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Empirical Testability of Sell-Up Effect in Revenue Management Theory through Organizational Issues.

Jean Michel Chapuis *

Abstract:

This paper deals with the effectiveness of sell-up techniques to enlarge the testability of RM theory. The hypothesis that reducing the availability of a product to restrict the diversion behavior of consumers increases revenues, can be confronted with reality through three research fields, namely the methodological heart, the design tuning and the organizational border. Empirical research methods should however be matched with the field under consideration. The paper supports the use of a questionnaire to survey whether sell-up is profitable at the organizational level.

* University of La Rochelle, Management Institute, 17000 La Rochelle, France. Tel: +335 46 00 31 00; Fax: +335 46 00 30 56; Email: jean-michel.chapuis@univ-lr.fr. This paper is financed by FSE as it is the result of a cooperation between Cerege Poitiers, Groupe Sup de Co - La Rochelle and the University of La Rochelle. The latest draft is available at http://jchapuis.free.fr/recherches/ (Sunday, May 08, 2005)

The author is a lecturer of Yield Management at the University of La Rochelle. He has been the Head of the International Hospitality Management Master since 2002, and is currently guest lecturer of CHN University of Doha, Qatar. Having completed a Ph.D. in Corporate Finance, he has orientated his research work towards Revenue Management and specifically on the way companies implement this strategy.

INTRODUCTION

For decades, we have learned to revere the letters of Revenue Management (RM). Its spirit of dynamic pricing and inventory controlling is widely shared among various industries, major companies and universities. A growing community of researchers attend various meetings and publish scientific papers in hundreds of journals.

In the case of airlines, the sell-up effect is when booking limits depend on the probability that some customers, when they find that their first choice class on a path is unavailable, take the next class up (on that path). Pfeifer (1989) has supported the proposition that sell-up is profitable because it extracts the value of the service from the consumer's utility, but his model is limited to two fare classes. Belobaba and Weatherford (1996) extended the EMRS model of Belebaba (1989) so that their heuristic is able to set a protection level considering sell-up for more than two fare classes. The core value of sell-up is that reducing the availability of product at the lower fares increases the revenues. Usually, simulation models prove that a sell-up tactic increases the revenues by 1 or 2 % (Belobaba and Weatherford, 1996). Gorin (2000) had run PODS simulations to reach the conclusion that an airline can improve its revenue by 1 % to 3 % depending on the used RM system.

However, a striking fact is that publications related to sell-up do not seem to use a full range of available research methods. A brief review gives the feeling that smart models and computer simulations are overused compared with other social sciences, which probably weakens the scientific validity of research results.

To undo this knot, this research explores three perspectives of the research field and compares various empirical approaches, so as to enlarge the testability of the Revenue Management theory without developing a new one. (i) Forecasting, setting booking limits, overbooking and pricing compose the methodological heart of RM; (ii) the design tuning is considered while expanding RM to other industries or new customers and (iii) the organizational border concerns the transactions between RM department and others within the firm. These are three fields where the RM theory can

be confronted with reality. The laboratory experiences, the insider database, the case studies and the survey studies are four available empirical research methods to achieve this. The corner stone of this paper is diversifying the approaches, while presenting their advantages and disadvantages to be aware of any limitation.

This paper deals with the organization level of the research fields to propose a new empirical test of sell-up theory. If the sell-up feature in a RM system increases the revenues according to computer simulations, managers that deal with daily RM should answer positively to the question whether sell-up is profitable at an organizational level, regardless of the system used.

The first section illustrates sell-up as a special case of demand diversion and tries to clarify the research topic inside Revenue Management. The second section studies the empirical methods available and how they should satisfy some conditions to justify conclusions. The third and last section concludes and opens to a questionnaire that helps testing the RM theory of sell-up at an organizational level.

1 REVIEW OF THE THEORY OF RM AND SELL-UP TO TARGET RESEARCH FIELDS

After reminding oneself of the nature of Revenue Management, this part firstly deals with sell-up in order to elaborate a research proposal about the profitability of sell-up models. However, confronted with the complexity of the task, this section secondly proceeds by dividing the research fields in order to simplify the analysis and improve the testability of hypotheses.

1.1 RM and sell-up

In order to maximize operating revenue, RM is the process by which a manager controls the availability of a product or service, marketed with a differential and dynamic pricing. Controls can be effective by varying prices, setting booking limits and managing fences. This approach is in line with Talluri and Van Ryzin (2004), who supported both price and quantity-based models of RM. Most authors often define RM as the application of control and pricing strategies to sell the right capacity to the right customer, in the right area, at the right time and at the right price. Kimes and Chase (1998) sum up that there are two strategic levers: product pricing (both differential and dynamic) and product availability controlling. RM has proven its potential impact on profitability in the past (Smith, Leimkulher and Darrow, 1992).

Each RM model relies on a prediction of the consumers' behavior at a micro market level[1], especially how they act and react to the manager deeds. According to Pfeifer (1989, p.151), diversion occurs when a passenger takes advantage of a discounted fare while willing to pay more. According to Belobaba and Weatherford (1996, p.344), diversion is the willingness of potential customers to purchase the product in a price class different from the one they originally requested, intended to purchase, or both. As one of the fundamental RM decisions is whether or not accept an incoming request of booking while maximizing profits, managers can reduce the availability of lowest fares to prevent this behavior. Depending on the individual consumer's choice process, Belobaba (1989, p.190) said that the unavailability of a desired flight and fare class can lead to: (i) a vertical shift to a higher fare class, same flight; (ii) a horizontal shift to a different flight, same fare and airline; (iii) a booking loss to the refusing airline. A RM system incorporates a sell-up effect when the optimization procedure (of protect levels) depends on the probability that some

[1] Weatherford and Bodily (1992) provide taxonomy of the most common assumptions.

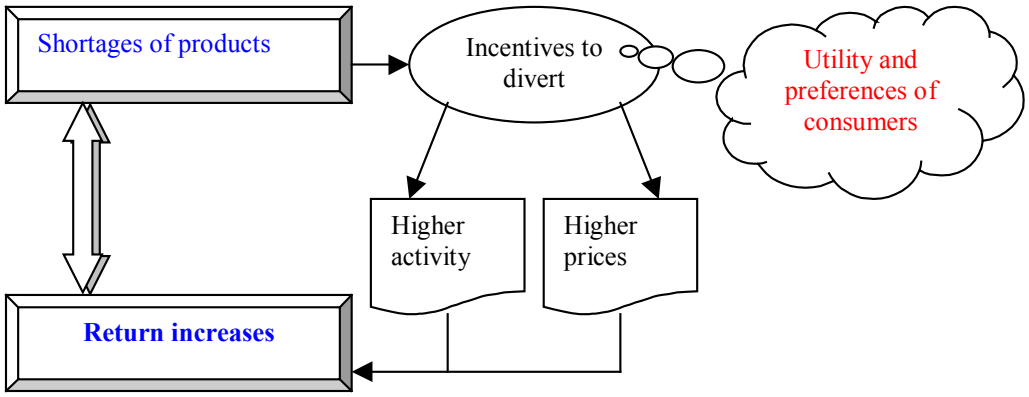
customers, when they find that their first choice class on a path is unavailable, take the next class up (on that path)[2].

The rationale for this improvement in a RM system is that the higher the demand for a product in a given fare class due to diversion, the higher the opportunity cost of using this product given a protection level, the higher the protection level (of higher fare classes) should be to maximize profit. As a consequence of sell-up, revenue increases while reducing the availability of a product marketed at its lowest rates by forcing "potential customers who are not sensitive [to the price differences] to pay the full fare once the authorized level of discount-fare seats are sold" (Pfeifer, 1989, p.150-151). The protection levels for the higher fare class booking of a product will increase, *ceteris paribus*, when managers decide to include in a system one or more possibility that consumers shift to other company's products or higher fare classes.

Assuming this hypothesis is true, one might expect as well that managers implement the sell-up tool in a RM system as long as its incremental revenue exceeds its maintenance cost and the implementation cost according to the NPV rule. Otherwise, what kinds of costs balancing off the sell-up revenue have been forgotten? Summing up, the hypothesis to test is that managers maximize revenues by making up a shortfall in products or increasing the scarcity of products. Two levers could be used to achieve this goal: booking limits and pricing. The theoretical framework is summarized in the next figure n.1.

[2] The recapture effect represents the probability that some customers, when they find that their first choice (product-date-price) is unavailable, accept another date or product (same price) of the same carrier. The analysis of recapturing a customer instead of selling up is similar to some extends.

Figure n.1: Theoretical framework



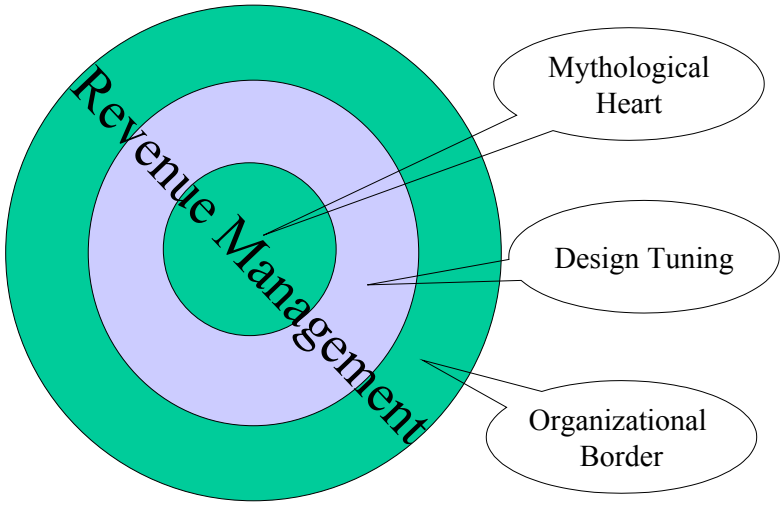
Legend: the research proposal about sell-up effect leads to the hypothesis that shortages of product increase revenues through higher price - protection level if sold-up (or higher activity if recaptured).

Moreover, this hypothesis is too wide to be testable in this form. Thus, this research explores new fields in order to propose new tests of it.

1.2 Dividing the research question to improve the testability of the theory

This research supports the idea that the progression of RM practices (from Littlewood's rule to more recent origins and destinations fares controls) reaches a point of decreasing returns, inside the field of RM itself, say its methodological heart. However, new opportunities could exist outside RM itself as the resolving a range of conflicts with other firm's polices increases corporate value. Those opportunities should be twofold considering or not a direct relationship with the customer. In other words, RM research questions are classified into three rings of a target shown in the next figure n.2**.**

Figure n.2: Target of RM researches.



The following explains each ring in order to understand their relationships.

1.2.1 The first ring deals with the methodological heart of RM

The main purpose of the research inside this ring is about algorithms that could boost operating revenues. The heart of RM is composed of four main parts: pricing, forecasting, overbooking, and booking limits. A new research could be classified as either quantity-based model or price-based model according to Talluri and Van Ryzin (2004). In the case of sell-up, three generations of papers redesigning models are identified.

i. From 1989 to 1996: Peifer (1989), Belobaba (1989); Bodily and Weatherford (1995) and Belobaba and Weatherford (1996) initially provide the main statements of the theory.

ii. From 1995 to 2000: firms have implemented a sell-up feature in their RM system. Caroll and Grimes (1995) explain how Hertz usually upgrades car rentals. Andersson (1998) relates the case of SAS airline. At the same time,

researchers challenge the forecasting of the probability that a customer buys-up in higher classes on understanding his or her first choice is unavailable. Gorin (2000) has proposed an approach to approximate this probability computing the inventory of bookings based on class closures. Hopperstad (2000) revised the 1996 Belobaba/Weatherford model to a more realistic hypothesis that not just the last denied request customer can buy-up.

iii. From 2000: hotel chains have used the RM with their own sell-up features. Kimes (2001) suggests that Disney was trying to maximize the revenue of its hotels overall rather than maximize the revenue for each one separately. Similarly, Marriott has developed revenue management for a particular city or region. Chapuis and Paquerot (2004) show that Accor group has set up since 2002 a system of Area Revenue Management, which is an optimization system of the flows of customers between its hotels in the large cities *via* a mix of sell-up and recapture effects.

This part splits from the next by the line of interaction commonly used in services industries. Above this line, the problem is about the RM process it self. Under this line, the problem is about the interaction of RM as an entity with the others departments of an organization.

1.2.2 The second ring deals with tuning the design of RM.

The consumer is the first external entity linked to RM, as the way a researcher assumes his or her behavior fundamentally determines the design of any RM system. Weatherford and Bodily (1995) summarize the most common assumptions of models and their relationships with sell-up, depending on what the researcher concentrates its efforts on. The community of researchers agrees that incorporating a consumer choice model in RM is a real challenge, in order to obtain a fine tuning of the design of the RM system in each situation.

Considering the impact of passenger choice preferences in situations where his or her booking request is rejected, Andersson (1998, p.471) points out it makes a difference to the airlines when he or she is prepared to pay more for the higher fare class being open for booking. For his study, the passenger preferences were estimated from choice analyses of interviews and logged bookings transactions. Then sell-up and recapture probabilities were estimated[3]. Talluri and Van Ryzin (2004) looks further on RM under a general choice model of consumer behavior. Britan and Caldentey (2002) believe there is an opportunity to combine efforts in market research to understand consumer choice behavior with the modeling and solutions techniques of dynamic pricing and revenue management. The open question about the fairness of RM between customers is also part of this ring theme research. The next ring deals also with the customers but in a broader sense.

1.2.3 The third ring deals with the organizational border of RM

This part of research tries to develop new knowledge about the way that RM practices co-exist with other departments' practices of the company inside the organizational architecture[4]. Lieberman (2003) points out that "it is also clear that

[3] Discrete choice analysis can be used for measuring the passenger `utility' of a particular product alternative. The sensitivity of the utility to price and product characteristics can also be derived. The method does require that passenger choices between alternative products can be observed; the numerical coefficients of the utility function then can be estimated. Data defining passenger choice situations could be retrieved from analyses of actual bookings logged; this approach is called `revealed preferences'. Choices also can be recorded in an interview situation where the passenger is presented with two fictitious product alternatives. This is the `stated preferences' method (also called `conjoint'). According to the choice theory, the passenger will gain some `use value' or `utility' when he or she has chosen and traveled a specific flight, class alternative. Once estimated, the utility function can be used for simulating sell-up and recapture (Andersson, 1998).

[4] In their analysis of the institutional devices through which decision-making rights are assigned within firms, Jensen and Meckling (1992, p.251) focus on how the costs of transferring information between agents influence organizations. They assume that the efficiency of an organization strategy depends on the way decision-making rights are located with specific knowledge and on the control system. They support that these two dimensions could design any organization (see also Brickley et al., 1998).

revenue management programmes are often less effective than they might be, as companies fail to take appropriate managerial and organisational actions". He prayed for integrating RM with others departments (p. 110). The research on the organizational border focuses on the location of decision-making rights instead of the methodological heart or the design tuning. The historical analysis of RM provides three examples in the past.

First, the practice of overbooking had surely modified the decision-making authority between front and back offices in hospitality for instance. Second the merger between the RM and Pricing departments is now common among global companies and the JRPM proves the community's interest on this question. The ways those two decision-making processes have been integrated are however neither clear nor well studied on a theoretical background[5]. Third, McGill and Van Ryzin (1999) specially point out the interdependence between RM and the planning departments in the case of airlines (see Caroll and Grimes (1995) for car rentals). They also introduce the relationship between RM and fare product design but no more. Grewal (2003) relates the Continental Airlines experience that shows the conflicts inherent to the objectives of each department and how the organization can be structured to reduced their costs.

Consequently, the methodological heart tends to expand and blend with the next rings. The work of Chapuis and Paquerot (2004) deals with all the three rings, as Area RM is about both marketing issues of sell-up and ownership structure issues as well. One of the original ideas of this paper is that the organizational architecture of a firm can affect the potential return of sell-up procedures in RM systems and explain the reluctance of managers to implement them. Is sell-up profitable at an organization level? The support for diverse research fields advocates adapting the empirical tests as well.

[5] Moreover, this issue must be addressed inside the organizational ring because pricing means more issues than the first ring (forecast and bid prices) or the second ring (consumer characteristics). Pricing is only one part of the 4P's of marketing (product, place and promotion).

2 AVAILABLE RESEARCH METHODS TO DEAL WITH RM ISSUES

KARL POPPER, 1998, p. 363 and 364: « Le contrôle que nos théories… exercent sur nous … est un contrôle *plastique*. Nous ne sommes pas *forcés* de nous soumettre au contrôle de nos théories, car nous pouvons les discuter de manière critique, et nous pouvons les rejeter librement si nous pensons qu'elles ne satisfont pas à nos normes régulatrices… Non seulement nos théories nous contrôlent, mais nous pouvons contrôler nos théories. » *La connaissance objective*, Flammarion, 578 p.

The determination of suitable booking limits and characterization of their structural properties over time has been the principal focus of academic research while the need for implementation approximations to optimal limits has driven practitioners' research (McGill and Van Ryzin, 1999). This research relies on the Popper's proposal and suggests that there are essentially four ways to control empirical knowledge in RM literature: the laboratory experiences, the uses of insider database, the case studies and the survey studies. Every empirical method has a role to play in testing theories. But their limitations lead to claim no conclusion that is based on a particular technique only. This section examines this range of alternative empirical methods and evaluates the pros and cons, according to the previous three research fields.

2.1 The laboratory experiences

This experimental method of research involves the scientist attempting to control the environment (in case of RM, demand pattern and consumer's behavior) and then to measure the effects of hypotheses, for instance sell-up. The researcher therefore aims to reproduce conditions so that the research will fulfil the requirement for causality from say a factor X on a dependent variable Y, *ceteris paribus*. Assuming the consumer's behavior and the organizational architecture are constant, this method is useful to test the effect of sell-up tactics on revenue and calibrating a specific model. However, it is

not adapted to understand the impacts of those former factors on revenues. Experiments are not common in social science because this environment is well known for being mostly unpredictable and affecting the causality on consideration.

For example, Belobaba and Weatherford (1996, p.350) used this method to test if total revenues are increased while incorporating the likelihood of sell-up into seat protection calculations. They had compared the performance of two heuristic decision rules (known as B/W) that incorporate sell-up effect with the performance of EMSRb. They expect that the heuristic decision rules that incorporate diversion outperform the one without sell-up. The comparison was made using *scenarii* with various factors[6] that could affect results and they ran 10,000 iterations to obtain outputs. Their combined heuristics can allow a manager to reap up to an additional 2% of revenues depending on the configuration of factors.

A consortium of airlines finance a Passenger Origin Destination Simulator (PODS) at the MIT. PODS is a "full-scale" simulation of both passenger choice and airline RM systems used to guide system development. It provides a realistic environment for testing RM methodologies, which impact on traffic and revenues in competitive markets. One of the major accomplishments of this simulator is to focus on sell-up models. Gorin (2000) has confronted the 1996 B/W model with the 2000 Hopperstad-B/W model (Hopperstad, 2000) and reached the conclusion that accounting for sell-up added about 1% to revenue gains under various PODS parameters.

After years of development, PODS is approaching "realistic" characterization according to Belobaba. Ability to simulate larger networks has opened up greater potential for PODS researches such as airlines' alliance strategies or impacts of new entrant competitors and impacts of pricing, fleet assignment and schedule changes on RM methods. These extensions tend to shift the debate toward organizational issues. (Belobaba, 2001).

[6] Namely the ratio of demand to capacity, the probability of up grading, the number of fare classes.

This method is useful to test the effect of sell-up tactics on revenue and calibrating a specific model. However it is not adapted to understand the impacts of the consumer's behavior and the organizational architecture changes on revenues, because as those changes take time, the experience environment could not be held constant at all. So, the traditional approach of empirical proofing of RM theory through the laboratory experiences could lack deep and tough analysis, when studying customers and organizations. Hopperstad and Belobaba (2004) have pointed out the sensitivity of results in PODS simulations to the assumed behavior of competitors. These kinds of relationship should therefore be tested using other methods.

2.2 The insider database

In order to test the validity of hypotheses gathering a lot of data from the past activity of the firm is another way to collect evidence. This task is probably done inside RM departments of airlines. For example, airlines try to estimate the probability of sell-up assuming that a price class is unavailable, from statistical analysis of their clients' bookings. The advantage of this method is that the data are more accurate than the laboratory data, so worthy for the approximations of theoretical algorithms. This is a qualitative approach to design one's system with in-depth analysis.

The weakness is that the representativeness of the samples might not support statistical inference. The results should not be generalized at all, assuming each case is unique. For instance, if increasing the protect level of a particular product in a company during one month does not produce the expected results (increasing returns by pushing clients to upgrade themselves), it does not mean that the theory of sell-up is false and to be rejected. Unlike readily available stock market prices, RM departments seldom communicate the results of such analysis because they are of some strategic value. Thus this method should be primarily used at the design tuning ring and to some extent at the methodological heart ring. However, consolidated database from diverse sources would be more useful to test RM theory than the laboratory experience test. First, because the

environment would be recorded as it was and not as the researcher thinks it was. Second, because the environment may change and those changes strength the validity of the theory as long as it survives.

2.3 The case studies

Looking at a few cases can also help to discover knowledge and elaborate more accurate RM models. A case study relates the story, the experiences and the feelings of someone about a defined subject. Case studies are a way to confront theories with reality, as a qualitative method. The reading of the others' stories could be much more informative for managers who want to implement RM in their companies than any smart model but hypothetical. For instance, a lot of airlines companies have implemented an O&D RM system and their experiences were shared between AGIFORSattendee[7]. This method can be very powerful helping researchers working on the design-tuning field, since they can compare their situations with past experiences. This method is also used when the research purpose is organizational learning (see Grewal, 2003). However, not enough observations (both in companies or periods studied) might be available to ensure statistical power for inference. So, the risk of shifting from the laboratory experience method to the case study method is to be stuck in particularities without any possibility of generalization.

[7] See the latest proceedings of AGIFORS Reservation and Yield Management study group Wishlinski, 2004, "Delta's experience on O&D RM", Auckland; Zeni, 2003, "Bid Price Control at US Airways: Benefits and Costs of O&D RM", Honolulu; Westerhof, 2000, "Implementind O&D RM at KLM", New York. Curiously, case studies about sell-up experiences are fewer. See also methodological aspects, Clarke K., 2004, "Case study: Implementing a revenue management system at Malaysia Airlines", *Journal of Revenue and Pricing Management*, vol. 3, n. 1, pp. 41-49.

2.4 The survey studies

As it is costly to collect data using case studies, an alternative is to ask to the decision-makers what they have done in a particular situation. Survey studies allow researchers to observe the behaviors and attitudes of managers using RM strategy and to test hypotheses. The sample would consider more people, more "numbers" but less in-depth interviews than in a case study and less number but broader than in an insider database analysis. Looking at the behavior of individuals (people or firms) on the market allows the acceptance or rejection of a hypothesis by statistical analysis as well as laboratory experience, based on the significance of results. For instance, Upchurch et al. (2002) use this approach to compare usage and competency factors of yield management principles as reported by those in charge of revenue enhancement within US lodging industries.

Summarizing the advantages and the disadvantages of each empirical test concludes this part. The idea is that more knowledge could be achieved by diversifying research approaches.

Table 1: Advantages and disadvantages of each method.

Methods	Pros	Cons
Laboratory experience	Useful to appreciate the impacts of various factors on returns.	Could lack openness to task environment (organizational characteristics of players).
Insider database	Compute a lot of data and provide accurate results in specific case.	Seldom communicated externally, qualitative approach to design one's system only.

Case study	Qualitative method, journalism, in-depth interviews.	Weak statistical inference, no possibility of generalization.
Survey study	A mix of advantages of previous methods.	Less efficient than any other methods to reach their goals.

Another original idea of this paper is that the fittest empirical method to the organizational research of RM is the survey study of sell-up practices, as shown in the next figure n.3. The 1-star expresses that the data are not available outside the firm. Anyway, those data should be biased towards mean values as others tactics and external factors influences profitability. The 2-star emphasizes that it's difficult to estimate the parameter for instance. The 3-star points out that the hypothesis (drawn by arrows) should be accept as true just by observing how many firms use sell-up optimizations in their RM systems - assuming that a company seeks profits.

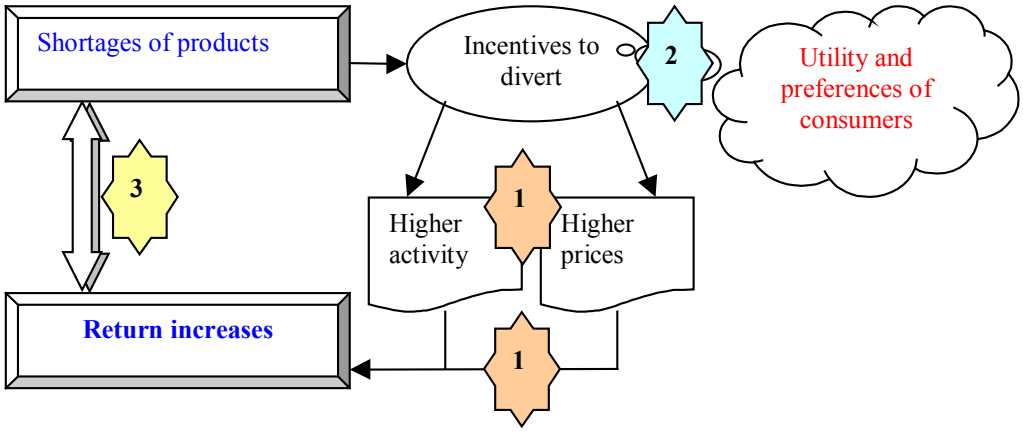


Figure 3: form of the test of the hypothesis

3 CONCLUSION

Expecting a sell-up or a recapture, Revenue Managers can take advantage of the consumer's willingness to change his or her plan, understanding his or her preferred choice is unavailable. From "does someone find the best sell-up model?" or "how to fit sell-up model to real case?", this research proposal shifts to "do managers try to implement sell-up models?". The contribution of this paper is twofold. First, it explores three fields of Revenue Management researches and matches the empirical methods to each one:

- Methodological heart and laboratory experiences;
- Design tuning and both insiders database and case studies;
- Organizational frontier and both case and survey studies.

This research does not however provide any new model instead of the existing ones. Second, the strategy is to test the hypothesis that sell-up is profitable at an organizational level by means of a questionnaire. McGill and Van Ryzin (1999) suggested a research prospect about the integration of departments implicated in RM issues. This paper goes ahead and elaborates a theoretical framework to understand this integration with the current theory and practice of RM. In other words, how the potential interdependencies between departments affect the probability of success and the operating returns of Revenue Management?

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