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A better understanding of the diffusion of innovations among the population

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Abstract

We have studied Rogers's diffusion of innovations proposal of five different types of people response to an innovation, finding that it is possible to classify the population in different income categories with the top income class acting like innovators in Rogers's categories, as well as the poorest people reacting similar to the laggard category. The research was based in the evolution of some home appliances ownership among Brazilian houses since 1970. Some results about abandonment of diffusion were shown, moreover short discussions about impact of the economy oscillations in the innovation diffusion process. The findings can be useful to direct some company strategies in questions like production ramp-up and needed resources by the time of the production development.

1. Introduction

The phenomenon of the diffusion of innovations among a population was proposed a long time ago, but discussions, researches and modeling proposals is still present in literature, because it is understood the problem is quite complex and not well established. One of the most known name in the area is Everett Rogers , who direct the problem to the importance of communication process in the diffusion, as well as how any population performs in different ways to an innovation, dividing into five categories: innovators, early adopters, early majority, latter majority and laggards (Rogers, 2003). Parasuraman and Colby (2002) also suggest five different categories of individuals responses to an innovation, calling them as: explorers, pioneers, skeptics, paranoids and laggards. Both focused the importance to identify such people in order to be more successful in market strategies, and almost all literature follows such division, trying to identify their behaviors, characteristics and values, as seen in Hall (2004) with a summary of diffusion of innovations.

To represent the diffusion of innovations patterns, some mathematic models were developed and Mahajan and Peterson (1985) discussed many of them, identifying the importance of three fundamental diffusion models: External-Influence, Internal-Influence and Mixed-Influence. It must be noted that mathematical models are still under development, and many proposals are made in the last years. Examples can be seen in Teng, Grover and Guttler (2002); De Cesare, Liddo and Ragni (2003); Schmidt and Gruel (2005).

It is a basic assumption that consumer behavior comprehension is important for marketing managers as well as operation managers. The first are continuously looking for market

responses for new products, and how to deal with them. The second need such information to better plan their production resources and investments, getting a reliable operation strategy, and this incurred that related subjects like production ramp-up, as well as, sales take-off impacts are under discussions (Terwiesch and Bohn, 2001; Ortt and Schoormans, 2004; Foster, Golder and Tellis, 2004; Ülku, Toktay and Yücesan, 2005). Such discussions gain importance by the discussions of product performance and time-to-market: products coming too early or too late can create problems to companies (Cohen, Jehoshua and Ho, 1996; Praxnikar and Skerlj, 2006).

An interesting paradigm seems to guide diffusion of innovations literature, trying to identify innovators or surrogate consumers, putting marketing efforts and mathematic models in such direction. Few consider two important aspects mentioned by Everett Rogers: homophily (degree to which a pair of individuals who communicate are similar) and heterophily (degree to which a pair of individuals are different in certain attributes) as a diffusion process driving force. Rosen (2000) mention homophily advantages between insurance agents and consumers.

When we decide to study the diffusion of innovations in Brazil, some concerns brought up, in spite of some previous studies: 1) Does these Brazilian people respond in the same way as predicted by the theory of diffusion of innovations? 2) How diffusion happened for some products? 3) Was it possible to identify such conditions?

To answer the questions we got help from Brazilian Census reports as an interesting source for products information, mainly in their original research data, called micro-data. The Brazilian Census Bureau, called IBGE (Brazilian Institute of Geography and Statistic) has a yearly survey called PNAD (National Houses Sample Research) that allowed to follow the

spread of some products among Brazilian households. Such data proved to be very valuable. Each PNAD survey something about 65.000 to 120.000 houses in all country.

We processed data since 1970 for some products, mainly household items. The researched products were TV sets (the product was first introduced in Brazil in 1950), radios (the product was first introduced in Brazil in 1920/30´s), refrigerators and freezers (their introduction happened in the 1940/50´s), water filters. We also choose another innovation, internal home water canalization. The data were processed and the results compared to the mathematical diffusion models. One main restriction was set: the research focused the first time that a new product arose in a house.

The results showed some interesting conclusions, like a weak correlation between price and innovation diffusion. It is also important to inform that, in Brazil, there is a strong correlation between family income and number of years in school, and this information can explain some of the results under the lights of the innovation diffusion theory. The study also propose a division of the people, not in the five Rogers´s categories, but in five household income, starting with families living under a minimum wage (nowadays something like US\$ 174) up to families above 10 minimum wages (US\$ 1.740) per month. Brazilian yearly Gross Domestic Product was, in 2005, equal to US\$ 6.771. Finally we stressed that this work is a descriptive study of the diffusion of some innovations in Brazil, possible to be applied to other household appliances with some restrictions.

2. Literature review

Diffusion of innovations was first mentioned by Gabriel Tarde and Georg Simmel at the end of nineteenth century to the beginning of the twentieth century. Kermak and

Mckendrick in 1927 proposed a model to epidemiological situations that can be considered as a reference for the innovation diffusion mathematical models. Both phenomenons (like diseases by viruses and innovations) seem to follow the same patterns. Schumpeter, in the first half of the twentieth century, discussed the innovation impact for the world economic growth.

In 1962, Rogers proposed a qualitative model for diffusion of innovation, and at the same period some researchers presented some quantitative models for diffusion, some considering only external factors for the diffusion, others considering only internal factors. Bass, in 1969, proposed one of the most used models that include external and internal influences, called mixed influence model. Since them, many authors explore the mathematical road trying to predict consumer behavior regarding a new product or service. (Mahajan and Peterson, 1985; Teng, Grover and Gütler, 2002; Allaway and Berkowitz, 2005). Many areas exploit diffusion of innovation concepts: in culture and social movements (Strang and Soule, 1998; Kauffman and Patterson, 2005), sociology (Wejnert, 2002); in geography, economics (Baptista, 1999; OECD, 2006); organizations (Lundblad, 2003); marketing (Mahajan. Muller and Bass, 1990); technology transfer (Coppola, 2006); family income is seeing as a strong predictor for brand loyalty and innovation acceptance (Uhl et al, 1970; Martinez, Polo and Flavian, 1998).

In the literature review, we find that few articles and texts explore family income as a diffusion of innovations predictor.

3. Previous considerations

Our research established some restrictions in order to understand how the innovation diffusion happens in Brazilian houses. The first was that innovation adoptions means the first time a consumer buy a new developed product, an innovation, for his own use. It is almost impossible to identify when a consumer first get in contact with an innovation and such restriction implies that our research does not reflect an isolated communication process, but the effective purchase, preceded, of course, by a previous acknowledgement. The research was supported by Census information, as well as another surveys made by the Brazilian Census Department (IBGE) related to household appliances, which implies in accept that diffusion happened at the first time an innovation was introduced in a permanent house. We do not considered replacement, or even substitution by another more recent manufactured of the same innovative family product (one door refrigerators to two doors refrigerators; or a 16 inch TV-set to a 20 inch TV-set, for example). The concept of house includes all people living at the same place, in a permanent manner.

There are some reports concluding that low income families could not purchase innovations because of the high price at their launching time. This was partially supported by our research, because the diffusion phenomenon of household appliances followed a typical S-curve, prescribed by the theory, even if the prices were accessible some time after the launching for one family income range. A price correction of household appliances was made, bringing them to present values, and for our surprise the prices of some items were about the same in decades. Our reference was the minimum wage since 1960 compared to the values at the end of our research (end of 2005). People were able to buy a product decades ago, why did they do it latter? Another restriction was that we were looking for the

first time an innovation was purchased, not which model or type (standard, luxury, etc.) and as a consequence, we looked for the minimum available market prices at any time. We went through newspapers since 1960, checking the announced prices.

It is important to remember that Brazil played a high inflation rate during decades, coming to a stabilized economy (in relation to prices variation). The inflation came to civilized rates only after 1994. This was another interesting discover of the research, even with high prices inflation; the innovation diffusion followed the theoretical distribution curves.

4. The diffusion process studies

We started with data from the whole country, without any division, and the results of the diffusion within the houses can be seen in figure 1. As mentioned before the elected innovations were mainly household appliances: refrigerators, freezers, TV-sets, radios, water filters, added by internal water canalization adoption.
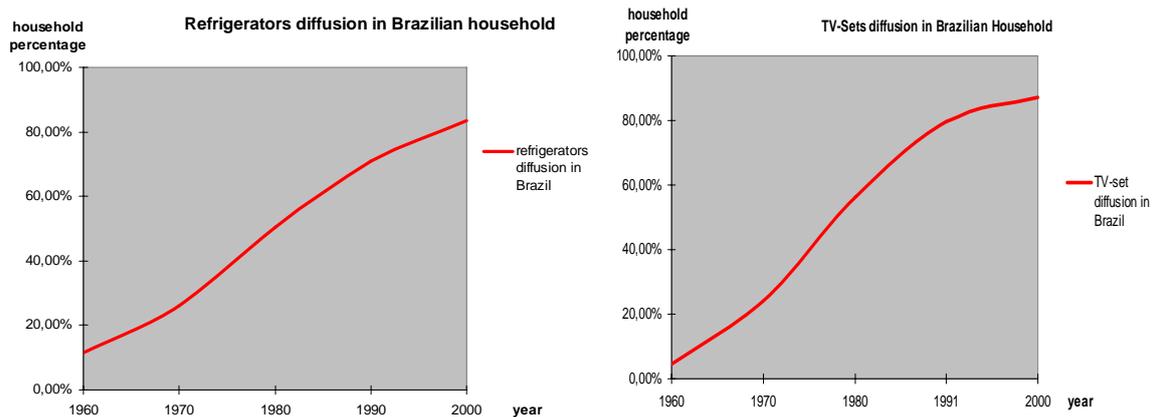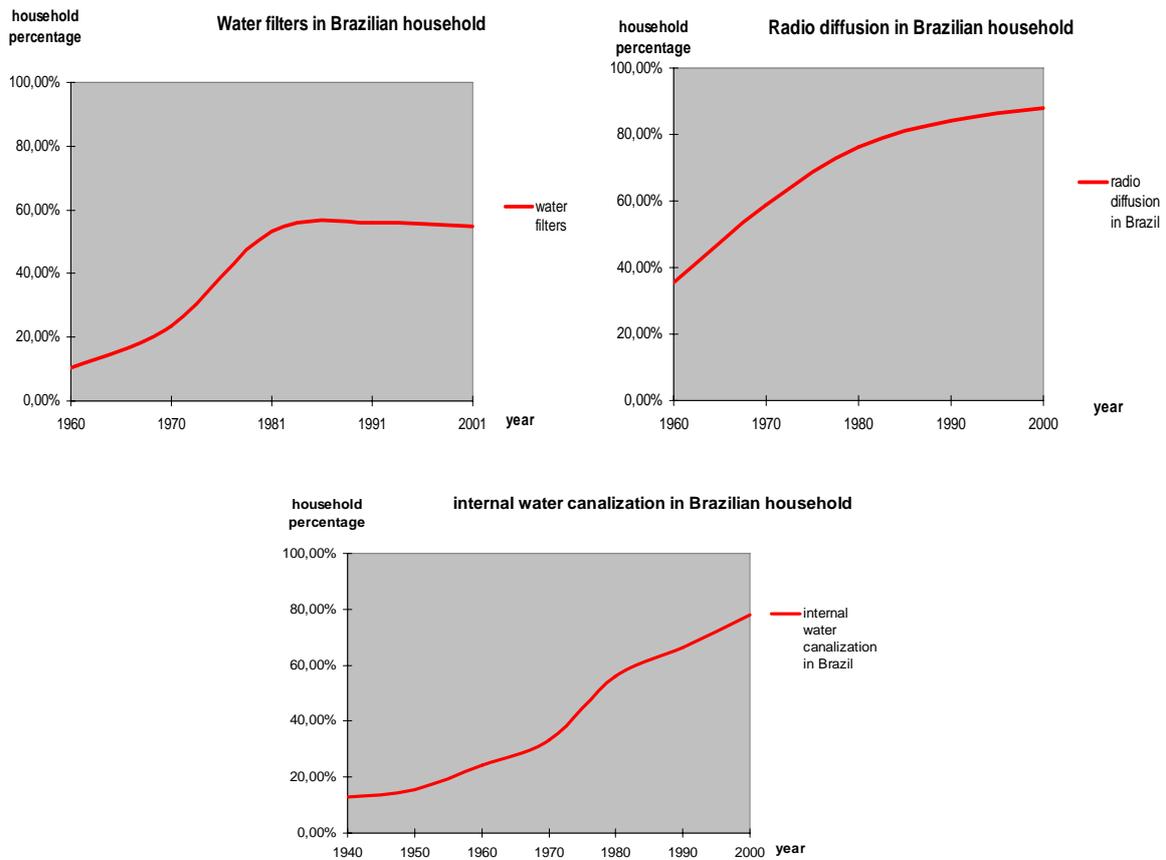
Figure 1 – Some innovation diffusions in Brazilian Households since 1960.

Looking at a total Brazilian diffusion of such innovations, the curves represented a type of diffusion in an S-shape, despite water filters started an abandon process in the 1980´s. The results reinforce the perception that diffusion concepts can be accepted for such items.

The curve inclination, as told by the theory, grows with different diffusion rate. This is particularly true when comparing home laundry machines with TV-sets, for instance. Refrigerators and TV-sets had different growth rates, as seen in figure 1. But two questions brought up: 1) Was the diffusion speed the same in cities and countryside? ; 2) Why water filters were in an abandonment course?

We split our data for cities and country and the results shows a delay between cities adoption and country adoption, as can be seen in the example of refrigerators.
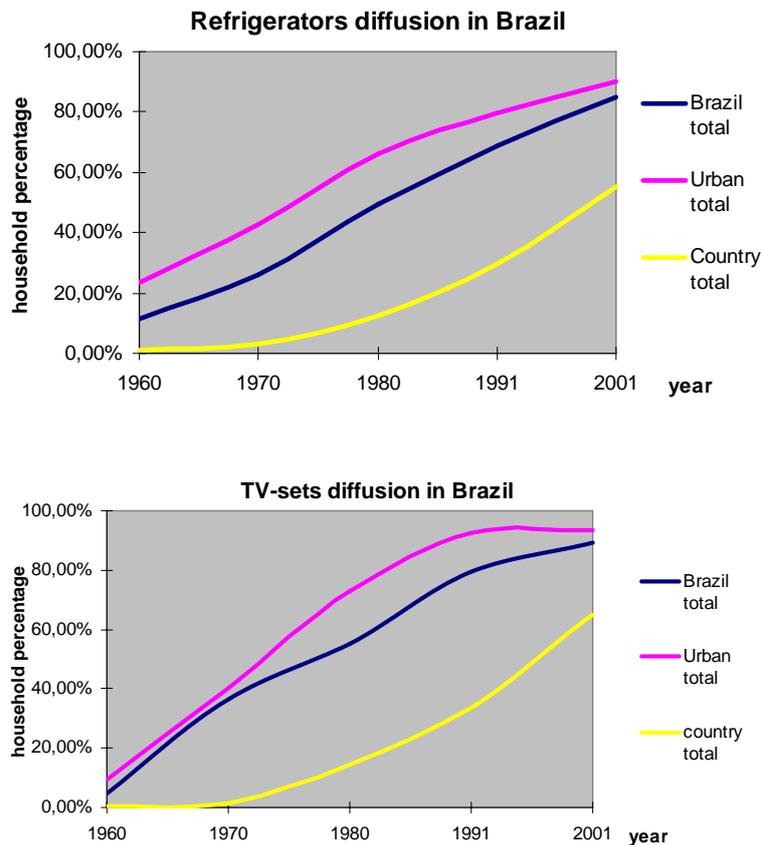

Refrigerators diffusion in Brazil

TV-sets diffusion in Brazil

Figure 2 – Urban and country households diffusion of goods.

The answer was interesting, urban houses are quite ahead in adoption regarding to country houses. These was confirmed in studies made with radios, water filters and internal water canalization, but a detailed analysis for water filters shows another situation, as is seeing in figure 3. Water filters abandonment started in different periods, as represented by the yellow and red curves.
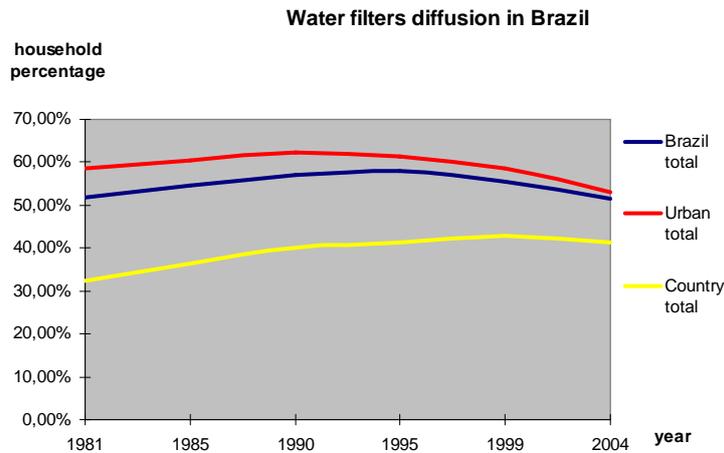
Figure 3 – Water filters diffusion and abandonment.

Conditions of diffusion abandonment were discussed by Greve (1995) and Rogers (2003), they reinforce their existence as an opposite diffusion process, appointing scarce studies about the subject. Answers to abandonment could be the introduction of good water delivery from water companies, but this is not true to country areas, indicating another phenomenon, maybe the introduction of mineral water sold in bottles.

The difference found between people living in urban areas and in country areas suggested that the former curves could represent a medium curve, so bringing difficulties whenever modeling or interpreting the identified situation. Could we understand that people living in urban areas are more innovative than country people? This is partly true, maybe because the information spreads faster in cities, or maybe because the imitation effect is stronger in cities.

The next step was to split the population among different incoming categories; the division was made into five family income month ranges: 1) under 1 minimum wage; 2) between 1 to 2 minimum wages; 3) from 2 to 5 minimum wages; 4) from 5 to 10 minimum wages and 5) above 10 minimum wages. This is a classical marketing survey division in Brazil.

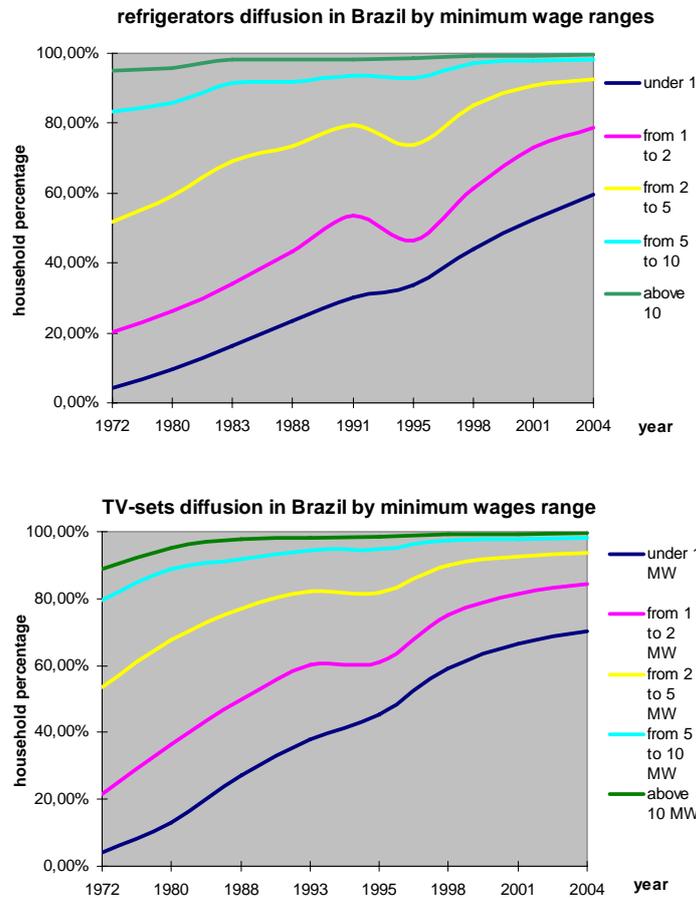Such division is represented in figure 4.

refrigerators diffusion in Brazil by minimum wage ranges

Legend:
- under 1
- from 1 to 2
- from 2 to 5
- from 5 to 10
- above 10

y-axis: household percentage (0,00% – 100,00%)
x-axis: year (1972, 1980, 1983, 1988, 1991, 1995, 1998, 2001, 2004)

TV-sets diffusion in Brazil by minimum wages range

Legend:
- under 1 MW
- from 1 to 2 MW
- from 2 to 5 MW
- from 5 to 10 MW
- above 10 MW

y-axis: household percentage (0,00% – 100,00%)
x-axis: year (1972, 1980, 1988, 1993, 1995, 1998, 2001, 2004)

Figure 4 – Diffusion of some innovations amongst different earning month values.

Some interesting behaviors arosed whenever the division was plotted. Poor people seems to act as laggards, and rich people seems to react like innovators amongst the population. This is well supported by the theory, but it was rarely represented in the literature.

High prices in the launching period could be a good explanation for such situation, and as told in item 3, prices could be an important factor in diffusion process, but such consideration could not be sustained,. A price review in magazines and newspapers since 1960, updating prices to 2005 in quantity of monthly earned salaries, surprisingly shows about the same prices for many household appliances, as can be seen in some examples in

the next tables. It is an important remark that we were looking for the cheapest announced prices, without simple or sophisticated model consideration.

Table 1 – Refrigerators prices since 1960.

Year Price	Price of refrigerators in quantities of minimum wage					
	1960	**1970**	**1980**	**1990**	**2000**	**2005**
I	1,82	2,51	2,36	3,88	2,58	2,56
II	2,48	2,67	2,57	4,06	2,77	2,80
III	2,69	3,19	2,58	4,11	3,30	2,80
IV	2,91	3,50	2,65	4,11	3,30	2,86
V	3,11	3,62	2,89	4,28	3,64	3,00
VI	3,11	3,62	2,89	4,38	3,64	3,33

Table 2 – Electric heated iron prices since 1960.

Year Price	Electric heated iron prices in quantities of minimum wages					
	1960	**1970**	**1980**	**1990**	**2000**	**2005**
I	0,03	0,04	0,08	0,35	0,10	0,13
II	0,03	0,04	0,08	0,35	0,11	0,14
III	--	0,05	0,19	0,36	0,13	0,17
IV	--	0,10	--	0,37	0,16	0,20
V	--	0,32	--	0,38	0,25	0,26
VI	--	0,32	--	0,53	0,27	0,26

Table 3 – TV-sets prices since 1960.

Year Price	TV-sets prices in quantities of minimum wages					
	1960	**1970**	**1980**	**1990**	**2000**	**2005**
I	2,08	2,13	2,09	3,45	1,56	1,90
II	2,58	2,67	2,17	4,13	1,61	2,00
III	3,00	3,19	2,21	4,54	1,61	2,00
IV	3,49	3,20	2,21	6,42	1,61	2,00
V	3,61	3,46	2,21	6,92	1,61	2,13
VI	3,85	3,47	2,46	6,92	1,65	2,33

The prices even increase for some items at the last 45 years, so prices decrease was not a good explanation for diffusion of such innovations among the population. This can support

that diffusion was not solely influenced by prices decrease, some other variables must be considered with great impact in the phenomenon.

A remark: about 1995, the curves tendency misrepresent the diffusion process, and this was explained by a quick family income level that took place since 1994 to 1996, because an macro-economic phenomenon in Brazil (in a short period the inflation went down from levels of 20% per month to 0,5% per month, suddenly leaving more money to poor people; families climbing to another income level was a huge and distorted the statistics). Refrigerators diffusion (more expensive than TV-sets) suffers more. Such deviation was not found within radios and water filters (cheaper items) but it was present in internal water canalization. It is important to note that during the researched period (1960 until 2005) Brazil suffered many economy disturbances, financial crisis, liquidity retrenchment, and even in that periods the diffusion was in an almost constant increase, reinforcing the perception that economy disturbances are not a strong variable to detain the diffusion process.

The research allowed us to get some data about dynamically continuous innovation of new products (Saaksjarvi, 2003). Such situation could be identified with the transition from black and white TV´s to Colour TV´s, which started in Brazil in 1972. The data were available just after Census 1980, but some interesting information could be drawn, as can be seen in figure 5. During 1980´s Black and White TV-sets had a sharply decrement in high income household, but they are still ascend in numbers of equipments in low income household.
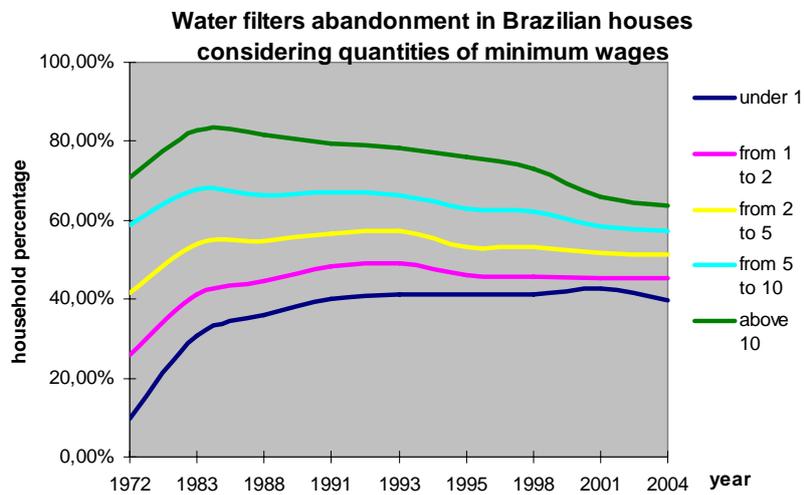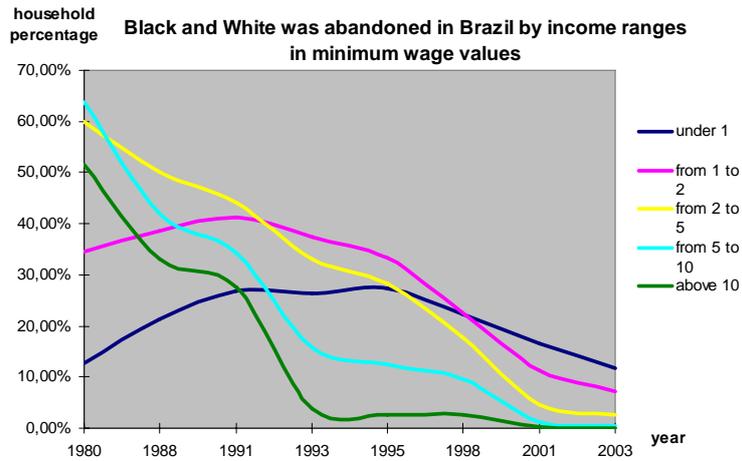
household percentage **Black and White was abandoned in Brazil by income ranges in minimum wage values**

Water filters abandonment in Brazilian houses considering quantities of minimum wages

Figure 5 – Abandonment of a product by different earning categories.

Again rich people act as innovator reacting fast to an older product, or in their point of view, a surpassed product. Poor people were in an ascendant way at the same period, but some time later the curve started to decrease. Poor people react as laggards. The same situation was detected with water filters discontinuation. When radios were studied, a slight decrease was detected from the beginning of the 1990 to nowadays and the phenomenon was the same, rich people left in advance. Such conditions could be understood as a perception problem.

By the other side, check of the curves suggest that rich people reacts in a different manner than poor people, responding in a special way. It looks like an exponential curve or the called external-influence model. We tested such conditions, preparing some adherences tests, like Kolmogorov-Smirnov, supporting the first impression. Curves response of rich people for innovations adhere better to exponential curve, with a rapid growth, saturating very quickly. Other incoming categories did not respond so better.

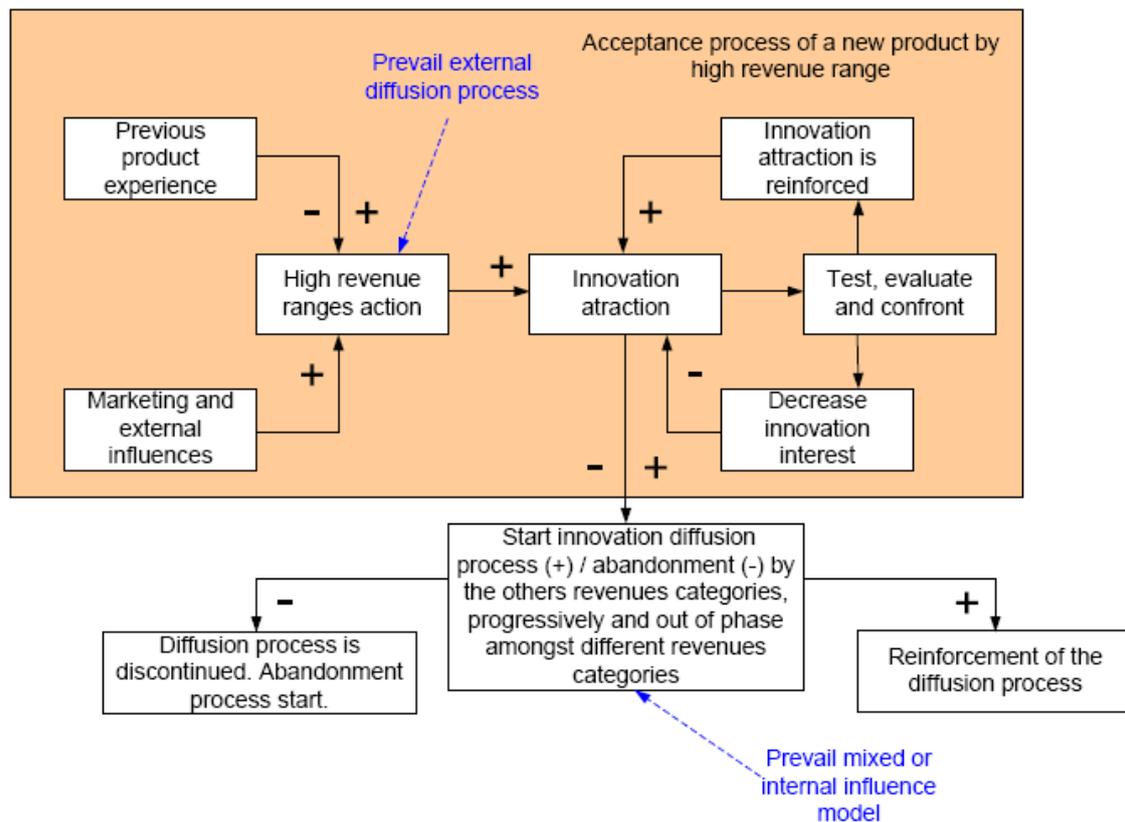The study supported us to suggest a descriptive model, showed in figure 6.

Figure 6 – Representation of the phenomenon of rich people reaction to innovations

Such discover allowed a suggestion: companies could concentrate in the top incoming categories reactions, in spite of trying to find innovators by other ways, such surveys are more common in marketing and the data can be easily got.

5- Conclusions

The study seemed very valuable to support many conclusions already made by the theory and other research, contributing with some new aspects not completely cleared by the literature, allowing identifying some interesting points:

1) Diffusion of innovations in Brazilian household can be assumed to follow theoretical approaches as S-curves (as demonstrated in refrigerators, TV-sets, radios, water filters and internal water canalization);

2) Cities and country areas presents some response delay regarding to innovations of different types (household appliances and water canalization, for example);

3) People behavior regarding to innovations seems different among different incomes, with the richest people responding more adequately to an external-influence model with the increase of internal influences behavior, since household income decreases;

4) Prices are not an important variable influencing the diffusion process, as showed with prices research during the last 45 years, but we are not discarding prices or telling they do not influence the diffusion process;

5) Abandonment process followed the same patterns as acceptance, with richest people being ahead of other income categories, as seen in water filters and black and white TV-sets. This can be an interesting aspect for strategy considerations, telling in advance how to deal with operations resources. Knowledge of income household class size can be useful in sales and production capacity or investments;

6) As seen, innovations are firstly purchased by rich people (innovators can afford to assume risks), and we can assume that other income categories react approximately as the category division proposed by Rogers: early adopters, early majority, latter

majority and laggards (poor people can not afford to loose money), and a free comparison is made in table 4

Table 4 – Comparison between Rogers proposal and income categories

Rogers (2003) – first proposed in 1962	Household income categories
Innovators	Above 10 minimum wage
Early adopters	From 5 to 10 minimum wage
Early majority	From 2 to 5 minimum wage
Latter majority	From 1 to 2 minimum wage
Laggards	Under 1 minimum wage

Our research is a description of the diffusion of innovation process in Brazilian household, as well as our proposed model is only descriptive, but we believe it can be another tool for operations strategy information and decision. We believe that further discussions should be made, mainly the proposal of a quantitative model able to describe the identified phenomenon, allowing the companies to foresee a market growth in a reasonable basis.

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