

# Where there is a will, there is a way? Assessing the impact of obstacles to innovation

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## Abstract

In order to obtain a correct estimation of the effect of the various obstacles affecting the firm's propensity to innovate, this paper claims that it is useful to distinguish between firms which do not innovate because they do not aim at doing so and firms which try but fail to succeed or give up because of too strong obstacles. Using the French CIS4 survey, a classification of firms is proposed, according to their degree of will to innovate. Several samples are built, including firms for which innovation is a concern (*willing* to innovate firms), with a more or less strong intensity. Using the stricter definition of firms willing to innovate, the estimated impact of the obstacles to innovation is significantly negative, while, as usual, a positive relationship is founded between innovation and the R&D expenditure, the size of the firm and the membership to a group.

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# 1 INTRODUCTION

A lot of studies analyze the firm's propensity to innovate all over Europe, most using data from the *Community Innovation Survey* (CIS). The empirical models generally assume that this propensity depends on:

- the inputs of innovation, typically the Research & Development (R&D thereafter) amount of expenditures;
- the characteristics of the firm, as its size;
- some environmental variables, often captured through industry or geographical location dummies;
- and, sometimes, the obstacles to innovation, CIS being one of the rare surveys which includes such variables (Galia and Legros, 2004).

Most econometric results are consistent with theoretical predictions as a positive relationship between the amount of innovation input, the size of the firm and the firm's propensity to innovate. However, the estimates of the effects of obstacles on the propensity to innovate are much less satisfactory. As noted by Mohnen et al. (2004), a non significant or even a significantly positive coefficient is associated with the variable *Obstacles*. Savignac (2008) notes the same awkward result when considering the impact of financial constraints on innovation.

In order to understand the reasons of such results, using the French CIS4 data, firms can be classified into three groups:

- About 40 % declare to have innovated;
- Around 1 % declare to have engaged into an innovation project, which is *ongoing or abandoned*;
- The other firms (about 59%) answer that they did not engage into an innovation project.

These figures suggests that firms which start an innovation activity have an extremely high probability to succeed. How to explain such a high success rate? Self selection may be an answer. Indeed, some firms expect to be faced to very high obstacles that they would not be able to overcome. Thus, they do not even try to engage into an innovation project and they declare to belong to the third group. Nevertheless, it can be argued that this group also contains firms which do not need to innovate.

This paper suggests that, in order to obtain correct estimates of the impact of obstacles on innovation, the group of firms not engaged into an innovative project should be splitted in two sub-groups:

- the group of firms which do not try to innovate because they are discouraged by the existence of obstacles;
- the group of firms which do not want to innovate, because they do not need to do so.

In the first group, there is probably a negative correlation between innovation and the expected obstacles. On the contrary, in the second sub-group, firms are not faced to any obstacles, just because they do not try to innovate. Consequently, the absence of innovation and the absence of declared obstacles are positively correlated, in a statistical sense. When the two groups' firms are blended, it is not surprising to obtain a positive estimate of the effect of declared obstacles on the probability to innovate, depending on the sample's composition.

The consequent endogeneity of the variables measuring the obstacles to innovation for firms trying to innovate is thus a relevant feature which should be taken into account as emphasized by Savignac (2008).

Concerning the estimation of the innovation function, the two sub-groups must be treated differently. The *discouraged* firms have to be included in the sample for estimation, but not the *non willing* ones. The aim of this paper is then to build a more appropriate sample of firms, for which innovation (and thus obstacles to innovation) is a concern. This population is called the *willing to innovate* firms, the second being the *non-willing to innovate* ones.

In order to check whether our basic assumption on the existence of *willing* versus *non-willing* firms is correct, one may try to identify some theoretical arguments. The related literature does not provide a lot of information about the firms which would not want to innovate. First, some theoretical models (Jovanovic, and Mac Donald, 1994) assume that several firms strategies may coexist in an industry: some firms have interest (and capacities) to innovate, some other to imitate, with different lags based upon traditional products and/or processes. The first ones are identified as *innovators*, the others being *imitators* or *laggards*.

Secondly, even if a positive relationship between quality of goods and innovation is generally assumed (Galia, and Pekovic, 2008), some products (or varieties of products) are in the opposite situation. In such cases, innovation is not necessary for a firm to be competitive, or would even be rejected by the market. Two kinds of goods are concerned: low-cost and *vintage* goods. In the first case, the firm is facing to a demand driven by price without possibility of substitution with a higher technological variety of the same product. Minimizing production cost is the only efficient strategy. The same situation occurs when considering products for which tradition is part of the image and characteristics of goods.

These arguments could suggest that there exist a strong heterogeneity across firms within a given industry in terms of innovation and they could be coherent with our

hypothesis. Nevertheless, they provide few empirical guidelines in order to identify the groups of willing *versus* non willing firms. Then, we adopt a data oriented strategy based on the French CIS4 survey in order to classify firms into the above mentioned groups. We are able to define three sets of willing to innovate firms: each one relies on a more or less broad definition the will to innovate. About one third of the whole sample of firms is found to be not concerned by innovation and should be excluded from the sample in order to estimate the innovation function .

On this basis, the innovation propensity model is estimated successively on the different sub-samples of firms. While the estimation on the full sample of firms provide a positive and significant effect of obstacles on the likelihood to introduce an innovation, the estimation on the sub-samples of willing to innovate firms produces more satisfactory results. When considering the only population of firms which aim at innovating, the *Obstacles* coefficient is significant and negative when using the narrow definition of will to innovate. Moreover, the other parameters's estimates as that associated to the membership to a group or those of size or R&D are coherent with previous studies and are robust across the different specifications. These results thus suggest that introducing a distinction between firms which will to innovate and firms which do not, is a useful modelisation strategy in order to measure the *true* effects of the obstacles on the propensity to innovate.

The rest of paper is organized as follows. Section 2 presents some theoretical and empirical justifications of the central assumption. Section 3 exposes CIS4 data and the way it is used in order to build the firms populations. In section 4 are presented the estimation results of a classical innovation propensity model. Section 5 concludes.

## **2 INNOVATION: TO WANT OR NOT TO WANT?**

According to the introduction, a firm:

- may be faced to obstacles but nevertheless innovate;
- may be faced to obstacles and, because of that, fail to innovate;
- may be discouraged of trying to innovate just because of obstacles;
- may simply not meet any obstacle, just because it does not want to innovate.

The first two cases seem well-accepted and frequently studied in the literature. The success in innovation is not certain even when a firm firmly wants to innovate. A large number of studies, including the present one, try to analyze the determinants of success or the causes of failure. But the assumption that some firms are not interested by innovation is very rare in the literature. Nevertheless, non innovating firms are not an empirical exception, but rather the most common situation. Table A2 of the data appendix indicates that less than one firm on three declares to be innovative in wholesale and retail trade, while the part of innovative firms is up than 50 % in the manufacturing. Then, assuming that all firms has the same need (and

consequently the same will) to innovate, whatever the industry, the only difference being between firms which succeed and firms which do not, would mean that hotels and restaurants are just more than twice times ineffective in terms of innovation than manufacturing firms. But, in this case, why some potential innovative entrepreneurs would not enter in industries with poorly innovative incumbents, in order to capture innovation rents? Clearly, the only plausible assumption is that innovation has not the same importance, according to the industry which is considered. In some sectors, the survival of about any firm is conditioned by innovation, while in others, a (possibly large) number of firms can survive, and even grow, without innovating. However, this assumption is rarely considered in the academic literature, particularly within theoretical studies: to our knowledge, there is no model explicitly including this non-innovating strategy. As a first trial in this study, two directions may be explored in order to find some analytical frameworks, which would not be consistent with the assumption underlying this study: one considers the *within-industry heterogeneity* and the other the *characteristics of products* .

## 2.1 The heterogenous industry model

Some studies suggests the existence of different kinds of innovation strategies, corresponding to different kinds of firms, namely *Innovators*, *Imitators* and *Laggards*. A theoretical model can explain this differentiation of firms in terms of innovation strategies. A central reference is the paper by Jovanovic, and Mc Donald, (1994) and a recent application is provided by Ceccagnoli (2005). It starts from an empirical statement: heterogeneity exists not only between industries, but between firms, within a given industry. This is true as well in terms of innovation outputs (as shown by table 2 of our appendix) as in terms of innovation inputs, as reported among other studies by Cohen, and Klepper, (1992), in the particular case of R&D activities: in each industry, reported R&D is zero for a significant (from 5 to more than 50 %) part of firms. Thus heterogeneity exists and leads to the existence of a large number of 'non effective' firms, in terms of innovation. Moreover, this is a time-persistent phenomenon. Some firms survive (and even grow) during several periods, without innovating and even without trying to do so. Within an industry, firms may innovate (being then leaders) or imitate (being then laggards). The different strategies lead to the increase of the firm's technological level. The choice between both is determined by the incentives and constraints which the firm is facing. Both strategies are interdependent. Because of the existence of such an heterogeneity within industry, innovators reduce their costs, while they allow some other firms to benefit from their knowledge. Thus, this heterogeneity drive innovation and output growth within an industry.

Let us consider a given industry with the associated technology adoption curve (a survey about technology adoption can be found in Geroski (2000)). At the first period, some firms produce their own knowledge in order to implement the first production

technology  $\theta_1$ . These *innovators* are the only entrants. At the second period, some firms (may be the same, may be new entrants) still innovate by implementing a more advanced technology  $\theta_2 > \theta_1$ . A fraction of the previous innovators does not innovate again during this period and just maintain the use of the first technology. Another part of new entrants acquired the first technology  $\theta_1$  (may be by buying it, may be by spillover effect). Those firms are *imitators* by choice or just *unsuccessful innovators*. By iteration, at period  $T$ , different technologies coexist: only one,  $\theta_T$ , corresponds to the implementation of innovation. The firms who implement such a technology are real innovators, the rest being imitators, more or less distant from the technology frontier. Different populations of imitators can exist, using respectively technology  $\theta_{T-1}, \theta_{T-2}, \dots, \theta_1$ , being respectively early imitators or *laggards*. As assumed by Dong and Saha (1997), the question is not only '*wether and how much to adopt*' but equally '*when to adopt*'. It may imply that, at a given time, a significant part of firms is not concerned by innovation, nor by imitation, just because time is not yet arrived.

This is an important point for our distinction between firms which aim at innovating and those which do not. The simplest scheme would be to assume that at each period, willing firms are innovators while non-willing are imitators, whatever imitation delay is considered. But two problems then arise. The first one concerns the possibility of failure in the attempt to innovate: how can one represent firms which try to innovate and then are not imitators but innovators, but which do not succeed? A possible answer is that a share of imitators at period  $T$ , using technology  $\theta_{T-1}, \theta_{T-2}, \dots, \theta_1$  (presumably the most recent ones, say  $\theta_{T-1}$  or  $\theta_{T-2}$ ) are innovators which have tried but not succeed in implementing technology  $\theta_T$ . It is important to distinguish between the two cases, according to our assumption: the first ones (unsuccessful innovators) are willing firms, while the second (imitators) are non-willing firms. A good way to identify the unsuccessful innovators, would be to consider the case of firms that have innovated during previous period. Then, non willing firms will be identified as being firms which never try (at any period) to innovate, but are early imitator or laggard<sup>1</sup>.

## 2.2 Innovation and the product quality: innovant, standardized and vintage goods

This part may be considered as an illustration of the previous one, introducing the characteristics of products. Some different varieties of products exist in an industry, and the innovation strategy differs according to the variety which is produced by the firm.

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<sup>1</sup>An other direction is suggested by Sadowski, and Sadowski-Rasters, (2006), who use the CIS4 questionnaire and consider that:

- Innovators are firms who introduce product/process *new for the market* ;
- Imitators are firms who introduce product/process *new for the firm but not for the market*.

A positive relationship is generally assumed (and sometimes found) between innovation and quality (Galia, and Pekovic, 2008). Some empirical tests are provided with very clear results, often issued from the business and management literature: Prajogo, and Sohal, (2001) found a positive relationship between quality in management and innovation, while Middleton et al. (2006), comparing Military Equipment Industries in 10 countries observed from 1971 to 2005, show that R&D and innovation improves the quality of products. More generally, the improvement of quality and innovation are considered as deeply linked, or even as synonymous, being the subject of what is called the *Economics of new goods* (Bresnahan, and Gordon, 1997)<sup>2</sup>.

But some exceptions exist. In some particular industries, or product varieties, in the Lancasterian sense (Thisse, and Norman, 1994), innovation and quality may be considered as contradictory. A first example arises for firms producing and selling very standardized goods for which consumer demand is stable one and there is limited possibility of substitution with other varieties of the same good, including more technology.

These firms have to produce such standardized goods using hard-proven processes, at the lowest possible cost. Innovation is not necessary in this case and may even be an obstacle as regards the cost minimization strategy. In this situation the incentive to innovate is very limited. Some examples can be observed within different industries, as food industries, textile and clothing or even in the automobile industry, where more and more low-cost models are proposed. Some intermediate goods, as some construction materials or basic varieties of steel, also constitute examples of such low-cost goods. However it is worth to keep in mind the existence of competition with low-wages countries, which is an obstacle to this strategy. This could explain why industries with less foreign competition are often those which are the less innovative.

Low-cost products are not the only case where innovation is not required, or not even welcome. Some other varieties of goods, that could be called *vintage* goods are in the same situation. An interesting case study would be brewery in Germany. According to the Germans brewers the way to produce what is authorized to be called (and sold as) *beer* in Germany, is based upon the *Reinheitsgebot*, a set of production rules edited by Wilhelm IV, Duke of Bavaria, in 1516...Any product that would not satisfy this 'purity act' would not be considered and then, not sold as beer<sup>3</sup>...In such a case, innovation is not simply unnecessary but forbidden. To innovate would mean changing not only the quality, but the nature of the product, in a process where the protection of health and tradition is closely mixed with the protection of a national industry. Several other examples can be found, especially in traditional consumers goods industries, where some firms have built such a *vintage* image, concerning a

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<sup>2</sup>Such an analytical framework is even one of the reason why it is so difficult to find studies which would just conceive the absence of innovation as a possible active strategy of the firm (i.e. not due to some constraints or failures).

<sup>3</sup>To our knowledge this rule has been rejected after 1993, but some other cases may be found in which products have to respect some (traditional) rules, in order to obtain labels.

variety of product, often luxurious ones : *Haute Couture* as well as wooden yachts...

## 3 DATA AND THE CLASSIFICATION OF FIRMS

### 3.1 The CIS4 survey

This study makes on the use of the data from the fourth French *Community Innovation Survey*(CIS4). The CIS is a harmonized survey conducted in EU members by the national statistical agencies and coordinated by Eurostat. CIS4 has been conducted in 2005 and firms from all industries are questioned about their innovation activity during the three calendar years 2002-2004 period. In France, about 25 000 firms of ten employees and more have been surveyed, with a answering rate of 86 %. After preparing and cleaning the dataset (see Appendix A for details), 19214 firms are considered in this study.

The structure of the questionnaire has to be carefully examined. Part 1 provides general information about the firm: size, affiliation to a corporate group, geographic level of the firm market (regional, national, European, world). As shown in table A3, most part of firms have a small size: about 79% have less than 250 employees. All industries are concerned: about 36 % of firms are located in manufacturing, 7 % in construction, 24 % in commerce, hotels and restaurants and around 30% in services. More than half of the firms are affiliated to a group. A majority of the firm population operates in a local (33%) or national (24%) market, while less than 15% (resp. 28%), operate in a European (resp. world) market.

Parts 2 to 3 concerns the outputs of innovation, with two similar sets of questions, the first one being related to product innovation, the second one to process innovation. The main question is '*During the three-years period 2002-2004, did your enterprise introduce new or significantly improved goods (processes)?*' with a possible binary (yes/no) answer. In this study, a firm is considered to have innovated when having responding *yes* to at least one of the questions related to product innovation, or process innovation<sup>4</sup>. By this 7726 firms are reputed to be innovative, which represent 40.2% of all the firms. Table A2 reports that the propensity to innovate significantly varies over the industries. Manufacturing firms are the most often innovative, but some services, as Financial Intermediation, exhibit the same rate which is found to be up than 50%. This share falls down under 40% for real estate, Electricity, gas and water and transports. The less innovative industries are Construction, wholesale & retail trade, and hotels and restaurants, being under 30%. Obviously, the level of

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<sup>4</sup>The sense of innovation is thus a technological one, while the answers to organizational or marketing innovations, presented further in the questionnaire (questions 10-1 o 10-3), have not been used in this study.

innovation rate does not oppose manufacturing to services, but different industries within both.

The strict definition of innovation can be enlarged thanks to question 4: 228 firms declare to have engaged one '*Ongoing or abandoned innovation activities*'. Table A3 provides some statistics related to the 7726 innovative firms, first, then to this population completed by the 228 firms which have ongoing or abandoned projects. Firms are classified according to their size class. It is worth to note that size is correlated with innovation: the larger the class of size, the higher the share of innovative firms. But some other variables are also correlated with the size, as the membership to a group or the market geographical level. This may lead to very careful interpretation when considering what could be the pure effect of size on the innovation propensity.

Then, the following questions (5 to 6) are devoted to the sources of innovation, particularly to internal R&D, external R&D and the acquisition of other external knowledge (embodied through equipment, software or others). All these variables are both measured in a qualitative dichotomous way (*yes/no*) and in a quantitative one (the amount of expenditure devoted to the knowledge acquisition). The CIS4 questionnaire is filtered: only the firms that have responded positively to one of questions 2 to 4 have to answer to questions 5 to 8.1. This corresponds to the sum of innovative firms (*yes* to question 3 and/or 4) and firms that declare to have engaged an ongoing or abandoned project (*yes* to question 4). Within this population, for which the amount of R&D is really observed, 60.75% declare a positive amount of R&D. This amount does not vary significantly inside of this population between firms which success (60.85% of firms use a positive amount of R&D) and those which fail (57.01%).

Part 8 of the questionnaire is related to the obstacles to innovation. This part will be carefully examined in the next section because it provides tools which permit to build the classification of firms according to their willingness to innovate.

### **3.2 A classification of firms using CIS4**

This section aims at providing an empirical implementation of the distinction between *willing* and *non willing* (to innovate) firms, by using the CIS4 survey. Unfortunately, there is no direct question about the will to innovate in the questionnaire. Then some indirect measurement must be deduced from the answers to other questions which are available in the CIS4 questionnaire.

First, relevant information is issued from the parts 2 to 4 of the questionnaire. A firm is considered to have implemented one innovation when having responding *yes* to at least one of the questions related to product innovation, or process innovation. Some other firms declare to have abandoned or yet unfinished innovation projects.

It seems quite plausible to assume that firms who have implemented innovation or at least have tried to do it, actually will to innovate. By this, the 7954 firms which have declared to innovate or, at least, to be engaged in an ongoing or abandoned innovation project, can be considered as part of the willing population.

What about the other 11260 firms? One may consider the question 8.2 about *obstacles to innovation*, and first the last item of it, devoted to the reasons why *it has not been necessary to innovate*. Two reasons are suggested: *No need due to prior innovations* and *No need due to market conditions*. The first item cannot be easily used in order to define non willing firms. If a firm answers positively to this question, it means that it has innovated before and, thus, it would be inconsistent to consider that it is a non willing firm, for two reasons. The first one is suggested by the heterogeneity model of subsection 2.3. The second reason is the existence of empirical findings about the persistence of innovation (Raymond et al., 2006, Cefis, and Orsenigo, 2001). Such reasons suggests that the positive answer to this question cannot be used as a consistent criterion for considering that a firm does not want to innovate. The case is different with the second item of question 8.2: it can be assumed that a firm which answers positively (at a certain degree) to the question about market conditions can be excluded from the population of willing firms: if a firm has no need due to market conditions to innovate, it has no major reason to do it. Moreover the other questions related to barriers to innovation may be considered. It is proposed in this study to assume that a firm which does not encounter any barrier to innovation, but even so do not innovate, is a firm which does not want to innovate.

The task is now to implement these mutually non exclusive criteria using the structure of the CIS questionnaire. The answers to barriers questions are graduated along four items: *Factor not experienced (0)*, *Low (1)*, *Medium (2)* and *High (3)*. Clearly, once is defined the general principle, one has to determine the degree to which to apply the selection rule. Three different definitions of willing firms are then proposed, corresponding to different intensity degrees in the response to the question 8.2 about obstacles to innovation:

- in the *broad* definition of willing firms (i.e. a *strict* definition of non-willing firm) all the answers to barriers to innovation are *High*, *Medium* or *Low*. 12506 firms are then concerned.

- in the *medium* definition of willing firms all the answers to barriers to innovation are *High* or *Medium* 11547 firms are then concerned;

- in the *narrow* definition of willing firms, which concern 10334 units, all the answers to barriers to innovation are *High*.

Some elementary statistics using the different classifications are provided in table A4 of the Data Appendix. First, even when using a large definition of willingness to innovate, 34.91 % of the firms are now excluded, as non-willing firms. Secondly, willing firms are larger, more often belong to a corporate group and operate on larger

geographical markets than non-willing. Finally, willing and non-willing firms are quite similar in terms of performance ratios, as Sales/Employee, or the growth average rate of sales. The economic characteristics of the two populations differ but there is no apparent performance gap due to the lack of innovation, at least when using the very rare performance indicators provided by CIS4. This is not incoherent with the assumption that some firms may survive and even grow without innovating.

## 4 ESTIMATION RESULTS

In order to assess the impact of obstacles on innovation, the following model is estimated:

$$P(\text{Innovation} = 1) = f(\text{Inputs}, \text{Characteristics}, \text{Obstacles})$$

where the propensity to innovate of the firm depends on:

- the inputs of innovation, in this case the internal R&D expenditures;
- the characteristics of the firm (its size) or of its environment (industry location and the affiliation to a group);
- some variables measuring the different obstacles that the firm declares to be faced to.:

The variables are built by using CIS4 data, as reported in Appendix A and some related statistics are presented in table A5. The estimation method of this model has to take into account the particular structure of the CIS4 data set. The CIS4 questionnaire is filtered: only the firms that have innovated or tried to innovate have to answer to questions 5 to 8.1, about the sources and means of innovation. Thus the inputs of innovation are not observed for all firms. A second problem concerns the R&D variable which is a zero left censored one. According to this, the *Tobit2* method proposed by Griffith, et al. (2006) is used. Finally, a last econometric difficulty concerns the variable *Obstacles* that may be endogenous. For this reason, the correction suggested by Rivers, and Vuong, (1988) is implemented: first, the variable *Obstacles* is regressed on the other explanatory variables, and secondly both *Obstacles* and the estimated residual of this regression are included in the main equation, as additional explanatory variables.

Estimations results are reported in table 1. The estimation is successively performed on each population of firms, as defined in section 3. The first column concerns the whole population, without any selection. As sometimes in the literature, the estimate for the *Obstacles* coefficient is positive and significant: the higher the barriers to innovation, the higher the innovation propensity. This is clearly not a satisfying result. Other variables exhibit the usual and expected results: innovation is positively linked to the size of firm (without any apparent turning point), to the membership of a group and to the amount of internal R&D spent by the firm. At the other end

of the population range, column 5 reports the estimation results on the 7 954 firms which 'self-declared' to be (or to try to be) innovative. These results are weak: there is no significant explanatory variables estimates. This is clearly due to the too small variability of the dependent variable (7726, i.e. 97.1% of firms, have innovated in this population). The lesson of these two polar cases is clear: it is inconsistent to consider that all the firms are concerned by innovation as well as to take into account the only firms which self declare to be concerned by innovation.

One may turn now on the estimations on the different populations of *willing to innovate* firms (columns 2 to 4 of table 1). As proposed in part 3, several embodied definitions are used, going from the narrow definition of willingness to innovate (which define a population composed of 10334 units) to a broader one (defining a population of 12506 firms), with an intermediate *medium* situation (concerning 11547 firms). The coefficient associated to the variables *Obstacles* remains significantly positive in the case of the broad *willing* population. It becomes non significant in the medium case, then negative and significant in the narrow population case. Indeed, it is worth to note that the results concerning the other variables do not vary over populations and conserve the right expected form. Innovation inputs (intramural R&D expenditures in this case) play a positive role on the innovation propensity. There also appears a positive relationship between innovation and firm size, and no turning point appears along the different size classes. The firms which are part of a group are more innovative and finally, industry location significantly matters. All these results are consistent with what is found in the literature.

These results suggest that the introduction of the distinction between *willing* and *non willing* to innovate firms has an effect on the significancy level and sign of the estimates, and, by the end, leads to more credible and satisfactory results. The case of *Obstacles* is particularly clear: the more restrictive the definition of willingness to innovate, the more coherent the estimated (negative) effect of the variable. The use of this narrow population also conducts to the higher number of concordant predictions (77.2 % versus 58.4 to 74.7% when considering other populations). Consequently, both the analytical assumption and its empirical implementation using CIS4 survey, does not seem to be inconherent.

## 5 CONCLUSION

The estimation of innovation propensity models may offer sometimes some unexpected results. This is particularly the case when introducing some variables measuring the effect of barriers to innovation. To obtain some positive estimates of this coefficient would mean that the higher the barriers the higher the probability to innovate, which is clearly a disturbing result. This study suggests a new approach

based upon a preliminary selection of firms. Some firms will to innovate, some others do not. The second ones, which represent a significant part of the population, have to be excluded from the estimation sample. CIS4 survey provides not only some measurements of the model variables (both outputs and inputs of innovation and characteristics of firms and their environment). It also contains useful information which permit to build a classification of firms according to their degree of willingness to innovate and then to implement the previous assumption. Thus, several populations are composed, according to the degree of intensity in will to innovate. After this, the innovation propensity model is estimated on the different populations of firms and the results are compared.

While the estimation on the entire population provides positive effect of obstacles on the propensity to innovate, the estimation on the sub-sample of willing to innovate firms leads to more satisfying results. Particularly, in the case of the narrow definition of willing populations, the coefficient of the *Obstacles* variable becomes significantly negative, while the other variables estimates conserve the usual aspect: a positive relationship between innovation and the R&D expenses level, the size of the firm and the membership to a group. This suggests that the distinction between willing and non willing to innovate firms is relevant for the obtention of satisfying results, when regressing the innovation propensity on both obstacles and inputs of innovation.

There will be two next steps in this research agenda. The first one is to build a theoretical model which provides a more structural framework to the central assumption. The model based on the distinction between innovators, imitators and laggards may provide the best analytical framework. The second point is to improve the classification method which leads to the distinction between the willing and non-willing firms. This could be made by the addition of data issued from other surveys than CIS4.

#### *Acknowledgements*

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## A APPENDIX: THE DATA

Initially 20672 firms are present in the French CIS4 database . Some observations are deleted according to the following criteria:

1. to drop any observations (1176) for which the average annual growth rate between 2002 and 2004 in sales by employee was more than 200 percent and less than -60% or missing.
2. to remove all observations (58) for which the ratios intramural R&D/sales and acquisition of R&D/sales were missing or greater than 1.
3. to drop any observations (18) for which the answers about geographic markets (Q1.2) and barriers to innovation (Q8.2) were missing.
4. to remove all the firms (200) belonging to the industry "Research and Development" (Nace 73).
5. Finally, 6 observations, for which the ratio Intramural R&D (multiplied by 1000) on the mean number of employee (2002-2004) and the ratio Extramural R&D (multiplied by 1000) on the mean number of employee (2002-2004) were greater than zero and least then one, are dropped.

All this led us to keep 19914 firms, for which are defined the following variables of table A1.

Table A1 presents the variables and the way they are built. Some elementary statistics are then introduced, with a distinction by industry (Table A2) and by class of size (Table A3).

*(Table A1 about here)*

*(Table A2 about here)*

*(Table A3 about here)*

According to the rules exposed in part 3.2, a distinction is made between firms which will to innovate and those which do not. Some comparisons between those two populations are presented in Table A4 and Table A5.

*(Table A4 about here)*

By the end, Table A5 introduces the variables which are used in the econometric specifications, i.e.:

- $\log\left(\frac{IntRD}{L}\right)$  = log of intramural R&D divided by average number of employees.

- $\text{Obstacles} = \text{Barrier1} + \text{Barrier2} + \text{Barrier3} + \text{Barrier4} + \text{Barrier5} + \text{Barrier6} + \text{Barrier7} + \text{Barrier8} + \text{Barrier9}$ .
- $\text{Size1}$  to  $\text{Size10}$  are dummy variables equals to 1 if the firm has a size belonging to the decile  $i=1, \dots, 10$ , 0 otherwise.
- $\text{dregion1}, \dots, \text{dregion26}$  are dummy variables equals to 1 if the firm is located in region  $i=1, \dots, 26$ , 0 otherwise.
- $\text{dind1}, \dots, \text{dind49}$  are dummy variables equals to 1 if the firm belongs to the industry defined by its Nace code on two digits, 0 otherwise.
- $\text{dmarloc} = 1$  if  $\text{marloc} = 1 \ \& \ \text{marnat} = 0 \ \& \ \text{mareur} = 0 \ \& \ \text{marwor} = 0$ , 0 otherwise  
 $\text{dmarnat} = 1$  if  $\text{marloc} = 0 \ \& \ \text{marnat} = 1 \ \& \ \text{mareur} = 0 \ \& \ \text{marwor} = 0$ , 0 otherwise  
 $\text{dmareur} = 1$  if  $\text{marloc} = 0 \ \& \ \text{marnat} = 0 \ \& \ \text{mareur} = 1 \ \& \ \text{marwor} = 0$ , 0 otherwise  
 $\text{dmarwor} = 1$  if  $\text{marloc} = 0 \ \& \ \text{marnat} = 0 \ \& \ \text{mareur} = 0 \ \& \ \text{marwor} = 1$ , 0 otherwise

TABLE A1: Variables Definition

Variable name	CIS4 question	Definition
Innoprod	2.1	introduc of new/significantly improved good/service (1/0)
Innoproc	3.1	introduc of new/significantly improved process (1/0)
Innotry	4.1	innovation activities abandoned or ongoing (1/0)
Group	1.1	Does the enterprise is part of an enterprise group (1/0)
Int.RD	5.2.a	Intramural R&D (in KEuros)
L	Other survey	Mean of total number of employees in 2002 and 2004
Marloc	1.2.a	Local/regional market within France (1/0)
Marnat	1.2.b	France market (1/0)
Mareur	1.2.c	Other Europe (1/0)
Marwor	1.2.d	All other countries (1/0)
Industry	Other survey	Nace code (two digits, Rev. 1.1).
Region	Other survey	NUTS 2 code
Barriers to Innovation <sup>5</sup>	8.2.a	availability of internal finance
	8.2.b	availability of external finance
	8.2.c	Innovation costs too high
	8.2.d	lack of qualified personal
	8.2.e	lack of information on technology
	8.2.f	lack of information on markets
	8.2.g	difficulty to find partner for innovation
	8.2.h	market dominated by established enterprises
	8.2.i	uncertain demand for innovative goods or service
	8.2.j	no need to prior innovations
	8.2.k	no need due to no demand for innovations

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<sup>5</sup>For each barriers, noted barrier1 to barrier11, the answer may be High (3), Medium (2), Low (1), Not experienced.(0)

TABLE A2 Distribution by industry (NACE Rev. 1.1) of firms

Industry	Nb. of firms	Sector Share	Nb. of innov. firms	% innov. among all firms
Mining and quarrying	141	0.73	44	31.21
Manufacturing	6970	36.28	3827	54.91
Electricity, gas and water	149	0.78	58	38.93
Construction	1329	6.92	363	27.31
Wholesale and retail trade	3897	20.28	1159	29.74
Hotels and restaurants	677	3.52	166	24.52
Transport, storage and comm.	1650	8.59	518	31.39
Financial intermediation	585	3.04	328	56.07
Real estate, renting act.	3627	18.88	1401	38.63
Education	1	0.01	1	100.00
Health and social work	2	0.01	2	100.00
Other service activities.	186	0.97	87	46.77
All	19214	100.00	7954	41.40

TABLE A3 Summary statistics on all firms by size

	Less 20	20-49	50-249	>=250	All
Nb. of firms	3169	6167	5830	4048	19214
% of firms	16.49	32.09	30.33	21.07	100.00
Nb. of employees (L)	15.43	33.73	112.67	1085.94	276.34
% innovative firms (large sense)	27.86	31.04	43.70	64.45	41.40
% innovative firms (strict sense)	26.70	30.10	42.14	63.41	40.21
Sales/employees	238.21	253.30	224.28	255.38	242.44
Part of a group (in %)	25.97	40.88	64.61	86.41	55.21
Local market (in %)	46.80	39.19	29.64	17.64	33.01
National market (in %)	23.54	24.49	24.24	23.91	24.13
European Market (in %)	11.77	14.33	16.16	14.60	14.52
World Market (in %)	17.89	21.99	29.97	43.85	28.34
Average rate of growth (04/02) of Sales/L	5.90	9.15	9.25	11.29	9.10

TABLE A4: Summary statistics on all firms, willing and non-willing

	Non Willing	Willing Broad	Willing Medium	Willing Narrow	Innovating	All
Nb. of firms	6708	12506	11547	10334	7954	19214
% of firms	34.91	65.09	60.10	53.78	41.40	100.00
Nb. of employees (L)	146.18	346.16	363.39	391.29	475.21	276.34
Sales/employees	238.41	244.61	245.55	243.41	265.61	242.44
Part of a group (in %)	48.48	58.83	59.89	61.57	68.18	55.21
Local market (in %)	45.62	26.24	24.34	21.87	15.53	33.01
National market (in %)	25.43	23.44	23.37	23.27	22.78	24.13
European Market (in %)	12.27	15.73	16.18	16.54	17.26	14.52
World Market (in %)	16.68	34.59	36.10	38.32	44.43	28.34
Average rate of growth (04/02) of Sales/L	9.24	9.02	9.11	9.18	9.68	9.10

TABLE A5: Summary statistics on all firms, including the regression variables

	Innovating	non innovating	All
Nb. of Firms	7954	11260	19214
%(RD>0)	60.75	na	na
% Innov.	97.13	0	40.21
% Part of a Group	68.18	46.06	55.21
% Local Market	15.53	45.36	33.01
% National market	22.78	25.09	24.13
% European Market	17.26	12.58	14.52
% World Market	44.43	16.97	28.34
	$\bar{x}$ $\sigma$	$\bar{x}$ $\sigma$	$\bar{x}$ $\sigma$
Int. RD / L (in logs) $x$ and	0.25 1.94	na na	na na
Labour Productivity (in logs)	5.06 0.89	4.83 0.93	4.92 0.92
Average growth rate of sales / L	9.67 28.18	8.68 29.36	9.09 28.88

TABLE 1: Innovation Function Estimates

Variable	all	firms willing to innovate			firms engaged
	firms	broad def.	medium def.	narrow def.	into innovation
N	19214	12506	11547	10334	7954
Intercept	-3.493*** (0.075)	-2.945*** (0.102)	-2.626*** (0.119)	-1.342*** (0.174)	1.954*** (0.300)
Int.RD/L	0.363*** (0.012)	0.333*** (0.015)	0.347*** (0.015)	0.333*** (0.016)	-0.008ns (0.037)
Obst.	0.289*** (0.044)	0.249*** (0.055)	0.021ns (0.058)	-0.475*** (0.070)	-0.113ns (0.129)
Resid_obst.	-0.208* (0.044)	-0.215*** (0.056)	-0.054ns (0.058)	0.294** (0.070)	0.065ns (0.130)
Group	0.186*** (0.025)	0.248*** (0.031)	0.196*** (0.034)	0.084** (0.040)	0.022ns (0.078)
Size2	0.329*** (0.046)	0.364*** (0.055)	0.380*** (0.058)	0.303*** (0.065)	0.071ns (0.143)
Size3	0.345*** (0.046)	0.432*** (0.055)	0.460*** (0.058)	0.342*** (0.065)	0.162ns (0.151)
Size4	0.450*** (0.047)	0.469*** (0.056)	0.496*** (0.058)	0.407*** (0.066)	0.154ns (0.149)
Size5	0.573*** (0.046)	0.646*** (0.056)	0.662*** (0.059)	0.532*** (0.070)	0.073ns (0.145)
Size6	0.738*** (0.047)	0.778*** (0.057)	0.803*** (0.059)	0.659*** (0.070)	0.020ns (0.142)
Size7	0.839*** (0.047)	0.928*** (0.057)	0.961*** (0.060)	0.732*** (0.072)	-0.008ns (0.138)
Size8	1.067*** (0.048)	1.118*** (0.058)	1.156*** (0.062)	0.862*** (0.076)	0.108ns (0.147)
Size9	1.200*** (0.048)	1.266*** (0.060)	1.279*** (0.064)	0.992*** (0.081)	0.265* (0.151)
Size10	1.483*** (0.050)	1.616*** (0.065)	1.584*** (0.071)	1.156*** (0.092)	0.374ns (0.158)
-2Log L.	25896.9	16636.4	14660.5	11675.9	2069.2
%conc.	74.7	74.3	74.2	77.2	58.4

Standard Errors between brackets.

\*\*\*, \*\*, \*: significant at the 1%, 5%, 10% level

ns: non significant