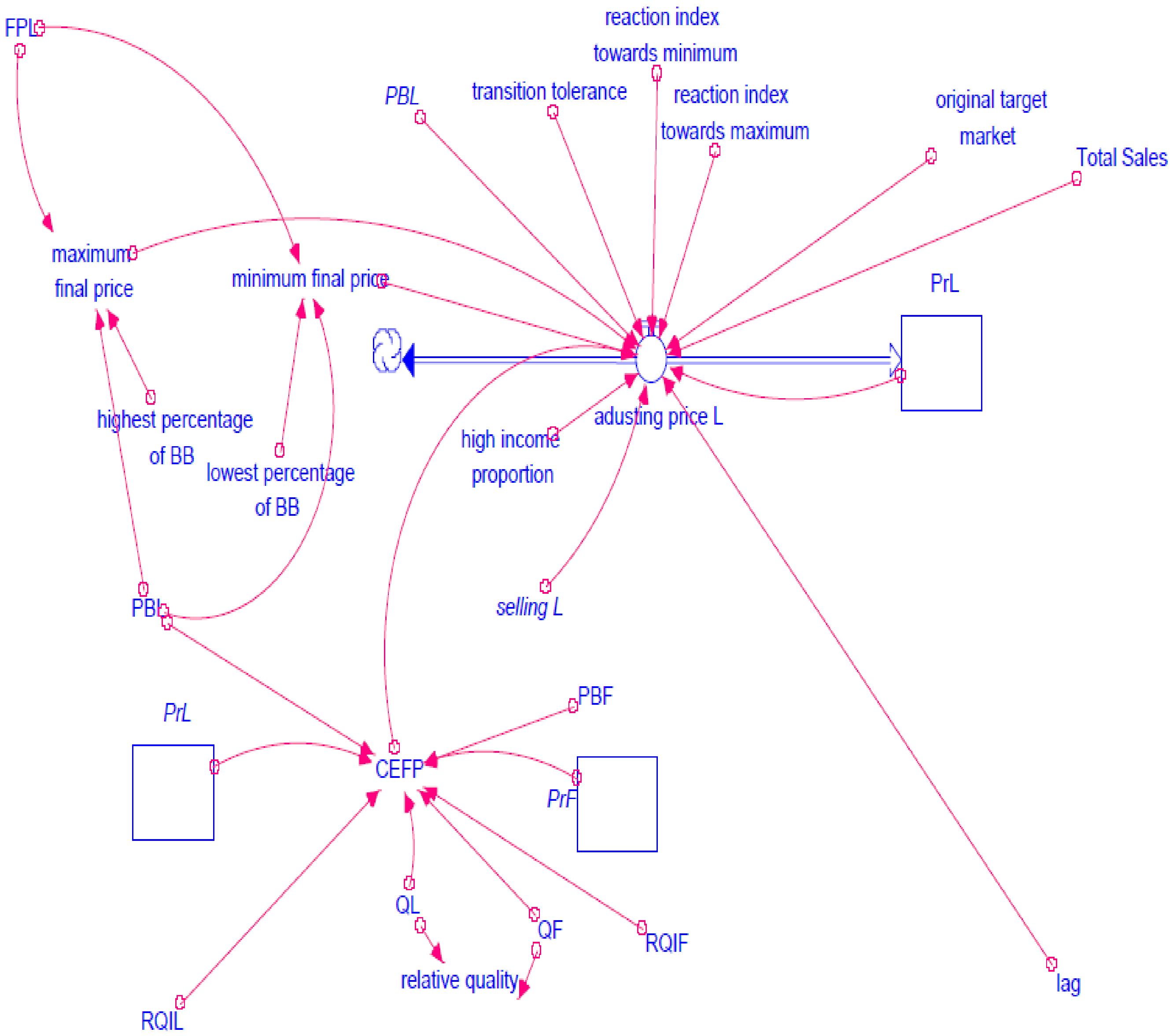

Figure 1. The adjusting of the leader´s price process

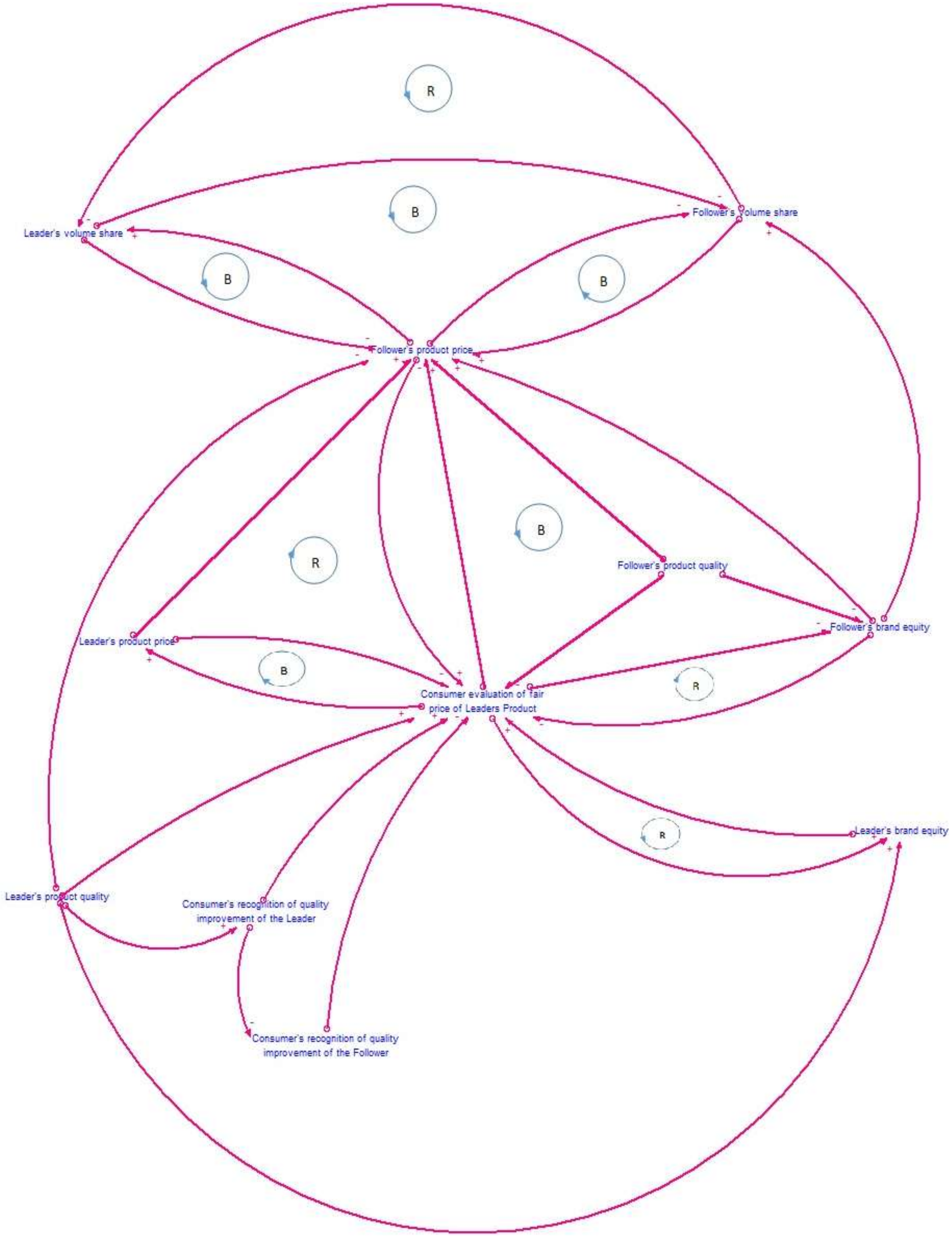

Figure 2. The CLD depicting the pricing processes of both competitors

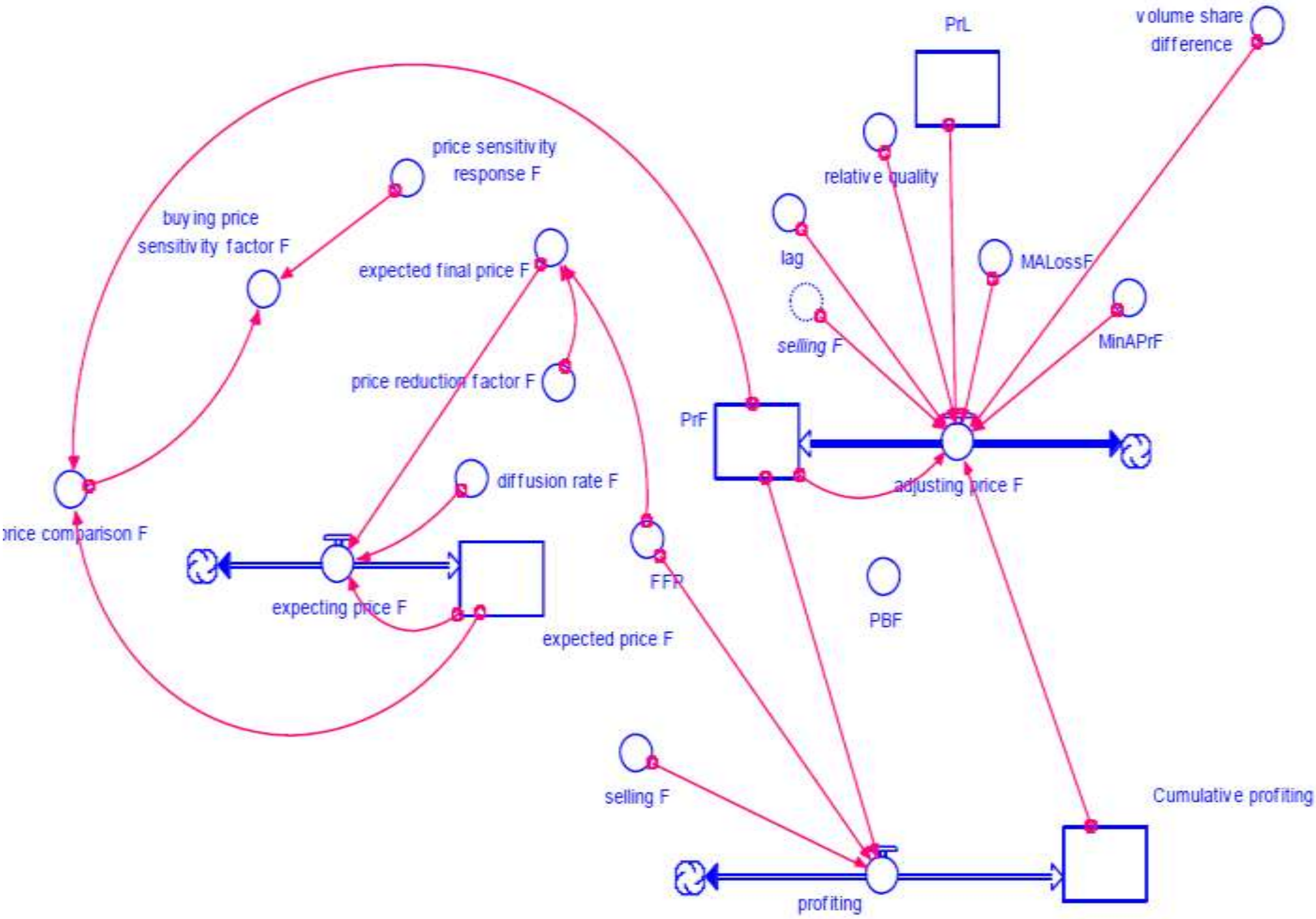

Figure 3. The adjusting of the follower's price is depicted

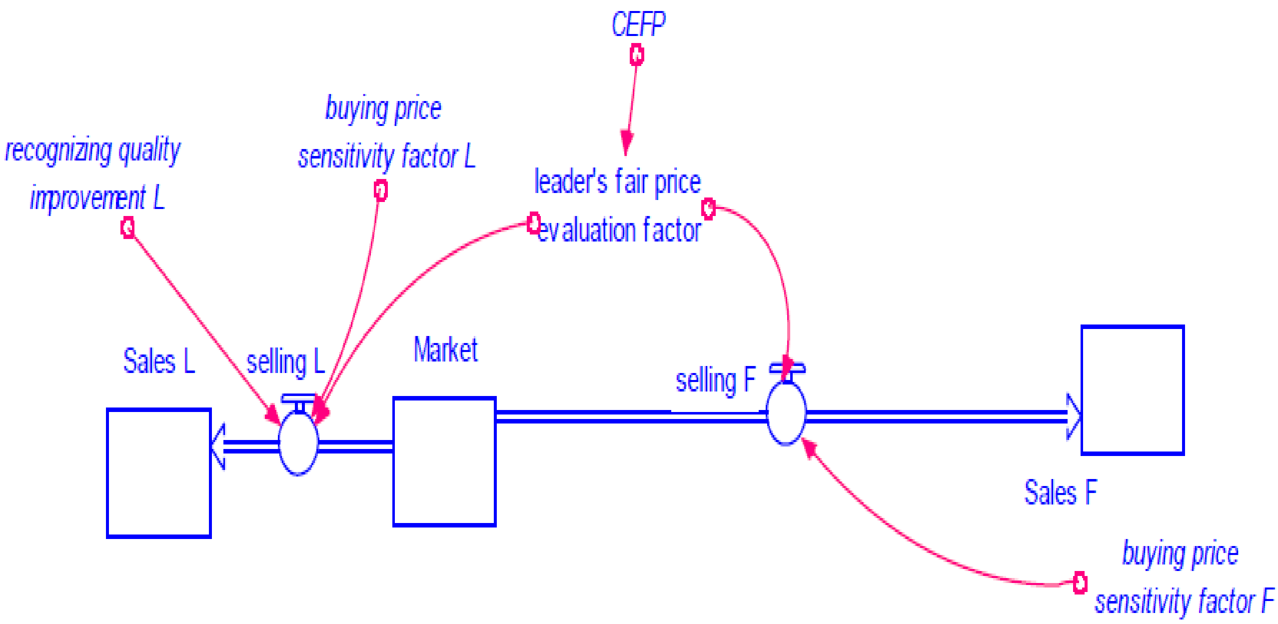

Figure 4. Depicts the selling process of both competitors

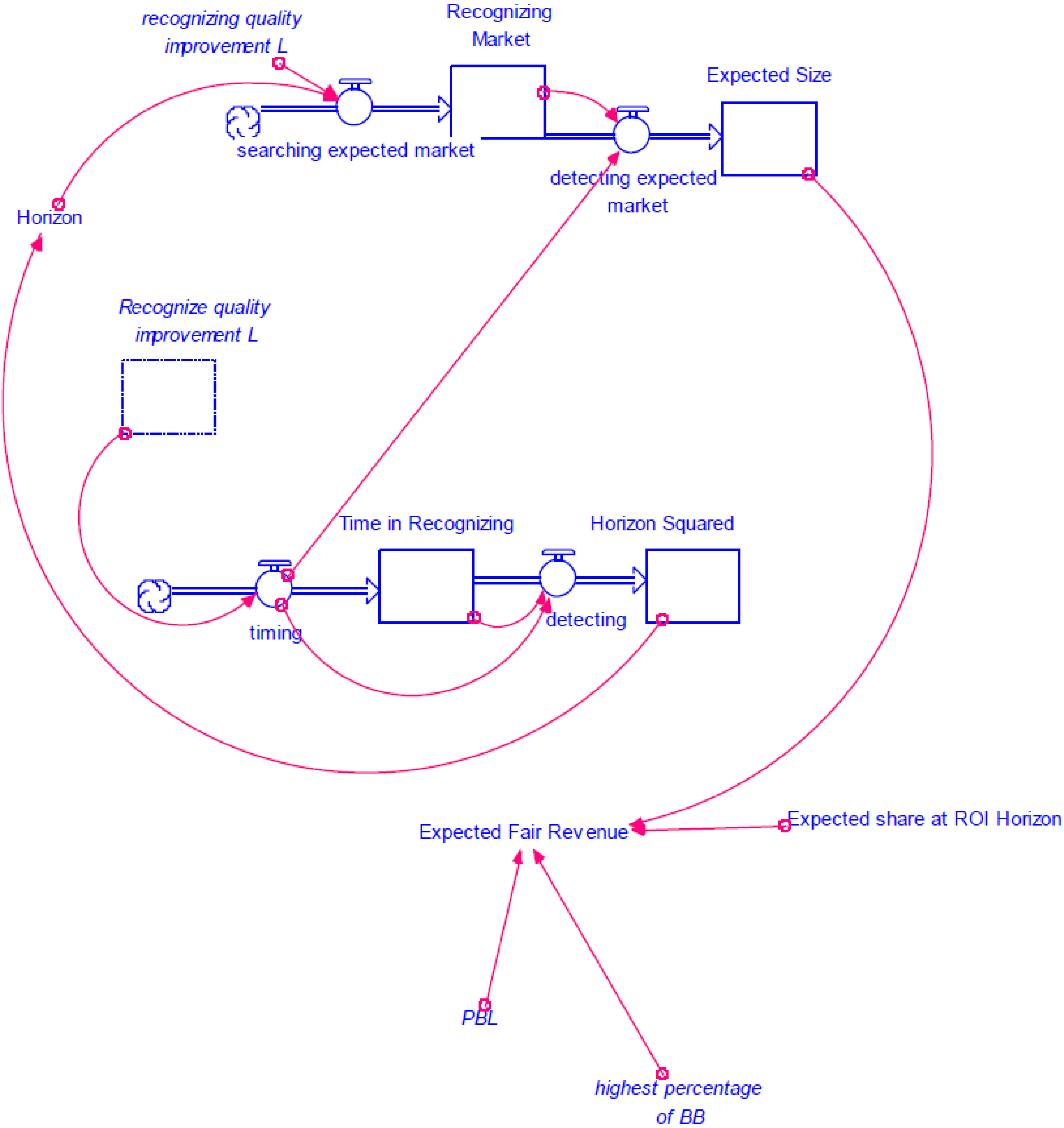

Figure 5. The fair price assessing process

In the next section the results of some simulations are given with a brief explanation of their implications.

***Simulations*[7]**

Table 1 below gives the specific values of the parameters of the model for the corresponding simulation considered, and the respective figures are included and commented.

[7] These are performed in IThink and the graphs here presented are the ones obtained by various simulations

Table 1. The parameters chosen for each simulation and their corresponding figures are here specified

		values of parameters in								
Parameters names	**simbols in model**	**Figures 5-7**	**Figures 8-10**	**Figures 11-12**	**Figure 13**	**Figures 14, 15**	**Figure 16**	**Figure 17**	**Figure 18**	**Figure 19**
lowest percentage of BB	r_D	0.296	-72	-72	-72	6.22	-77.926	-50.667	-50.667	0
highest percentage of BB	r_U	120	120	120	120	87.11	61.333	120	120	120
proportion that highly recognizes L	α_L	0.0352	0.0352	0.0352	0.0352	0.1407	0.1	0.0815	0.0815	0.12
proportion that highly recognizes F	α_F	0.07	0.07	0.07	0.07	0.07	0.2296	0.037	0.037	0.1185
proportion of crossed inflence	γ_{FL}	0	0	0	0	0	0	0	0	0
fashion bonus	FB	100	100	100	100	100	100	100	100	0
rate market increase	μ	0	0	0	0	0	1000	0	0	0
MALossF	$MALossF$	0	-600000	-600000	-600000	0	0	-600000	-600000	-600000
Min A PrF	$MinAPrF$	14	14	14	14	14	14	14	14	14
QF	q_F	100	100	100	100	87.18	81.852	85.11	85.11	85.11
lag	τ	20	20	20	20	75	114.815	0	0	0
BBF	BB_F	40	40	40	40	40	40	21.4815	21.4815	21.4815
BBL	BB_L	40	40	40	40	40	40	40	40	40
reaction index towards minimum	κ_D	0.0363	0	0.02593	0	0.0363	0.0363	0.00963	0.00963	0.00963
reaction index towards maximum	κ_U	0.02926	0	0.02593	0	0.2926	0.02926	0.00815	0.00815	0.02923
high income proportion	$H/_M$	0.344	0.1407	0.1407	0.1407	0.1407	0.1404	0.0074	0.0074	0
trasition tolerance	δ	0	0	0	0	0	0	0	0	0
FFP	FFP	75	75	75	75		75	75	75	75
coefficient of innovation L	ι_L	0.00344	0.00344	0.00344	0.00344	0.00344	0.00344	0.00048	0.00048	0.0001
coefficient of innovation F	ι_F	0.00104	0.00333	0.00333	0.00333	0.00104	0.00104	0.00333	0.00333	0.00333
price sensitivity response L	s_L	0.01963	0.05778	0.05778	0.00259	0.1889	0.001	0.0037	0.0037	0.0037
price sensitivity response F	s_F	0.0211	0.1	0.1	0.00296	0.05	0.001	0.04556	0.04556	0.04556
price reduction factor L	r_L	2	2	2	2	2	2	2	2	2
price reduction factor F	r_F	2	2	2	2	2	2	2	2	2
expected share at ROI planning horizon	$E(sh_i)$	0.5	0.6	0.5	0.5	0.5	0.5	0.5	0.05	0.5

Example 1

In this first simulation a skimming pricing is presented through Figures 5-7; in Figure 5 the dynamic of prices is shown, in Figure 6 the share behavior can be observed, the competitor's; market share was significantly increased. The volume share is not included in these figures but the competitor achieved to equalize it to the leader's one. Finally, from Figure 7, it can be concluded that the accumulated revenue of the leader was successful and greater than the competitor's

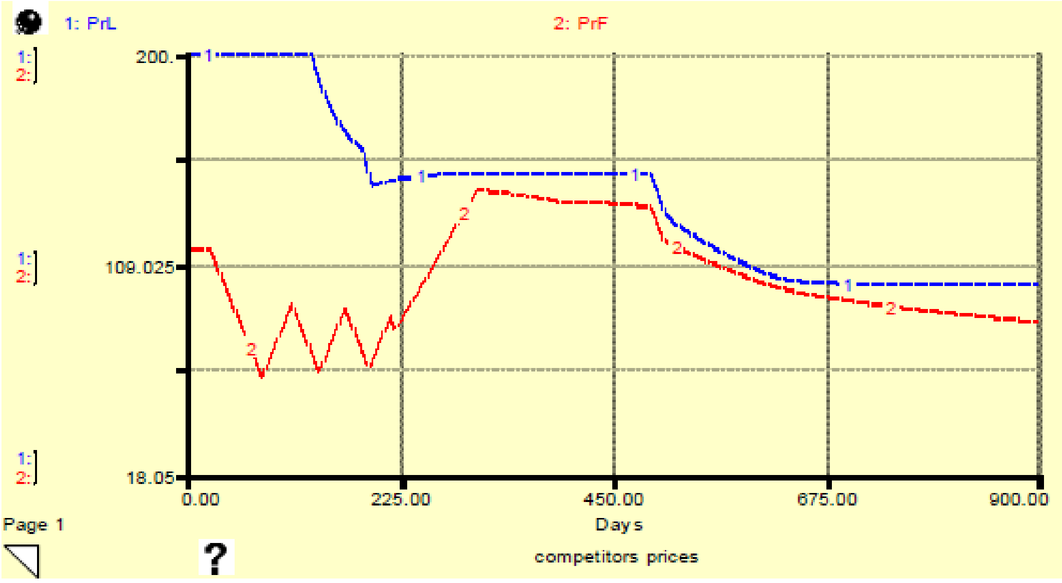

Figure 6. The parameters chosen by the leader resulted in a successful skimming of the market strategy

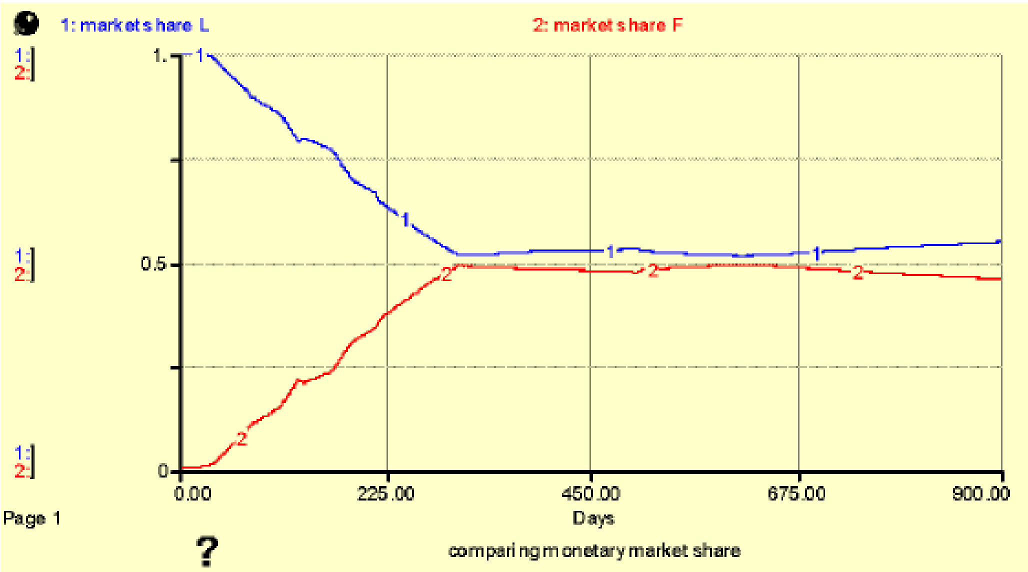

Figure 7. The competitor's strategy succeeded in growing market share

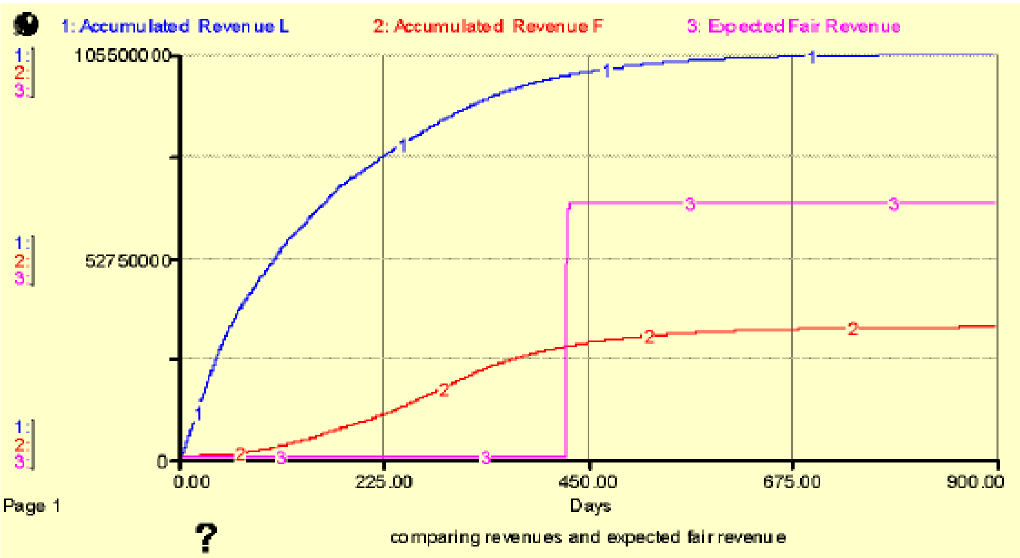

Figure 8. The leader's strategy succeeded since it surpassed its Expected Fair Revenue, in addition, its competitor's revenue was also surpassed

Example 2

In the following example the leader’s price will remain unchanged but due to the price sensitivity of the market this strategy becomes unsuccessful.

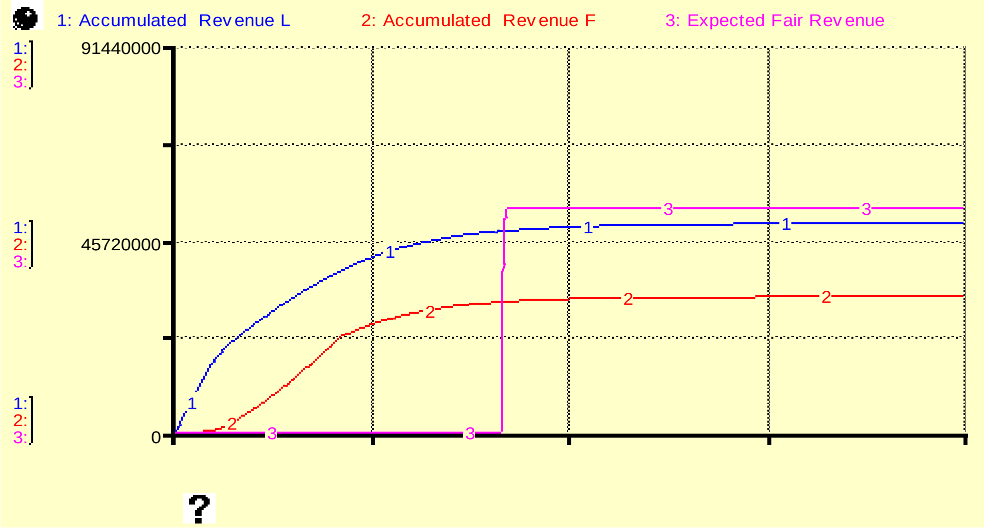

Figure 9. The leader’s price has not changed but, due to the price sensitivity of the market, this led to accumulated revenue below the expected one

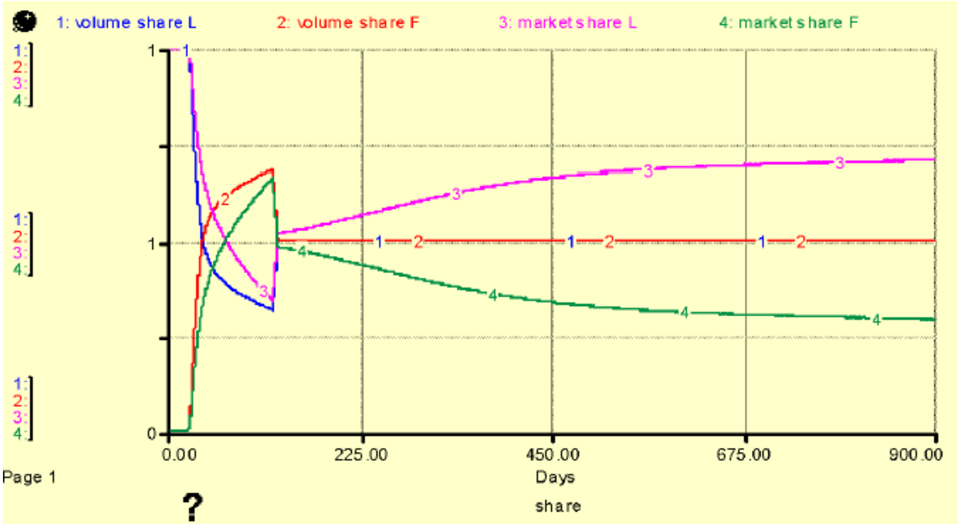

Figure 10. The follower´s strategy succeeded in selling the same amount of products as the leader but the market share favored the latter

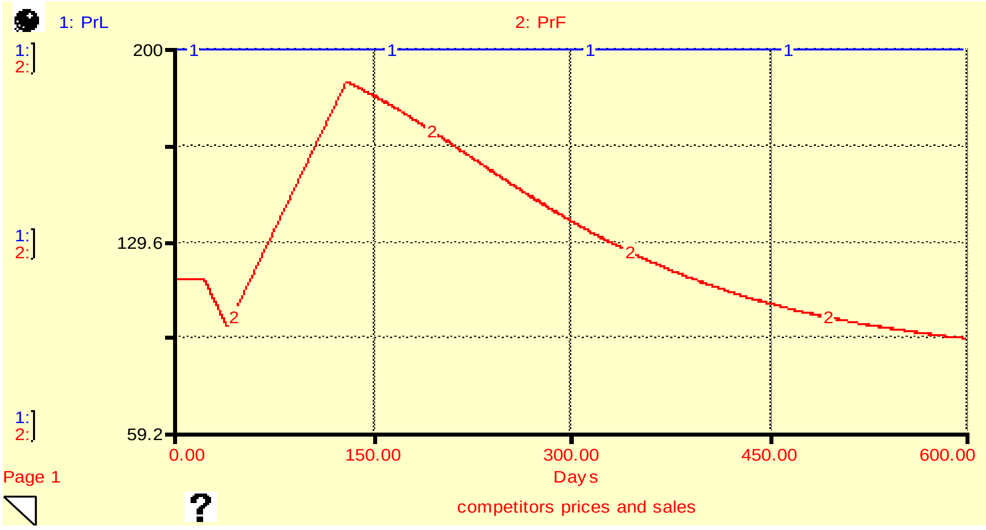

Figure 11. The leader maintains its price regardless of its low revenue

It is interesting to observe that just by letting the price to change, according to suitable reaction indices towards the maximum and minimum, the leader´s performance is increased. In terms of parameter values, see table 1, the only parameters that change correspond to those reaction indices.

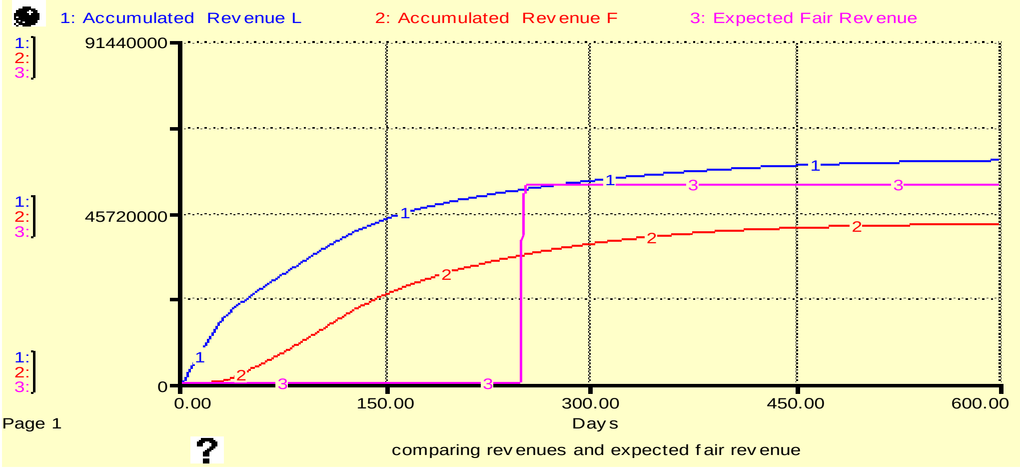

Figure 12. Just by letting the leader´s price reaction indices towards the maximum and minimum be as it is set in

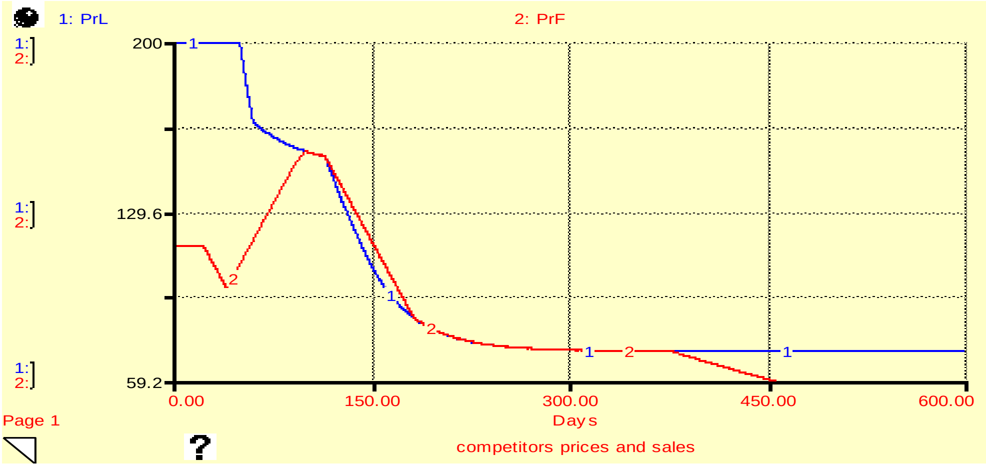

Figure 13. Here the dynamic prices in example 2 are depicted

Example 3

This example shows that under very small price sensitivity, when price is not changed the leader's revenue is successful and better than the follower´s.

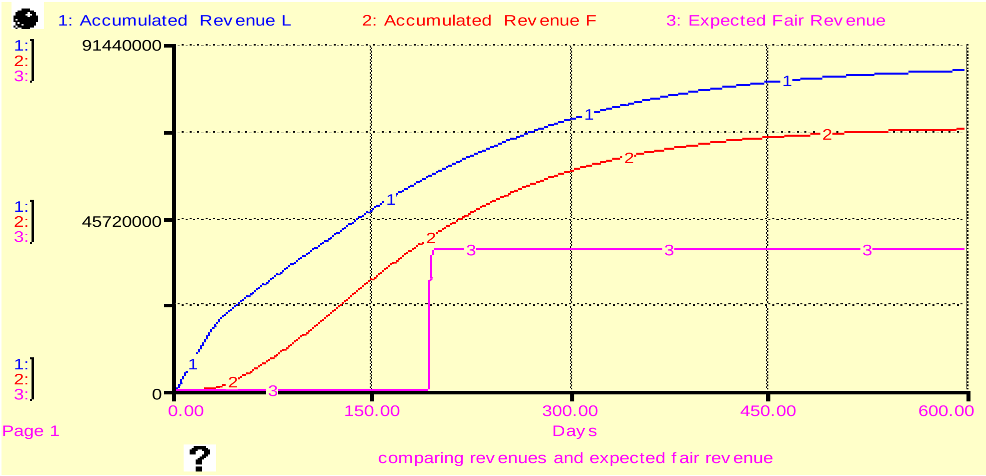

Figure 14. Here the price sensitivity is very small and, in spite the price has not been changed, the leader´s strategy is successful

Example 4

This example is chosen to show a qualitatively similar dynamics of pricing than the one shown in (Liu, 2010), when analyzing the Nintendo vs. Play Station case, can be obtained for suitably chosen parameters.

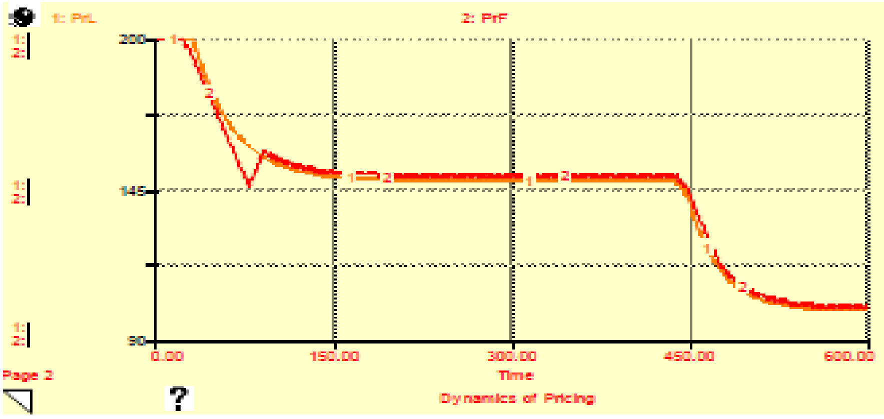

Figure 15. Qualitatively similar dynamics to the one observed in the dynamics of pricing in the video game case.

Some Remarks on Dynamic Price Elasticity along the Diffusion Process

In the light of the last example, the market becomes very important since its sensitivity to price is essential in pricing strategies. One usual way to examine this sensitivity is price elasticity, using the model introduced in this paper we compare the behavior of price elasticity, both for the leader's product as well as that of the follower's.

Based on Rogers's assumptions about the innovators role in the first stages, and the fact that they correspond to a highly educated part of the society with economic power, it is quite reasonable to conjecture that price elasticity must be small at those first stages and then start to grow. In (Parker P., 1992) the hypothesis that price elasticities of adoption begin low and then increase as the adoption life cycle matures was tested. Interesting outcomes were found and evidence was offered about various possible behaviors according to different products studied. In (Parker P., 1992(b)) the same question is raised and different patterns are proved to exist from empirical data: increasing and then decreasing in an inverted U shaped form; just decreasing in an L shaped way; increasing then decreasing and then increasing again, decreasing then increasing and again decreasing. Those patterns are associated both to different products and price strategies searching optimality. Concordance with the cited observations on the dynamics of the elasticity mentioned was found as well as concordance with empirical results reported in (Parker & Gatignon, 1996) where the order of entry into the market is important in the shape of the dynamic elasticity. The purpose of this section is to produce parameters values, corresponding to specific situations of the market, in such a way that those patterns above mentioned will be coherently obtained, in this fashioned the importance of the present modeling will be apparent.

In what follows price elasticity is analyzed in the parameter setting specified in table 2, it is computed from the definition $\varepsilon_i(t) = \frac{p_i}{q_i}\frac{dq_i}{dp_i}$ where p_i stands for the i^{th} price and q_i for the i^{th} units sold, and $\frac{dq_i}{dp_i}$ is $\frac{selling\ i}{adjusting\ price\ i}$ when $adjusting\ price\ i \neq 0$ where $i = L\ or\ F$. In the first simulation performed the shape of the dynamic of price elasticity is increasing followed by a decreasing behavior for the leader's product, nevertheless, a sudden increase followed by a decrease is also observed at the end of the product cycle. In the dynamic elasticity of the follower, a sudden increase is followed by a slow decrease with slight up and downs that coincide with the sudden price changes, see Figure . In Figure the selling of both products is shown, comparing both figures help to understand the elasticity behavior.

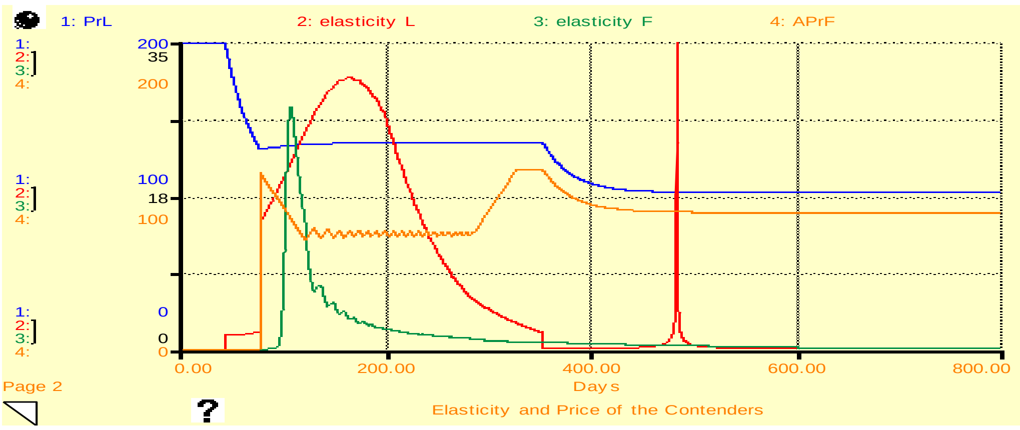

Figure 16. In this figure the leader´s and the follower´s price and dynamic elasticities are depicted, note the increase of the leader´s elasticity at the entrance of the follower´s product, both elasticities start low, increase and decrease but, at the end of the leader´s product cycle, the elasticity grows again and finally decays.

In the usual adoption diffusion process the market of potential adopters remains fixed, nevertheless, it can be assumed that the number of potential adopters may grow. In the next simulation we let M to increase at a very high rate. The main feature change of the leader´s price elasticity behavior is apparent, stages where the leader´s price elasticity is increasing are observed while the follower´s elasticity behavior is similar to the one previously seen. A final stable selling situation is observed with mild changes for very low elasticities, meanwhile, a price war sustains a very similar selling situation for both competitors.

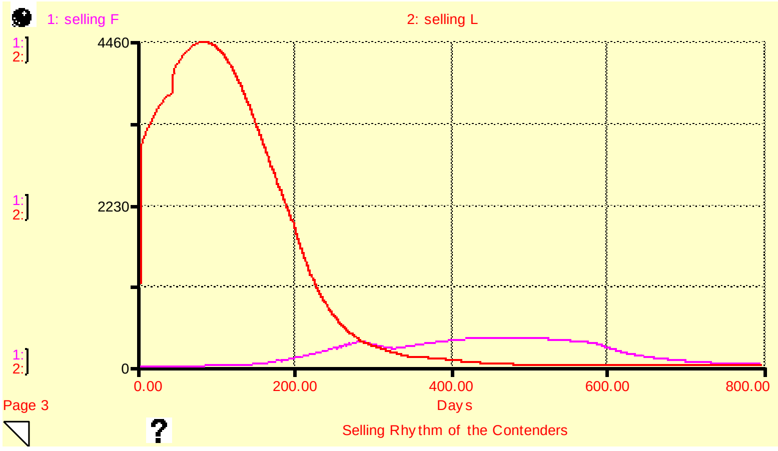

Figure 17. In this figure both selling rhythms are depicted, it is interesting to compare it with Figure

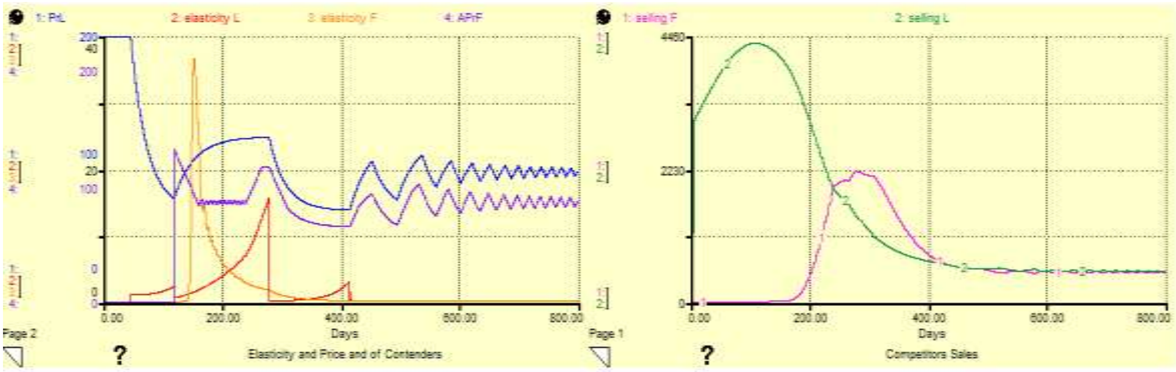

Figure 18. Price and dynamic elasticities are compared as well as selling of both competitors in a market increasing scenario.

Finally we observe that in (Crittenden, 2005) the dynamic price elasticity for the adoption of AS/400 Minicomputers was estimated, in Figure , a comparison is made with a simulation obtained from the model developed in this paper. Though numerically they are different, qualitatively they resemble very much, particularly in the form of the corresponding curves with respect to the adoption process.

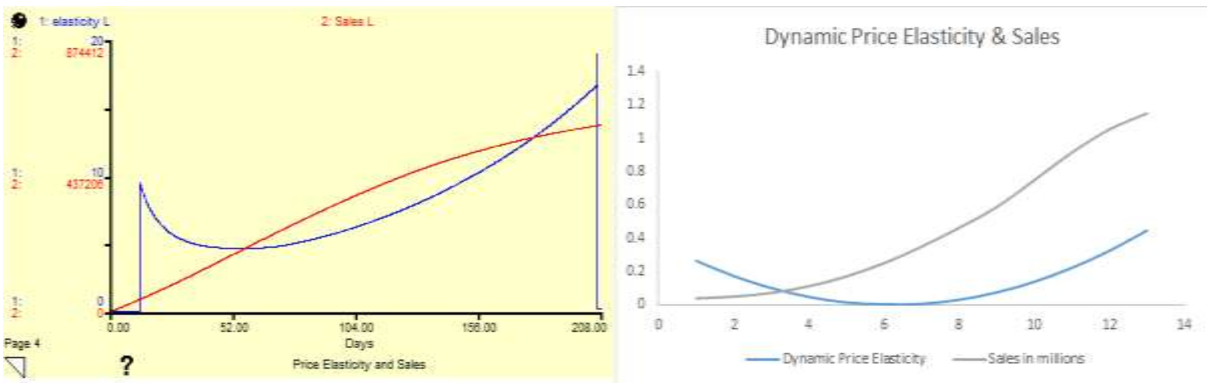

Figure 19. A comparison between a simulation and the empirical estimation in (Crittenden, 2005). Note the similarity in the qualitative behavior the simulated experiment and the estimation from data.

Example 5

Several qualitative behaviors of prices and sales reported in literature from empirical observations (Krishnan, Bass, & Jain, 1999) can be obtained by a suitable choice of parameters of this model in Conner (1995) it is observed that the entrance of a follower can benefit the leader, in Figure

16 it is observed that the decreasing trend of price changed to become increasing with the entrance of the new product. It can be pointed out that this happened due to the favorable evaluation of fair price of the market.

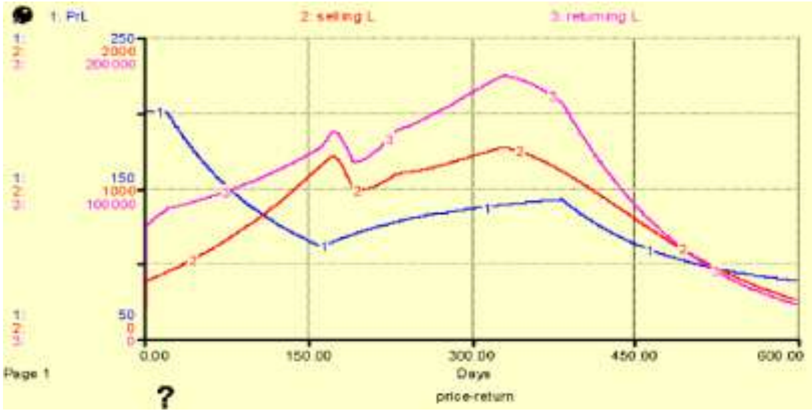

Figure 20. The entrance of the follower at day 161let the leader increase its price, which was decreasing and improve its return in spite of the competition (scales are different)

Figure 21. Usual price and return in product cycle empirically observed (scales are different)

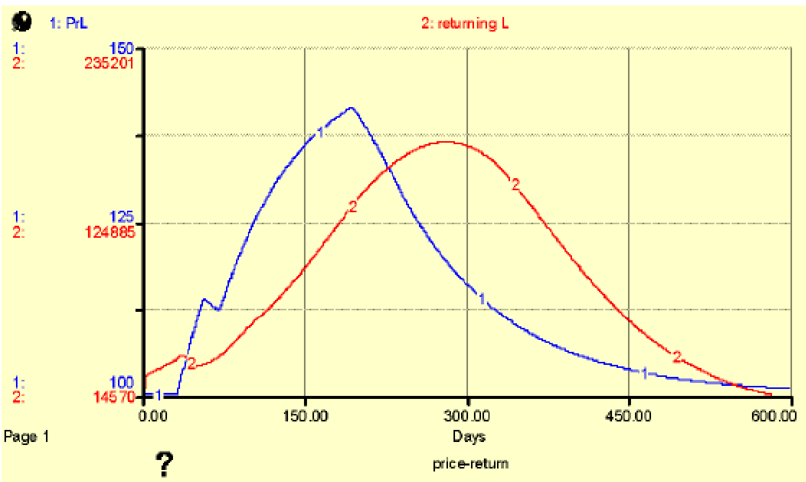

Figure 22. Another price and return curves similar to some found in empirical observations (scales are different)

Conclusions

In the light of the examples exposed in this paper, it is possible to appreciate that empirical data can be simulated using appropriate parameters of the model. It must be observed that it is not intended to find an optimal price strategy, but it is useful to produce scenarios in the decision making process when a new product is introduced into the market. We end up remarking that, by letting the potential market to increase, unsuccessful strategies may turn into successful ones

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