The Determinants of the Continuity and Consistency of the Innovative Behaviour of Product and Process Innovators

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Summary:

Using qualitative firm level data about the French manufacturing industries on two periods of time (1985-90 and 1990-1992) this study tries to check whether we can establish an empirical distinction between the different technological dynamics/trajectories associated with product, process and product & process innovations. These dynamics will be measured *continuity*" (innovativeness of the technological trajectory) and the "*consistency*" (specificity of the technological trajectory) of the innovative behaviour between 1985-90 and 1990-1992. We test the impact of a number of explanatory variables on the probability of "*continuity*" and on the probability of "*consistency*" of the innovative behaviour between 1985-90 and 1990-1992 while controlling for the initial type of innovation in 1985-90.
We obtain interesting results:

- The "continuity" of the innovative behaviour differs widely according to the initial type of innovation: highest continuity for product & process innovators, lowest for process innovators. Whatever the initial type of innovation, the probability of continuity is positively and significantly influenced by a number of factors. However, other factors are specific to each sub-population of innovator. They show that despite general patterns, different technological dynamics may be at work depending on the initial type of innovation.
- Concerning the "consistency" of the innovative behaviour, we surprisingly obtain a similar rate of consistency (53-54%) for each type of innovator. However, after computation of a logit model, we have obtained heterogeneous estimated coefficients for each sub-population. Despite homogenous aggregate results, in each sub-population, the consistency of the innovative behaviour does not seem to be explained by the same explanatory variables.

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I Theoretical motivations

Usually, the distinction between product and process innovation is done by reference to their different economic consequences. Product innovation is supposed to provide a monopoly power and to enhance firms' sales whereas process innovation would decrease unit costs. Using this distinction as a starting point, current theoretical and empirical models try to identify key factors determining a higher valuation of product innovation (i.e. of the sale-increasing strategy) in comparison to process innovation (i.e. of the cost-reducing strategy) (Gomulka, [1990], Athey, Schmutzler, [1994], Cohen, Klepper, [1996], Bonano, Haworth, [1998], Yin and Zuscovitch, [1998]).

Contrasting with this allocative view, Klepper, [1996] has developed a model of product and process innovations over the product life cycle in which the probability of product and process innovations do not only depend on the trade-off between sale-enhancing *versus* cost-reducing strategies but also on specificity associated with product and process innovations. More specifically, in this model the probability of product innovation is a function of firms' initial *"distinctive capabilities"*. *"In contrast, process innovations tend to be incremental and based on information that firms commonly generate through production"* (P.565).

These contrasting hypothesis for product and process innovations can be viewed as an implicit assumptions about the learning processes driving firms to product innovations or to process innovations. In a temporal perspective, the distinct learning processes associated with product and process innovations would result in different micro-economic technological dynamics/trajectories for product, process, product & process innovators.

Using qualitative firm level data about the French manufacturing industries on two periods of time (1985-90 and 1990-1992) we will try to check whether we can establish an empirical distinction between the different technological dynamics/trajectories associated with product, process and product & process innovations. These dynamics will be measured using two simple indicators that are the "*continuity*" and the "*consistency*" of the innovative behaviour between 1985-90 and 1990-1992. We will also test the impact of a number of explanatory variables on the probability of "*continuity*" and on the probability of "*consistency*" between 1985-90 and 1990-1992 while controlling for the initial type of innovation in 1985-90.

In a first methodological section, we will describe the data base, discuss its limitations and explain the empirical procedure that will be implemented. In a second section, we will present and comment the results.

II Methods

In a first point we describe the data base that will be used to carry out the empirical analysis. It opens up interesting opportunities of work but it imposes also important constraints that will be discussed in a second point.
In a last point we present the empirical strategy that will be implemented:

1- definition of 3 sub-population according to their initial type of innovation in 1985-90,
2- comparison over these tree sub-populations of two indicators (the "*continuity*" and the "*consistency*" of the innovative behaviour),
3- identification of significant explanatory variables that could explain the degree of consistency and continuity of firms.

1 – Data sources

We use three French innovation surveys conducted on two periods (1985-90 and 1990-92).

- The first one was conducted by the SESSI in 1991. It covers a five years period]1985-1990] and was sent to 25,000 firms with more than 20 employees with a sampling rate of 100% for firms with more than 500 employees and 83% for firms with less than 500 employees. For this first survey our analysis uses 10,137 innovating firms distributed as it follows: 2,038 product innovators, 1,855 process innovators, and 6,244 product & process innovators.

- The second survey was carried out in 1993 by the SESSI according to the Oslo manual. It is a CIS survey. It covers a three-year period [1990-1992] and has been sent to 4,500 firms with more than 20 employees. The sampling rate is 100% for firms with more than 1,000 employees, 50% for those with 500 to 1000 employees and 33% for those with less than 500 employees. These firms were sampled from the 1991 innovation survey. For this survey our analysis uses 1,645 innovating firms distributed as follows: 482 product innovators, 355 process innovators, and 808 product & process innovators.

- The third survey deals with the appropriability conditions of innovations. It was conducted in 1993 by the SESSI. It covers a three years period [1990-92] and was directed to firms with more than 50 employees. The sampling rate is 100% for firms with more than 1000 employees, 50% for those with 500 to 1,000 employees and 33% for those with less than 500 employees. Firms in this survey are not necessarily in the CIS survey but are all present in the 1991 survey. This survey is interesting in that it makes a distinction between answers for product innovation and answers for process innovation in the same question. For this survey our analysis uses 997 innovating firms distributed as follows: 317 product innovators, 147 process innovators, and 533 product & process innovators. Results from this survey will only be used at an aggregate level.

Table 1: Summary statistics for each survey

	Number of innovating firms implementing			
Survey	**Product innovation**	**Process innovation**	**Product & process innovation**	**Total number of innovating firms**
1990]1985-1990] >20 employees	2038	1855	6244	10137
Distribution for the 1990 survey	20%	18%	62%	100%
CIS [1990-1992] >20 employees	482	355	808	1645
Distribution for the CIS survey	29%	22%	49%	100%
Appropriability [1990-1992] >50 employees	317	147	533	997
Distribution for the appropriability survey	32%	15%	53%	100%

In addition to these surveys on innovation we use three annual French surveys on firms[1] for 1987, 1990, 1992. The unit of analysis is the firm. They provide us with information about the number of employees, the cash flow, etc. We completed this information with data about the firms' branches of activity for the same periods (1987, 1990, and 1992). In branch surveys, the unit of analysis is the firm in each of the particular branch in which it evolves. It is a means of calculating a diversification index according to the repartition of the cash flow across different branches. It is also possible to compute a specific index of concentration faced by each firm according to its particular diversification profile.

In all cases, estimations are done on the manufacturing industry with the exclusion of the building industry and the food industry.

2 - Opportunities for analysis and limitations of the data base

Opportunities for analysis.

- Surveys have been conducted according to specific sampling procedures so that for each observation (i.e. a French industrial firm with more than 20 employees) the SESSI provided us sampling weights. They have been included in all our computations.
- The first innovation survey (]1985-90]) covers a partly different period of time than the two others ([1990-92]),
- The sampling procedure is such that all firms observed in the second period (1990-92) had previously been sampled in the first survey (1985-90).

All these factors make possible to follow firms on two periods (1985-1990 / 1990-1992) and to explore the determinants of the "continuity" and "consistency" of each of this three innovative behaviour on two periods. The following cross-table can be constructed and studied so as to identify specific "innovative trajectories" between 1985-90 and 1990-92 :

Weighted by cofred: Frequency / Percentage / Row percentage / Col. Percentage

		Type of innovation in 1990-1992				
		No innovation	Product innovation	Process innovation	Product and process innovation	Total
Type of innovation in 1985-1990 (initial type of innovation)	**No Innovation**	7585,20	457,59	657,36	476,94	9177 ,1
		32,47	1,96	2,81	2,04	39 ,28
		82,65	4,99	7,16	5,20	
		53,03	16,10	29,29	12,01	
	Product innovation	1372,90	838,42	147,48	565,58	2924 ,3
		5,88	3,59	0,63	2,42	12 ,52
		46,95	28,67	5,04	19,34	
		9,60	29,50	6,57	14,24	
	Process innovation	1803,90	132,16	576,73	348,48	2861 ,3
		7,72	0,57	2,47	1,49	12 ,25
		63,05	4,62	20,16	12,18	
		12,61	4,65	25,70	8,78	
	Product and process innovation	3543,00	1414,40	862,44	2579,40	8399 ,2
		15,17	6,05	3,69	11,04	35 ,95
		42,18	16,84	10,27	30,71	
		24,77	49,76	38,43	64,97	
	Total	14304 ,9	2842 ,57	2244 ,01	3970 ,42	23362
		61 ,23	12 ,17	9 ,61	17 ,00	100 ,00

*For more details about this table see **appendix 3**.*

[1] These surveys are called EAE. It means « Enquête Annuelle Entreprise » or annual firm survey.

Limitations

Despite the interest of such data we have to face important limitations.

- First, unfortunately non innovative firms were not compelled to answer to all the questions so that they can not be easily compared with innovative firms. As a consequence, we will drop non innovative firms in 1985-90 from our sample so as to restrict the analysis to innovative firms.

- Second, the 1991 survey doesn't exactly use the same definitions for product and process innovations as that are used in CIS and appropriation surveys. However, we can easily find a common classification for product, process, product & process innovators as it is indicated in ***Appendix 1***. As a matter of fact, it is impossible to compare the different proportions of product, process, product & process innovations calculated for each period. We can only estimate probabilities of transitions from one state in the first period to another in the second period.

- Third, when a firm both innovates in product and in process during the same period, it has been classified as product & process innovator. It allows to highlight potential divergent behaviours for product & process innovators and to control for specific size effects. However, when we classify a firm as a product & process innovator, we are not sure that it has really innovated in the same time in product & process or at least that these two types of innovation are connected. As a result we overestimate the real number of product & process innovators.

- Fourth problem is the different length of time covered by the first survey (5 years) and the second one (3 years). It is straightforward that the probability of innovation on a 5 years period is higher than on a 3 years period. So, once again, we can't compare the percentage of innovative firms estimated using these two surveys and conclude that the x type of innovation is growing, … . However, we can estimate for each firm a probability of transition from one state in the first period to another state in the second period. These probabilities can be compared. The hypothesis to be formulated is the following: the explanatory variables develop their impact in the short run (in a three year period) and not on a longer run (5 years). If this condition was wrong, some explanatory variables (the long run ones) would be significant in the first period and not in the second although their real impact would be the same.

- Fifth problem, the year 1990 is included in the 3 surveys. It entails an artificial increase in the probability for a firm to be declared innovative in both periods and in the same type of innovation whereas it has only done one innovation in 1990. Nevertheless, we can do the hypothesis that the conduct of an innovation in the year 1990 (which is an overlapping year for the three surveys) is not correlated to our exogenous variables. We must also do the hypothesis that the probabilities of innovation in product, process, product & process are equally distributed over time. For example the year 1990 should not be less process innovative in comparison to product and product & process. If this condition was wrong, and even though the real rate of «consistency» of the three types of innovation had been the same, we would have observed a distortion in favour of a higher «consistency» for product and product & process innovations than for process innovations!

- Sixth problem, questions addressed to firms are different in the first survey and in the two second. We can't estimate exactly the same models in the first and second period. We have tried to overcome this problem using different variables to measure a same concept. As a

result, we can not easily replace the 1985-90 explanatory variables (used as lagged variables) by 1990-1992 explanatory variables (that would be current variables).

Given this important number of limitations, we have to be careful in our comments. Results are prospective. However, we will show that they can provide interesting general insight about the likely existence at the firm level of product, process, product & process technological trajectories.

3 - Empirical schedule

- 1/ Selection of three sub-populations according to their initial type of innovation,
- 2/ Identification of potential specific technological trajectories associated with each sub-population. We use two measure to characterise a trajectory: its continuity and its consistency.
- 3/ Selection of potential explanatory variables of the continuity and consistency associated with each sub-population.
- 4/ Description of the econometric model.

Definition of 3 sub-populations according to their initial type of innovation.

Before any investigation we have to define what are our sub-populations of reference. We have defined 3 sub-populations according to their initial type of innovation:
- product innovators in 1985-90,
- process innovators in 1985-90,
- product & process innovators in 1985-90.

The evolution from one type of innovative behaviour in 1985-90 to 1990-92 defines a specific trajectory.

Table 2: Typologies of technological trajectory

		Type of innovation in 1990-92 (four level endogenous variable)			
		Non innovator	**Product**	**Process**	**Product & process**
Type of innovation in 1985-90 (sub-populations)	**Product (sub-pop 1)**	No continuity	***CONSISTENCY***	No consistency	No consistency
	Process (sub-pop 2)	No continuity	No consistency	***CONSISTENCY***	No consistency
	Product & process (sub-pop 3)	No continuity	No consistency	No consistency	***CONSISTENCY***
		No CONTINUITY	***CONTINUITY***		

If the hypothesis that product and process innovators follow different trajectories is true then we can expect to observe different characteristic of the technological trajectories associated with sub-population 1, 2 and 3. We have developed two different measure of the characteristics of a technological trajectory: its "continuity" and its "consistency".

Two characteristics of a technological trajectory: the "continuity" and the "consistency" of the innovative behaviour

Usually, the concept of technological trajectory is used to describe the technological dynamics of sectors in the context of a paradigm (Dosi, [1988], Klevorick et al., [1995]). In this view Klevorick et al., [1995] have shown the existence of product and process trajectories at the sectoral level. *"A central idea of this work is that the development or use of some technologies*

may be subject to self-reinforcing, positive feed-back cycles that, once set in motion by what may be considered as small, random events, may become 'locked-in' to a particular time path development.", Cohen, [1995], p.220.

Rather than working at the sectoral level, in this study we will work at the firm level. We will try to identify potential trajectories associated with the initial type of innovation that a firm has developed on the 1985-90 period.

We will use two measures of the potential "self-reinforcing" phenomenon associated with each initial type of innovation: the "continuity" and the "consistency". These measures are calculated between 1985-90 (time t) and 1990-92 (time t+1):

- "*Continuity*" of the innovative behaviour: an innovative firm is "*continuous*" when it innovates in product, process or product & process in time t and keeps on innovating in time t+1 whatever the type of innovation in time t+1. In this case the population under inquiry is only composed of INNOVATIVE FIRMS IN 1985-90 that have also been included in the 1990-92 CIS survey. The variable CONTINUITY is a binary variable. It measures a rate of survival in the innovative behaviour, and provides a kind of measure of the **innovativeness of the technological trajectory**.
  - CONTINUITY=1 if the firm innovates in product or process or product & process in time t and is still innovating in time t+1 whatever the type of innovation in time t+1.
  - CONTINUITY=0 if the firm innovates in product or process or product & process in time t and does not innovate anymore in time t+1.

- "*Consistency*" of the innovative behaviour: an innovative firm is "*consistent*" when it innovates in time t and in time t+1 in the same type of innovation. In this case the population under inquiry is composed of INNOVATIVE FIRMS (IN 1985-90 **AND** IN 1990-92). The variable CONSISTENCY is a binary variable. It measures the stability of the innovative behaviour between two periods and gives a idea of the **specificity of the technological trajectory**. Consistent firms are always continuous firms.
  - CONSISTENCY=1 if the firm innovates in (product **or** process **or** product & process) in time t and is still innovating in time t+1 in the same type of innovation.
  - CONSISTENCY=0 if the firm innovates in (product **or** process **or** product & process) in time t **AND** is still innovating in time t+1 **BUT** not in the same type of innovation. (It moves from product to process for example).

If we observe different level of continuity and consistency between the tree sub-populations that we have defined then, it will be possible deduce that the type of innovation developed in time t can induce the development of a specific technological trajectory as defined by its "continuity" and "consistency". We will also try to identify potential explanatory variables of the continuity and consistency of the innovative behaviour in each of these 3 sub-populations.

Identification of potential explanatory variables for the "continuity" and for the "consistency" of the innovative behaviour

Once we will have identified some aggregate properties of each trajectory in term of continuity and consistency we will test the sensitivity of each sub-population to a number of explanatory variables.

We will test the impact of:

1- **the past evolution of the demand** addressed to the firm in comparison to the evolution of the demand addressed to its competitors (measured by log(market share in 1990/market share in 1987)),
2- the **external origin of the technological knowledge** (upstream, down stream, ...),
3- the **market structure** of the sectors on which the firm operates (log(Herfindhal index),
4- the degree of **technological opportunities** at the sectoral level (log(percentage of innovative firms in the sector)),
5- the **characteristics of the firm** (market share, diversification level across different branches of activity),
6- the **organisation of its technological** activity (in the firm *versus* in the consortium, using laboratory structure *versus* non-laboratory structure),
7- the **sectoral appropriability conditions** (patent, secret, complexity, lead time).

*For details about the calculus of these explanatory variables see **appendix 2**.*
*For descriptive statistics see **appendix 3**.*

We do not have *a priori* hypothesis about the estimated coefficients associated with these variables. We only expect to observe different impact of these variables on the probability of continuity and consistency according to the initial type of innovation that has been developed in 1985-90.

Econometric model

We want to model the probability of observing a positive outcome for two binary variables:

- the continuity of the innovative behaviour (probability of non-stop innovation on 1985-90 and 1990-92).
- the consistency of the innovative behaviour (probability for a non-stop innovator to innovate in both period in the same type of innovation).

First, we want to explain these probabilities by a number of exogenous variables (that have been described above). Second, we wish to test whether the initial type of innovation developed by a firm affects significantly the realisation of a positive outcome and modify the impact of the exogenous variables.

To model these links we have chosen to use a binomial logit model estimated using the maximum-likelihood method. So as to take account of different behaviours (different slopes) according to the initial type of innovation (for each sub-population) the following formulation has been estimated for each endogenous variable:

$$P_{ip}\left(Endo=1\right)=\frac{e^{\sum_{k=1}^{K}\sum_{m=1}^{M}a_{km}\times x_{ikm}}}{1+e^{\sum_{k=1}^{K}\sum_{m=1}^{M}a_{km}\times x_{ikm}}} \qquad \text{Equation 1}$$

Where :

$P_{ip}\left(Endo=1\right)$ is the probability of observing for a firm i belonging to the sub - population p the event Endo = 1

Endo is a binomial endogenous variable (0 or 1), in our case :

- Endo = **Continuity** of the innovative behaviour from 1985-90 to 1990-92 with two values 0/1,
- Endo = **Consistency** of the innovative behaviour from 1985-90 to 1990-92 with two values 0/1,

i stands for a specific firm,
k stands for a specific sub-population, in our case K=3, k:(initially product innovator in 1985-90, initially process innovator in 1985-90, initially product & process innovator in 1985-90),
m stands for an exogenous variable in our case when we do not include dummies for sectors and use explanatory variables from 1985-90 we have M=16 (15 “true” explanatory variables plus one intercept),
$\mathbf{x}_{ikm}$ are the observed values of the explanatory variables m, for a firm i belonging to the pth sub-population, if k<>p then x_{ikm}=0.
α_{km} are the estimated parameter associated with the explanatory variable $\mathbf{x}_m$ for the kth sub-population. The total number of coefficients to be estimated for each model is K*(M). When we do not include dummies for sectors and use explanatory variables from 1985-90 we estimate 48 parameters.

III Results

In a first step we will present results concerning the «continuity» of the innovative behaviour according to the initial type of innovation:
- What are the more *continuous* innovators?
- What are the determinants of this *continuity*?
- Do the determinants differ according to the initial type of innovation?

In a second step we will present results concerning the «consistency» of the innovative behaviour according to the initial type of innovation:
- What are the more *consistent* innovators?
- What are the determinants of this *consistency*?
- Do the determinants differ according to the initial type of innovation?

1 - The «continuity» of the innovative behaviour

What are the more *continuous* innovators?

We observe that the proportion of «continuous» innovators from 1985-90 to 1990-92 differs significantly according to the initial type of innovation:

Table 3: The "continuity" *of the innovative behaviour between 1985-90 and 1990-92 in function of the initial type of innovation in 1985-90.*

(Weighted by sampling weight)		Type of innovation in 1990-92				
		Death	Product	Process	Product & process	Total
Type of innovation in 1985-90	Product	46,95%	28,67%	5,04%	19,34%	100%
	Process	63,05%	4,62%	20,16%	12,18%	100%
	Product & process	42,18%	16,84%	10,27%	30,71%	100%

Distribution (Weighted by sampling weight) in parenthesis 95% CLM		Proportion of **continuous** innovators between 1985-90 and 1990-92
Type of innovation in 1985-90	Product	0,53 (0.48-0.57)
	Process	0,37 (0.32-0.41)
	Product & process	0,67 (0.55-0.60)

- 67% of the product & process innovators in 1985-90 still innovate in product or process or product & process in 1990-92;
- 53% of product innovators are continuous;
- only 37% of process innovators are continuous.

This diversity in the level of continuity across sub-populations tends to show that **each type of innovation leads to a specific dynamics in term of innovativeness**.
So as to study this topic more in depth, we have run a logit model in which the «continuity» variable (0 if non continuous, 1 if continuous innovator) is explained by exogenous variables measured on the 1985-90 period. That is, we use lagged explanatory variables.
Results of the estimation are reported in the following table. All estimated coefficients have been estimated in the same logit model according to equation 1. We have three columns because we have estimated for each explanatory variable 3 coefficients, one for each type of innovator in 1985-90 (K=3). Coefficients can be compared to each other in line and in column. We have also introduced one constant for each sub-population.

Table 4: The determinants of the «continuity» of the innovative behaviour between 1985-1990 and 1990-1992.

The determinants of the «continuity» of the innovative behaviour between 1985-1990 and 1990-1992.

- Endogenous variable: the «continuity» of the innovative behaviour between 1985-90 and 1990-92 (0 if not continuous, 1 if continuous).
- Exogenous variables from 1985-90 excepting the sectoral appropriability conditions (1990-92). No dummies for sectors.
- Population: 2435 industrial firms that innovate in 1985-90 AND that have been sampled in 1990-92.
- Three sub-populations are defined: Product innovator in 1985-90/ process innovator in 1985-90/ process innovator in 1985-90.
- Estimation of the probability of «continuity» at the firm level: maximum likelihood estimation of a binomial logit model. Sample weights are included.

See ***appendix 2*** for a full description of the explanatory variables		**Endogenous variable** **Continuity of the innovative behaviour**. Different slopes are simultaneously estimated depending on the initial type of innovation in 85-90. **Initial type of innovation (sub-populations)**		
		Product innovator in 1985-90 (k=1)	Process innovator in 1985-90 (k=2)	Product & process innovator in 1985-90 (k=3)
Lagged explanatory variables from 1985-90.				
Constant	constant	0,6582	-0,6263	0,8501*
Demand conditions				
Past market share evolution(1987-90)	LDPM	0,4763**	0,5438**	0,4081***
External sources of technological knowledge over 1985-90				
Upstream activities	UP	-0,0218	0,212**	-0,0929
Downstream activities	DOWN	-0,00134	-0,0967	0,3839****
Science	SCI	0,00134	0,0395	0,2444****
Subcontractors	STT	0,2436**	0,2244**	0,1041*
Market structure in 1987				
Concentration level (Herfindhal index)	LH87	0,0881	0,2005**	0,0303
Percentage of innovative firms in the sector	LPCI	1,9271****	0,3325	1,128****
Characteristic of the firm in 1987				
Market share in 1987	LPM87	0,1018	-0,0115	0,2594****
Concentration index in 1987	LDIV87	-0,2392	0,2338	0,0408
Strategy of the firm over 1985-90				
Relative importance of research in laboratory and non-laboratory research	L_F	0,01	-0,1459*	-0,0318
Relative importance of research inside the firm and research in the consortium	E_G	0,2144****	0,2562***	0,2395****
Sectoral appropriability conditions (evaluated for 1990-92)				
Efficiency of patent for product in comparison to process	BRV	0,1587	0,3811	-0,1228
Efficiency of secret for product in comparison to process	SEC	-1,7272***	-0,8988	-0,4089
Efficiency of complexity for product in comparison to process	CPX	1,7451***	0,8943*	0,8283**
Efficiency of time advance for product in comparison to process	TIM	0,229	-0,1838	0,2256

Initial	-2LogL=	3375
Final	-2LogL=	2925
Gain :	347 with 48 DF (3*(15+1))	(p=0,0001)
Pseudo-R-square (1-L1/L0) =	0.13	

		predicted		
		continuity	**Death**	
Observed	**continuity**	1003	387	1390
	Death	404	641	1045
		1407	1028	2435

Well predicted observations 67%

		predicted	
		continuity	**Death**
Observed	**continuity**	0,411909651	0,1589322
	Death	0,165913758	0,2632444

What are the determinants of the «continuity» of the innovative behaviour?

The model as a whole is highly significant (Table 4). The pseudo R Square is good for this type of data (13%) and we classify correctly about 67% of the observation with a .50 cut-point.

We find four explanatory variables that induce a significant and positive impact on the probability of continuity whatever the sub-population (initial type of innovation in 1985-90):

- LDPM (past evolution of the market share): whatever the initial type of innovation, when the past evolution of the market share is positive then we observe an increase in the probability of «continuity» in the innovative behaviour. It tends to show that **economic feed-back are important elements in the «continuity »**of the innovative behaviour.
- STT (specialised suppliers): the use of external suppliers of technology tends to be a general factor of continuity in the innovative behaviour.
- E_G (Relative importance of research inside the firm and research in the consortium): The more Research in the firm in comparison to research in consortium the higher the probability of continuity in the innovative behaviour.
- CPX (Efficiency of complexity for product in comparison to process): It indicates that the use of complexity as a mean of appropriation for product innovations re-enforces the «continuity» in the innovative behaviour whatever the initial type of innovation !

We have run a similar model with dummies for sectors (see appendix 5). Results are very close. 7 dummies, out of 20 have significant parameter estimates. It tends to show that the level of continuity varies significantly across sectors. However, the other estimated coefficients, are not really affected by the introduction of these dummies. The quality of these two models is not very different (about 67% of the observations are well predicted in both cases and the adjusted R square is at 13%). From our point of view, the interest of a model without dummies is that it enables to identify the sources of the sectoral effects rather than the identity of the sector (appropriability conditions, market structure).

In both cases (with or without dummies for sectors), behind these basic relationships, many differences can be observed depending on the initial type of innovation in 1985-90.

Do the determinants of the «continuity» differ according to the initial type of innovation?

Results reported in table 4 and in appendix 5 show that the continuity of the innovative behaviour in each sub-population is not only determined by common factors but, also, by specific explanatory variables.

Initially product innovator

For firms initially product innovator in 1985-90, we observe an important impact of the **sectoral opportunity conditions** LPCI (percentage of innovative firms in the sector). When LPCI increases the probability of «continuity» increases sharply, more than for product & process innovators. This variable has significant estimated coefficient for process innovators. SEC (**Efficiency of secret for product in comparison to process**) decreases significantly the probability of «continuity» for product innovators whereas it is not at all significant for other sub-populations. This strange result (higher appropriability leads to lower probability of the innovation in the future) tends to show that technological spill-over are crucial for product innovators: it means that the collective outcome of the diffusion process may boost rather than discourage the subsequent innovative activity of product innovators.

Initially process innovator

For process innovators in 1985-90, **upstream sources of technological knowledge** (UP) have a significant and positive impact on the probability of continuity. This is not the case for other sub-populations. Interestingly, the **concentration level** (LH87) would also have a significant and positive impact on the «continuity» of the innovative behaviour. Next, but not highly significant, we observe that a technological organisation of the firm based on **laboratory research** (L_F) would lead to *lower* probability of continuity. It would be the sign that process innovators ground their "innovativeness" on a "on the floor research" rather than on a "formalised

Initially product & process innovator

Turning now to product & process innovators in 1985-90, we see that **external sources of technological knowledge** (excepting UP) are important factors of «continuity» (DOWN (downstream sources), SCI (science), STT (sub-contractors). As expected, product & process innovators with high **market share** (LPM87) have higher probability of «continuity». Interestingly, higher LPM87 does not result in higher probability of «continuity» for other types of innovators.

These results were difficult to predict *a priori* and tend to indicate that two clear sets of explanatory variables can be distinguished:

1- First a set of explanatory variables that affects significantly and in the same positive way the probability of continuity for product, process and product & process innovators (LDPM, STT, E_G). These variables can be labelled as general factors of innovativeness.
2- Second a set of specific factors of innovativeness that affects differently each sub-population. It tends to show that our three sub-populations of reference are also very heterogeneous:
    - Product innovators: They are mainly influenced by sectoral variables such as appropriability conditions (SEC) and opportunity conditions (LPCI).
    - Process innovators: Micro-level variables such as UP or L_F have a significant impact. Surprisingly, LH87 has also a positive impact on their probability of continuity.
    - Product & process innovators: External sources of technological knowledge are the key elements of the «continuity» of the innovative behaviour of this sub-population. The size of the firm (LPM: market share) is also significant and positive.

What are the more *consistent* innovators?

RECALL: We restrict our sample to innovative firms in 1985-90 AND in 1990-92 (1395 firms). A firm is said to be "consistent" when it innovates in both periods in the same type of innovation. The consistency measures the specificity of the technological trajectory.

Table 5: The "consistency" of the innovative behaviour between 1985-90 and 1990-92 in function of the initial type of innovation in 1985-90.

Raw data (no sampling weight)		Type of innovation in 1990-92			
		Product	Process	Product & process	Total
Type of innovation in 1985-90	Product	132	24	103	259
	Process	21	87	62	170
	Product & process	257	144	565	966
					1395

Distribution (Weighted by sampling weight)		Type of innovation in 1990-92			
		Product	Process	Product & process	Total
Type of innovation in 1985-90	Product	0,540	0,095	0,364	1
	Process	0,124	0,545	0,329	1
	Product & process	0,291	0,177	0,531	1

Distribution (Weighted by sampling weight) in parenthesis 95% CLM		Proportion of **consistent** innovators between 1985-90 and 1990-92
Type of innovation in 1985-90	Product	0,540 (0.479-0.60)
	Process	0,545 (0.469-0.62)
	Product & process	0,531 (0.499-0.56)

Surprisingly, we do not observe any important difference of "*consistency*" in the innovative behaviour between initially product, process, product & process innovators. In each sub-population, about 53-54% of the innovative firms in 1985-90 that still innovates in 1990-92 keep on innovating in the same type of innovation!
Nevertheless, this aggregate homogeneity does not preclude that the same explanatory variables are at work in determining this result. To identify hypothetical explanatory variables, we have computed two logit models (one with exogenous variables from 1985-90 and another with explanatory variables from 1990-92). Results will be discussed in the following section.

What are the determinants of the "consistency" *of the innovative behaviour*?

In contrast with previous results about the "continuity" of the innovative behaviour, in the case we do not obtain any general factor of consistency (significant and positive estimated coefficients for all sub-populations) (see tables 6 and 7). It means that each sub-population is highly heterogeneous in term of the determinants of its consistency.
We must also report an important reduction in the explanatory power of our model when we use exogenous variables calculated on the 1985-90 period (See table 6, the Pseudo R Square falls from 13% to 7%!). It would mean that our lagged explanatory variables are not suited to study the «consistency» of the innovative behaviour. When we use explanatory variables from the 1990-92 period (no lag) we obtain better results with a pseudo R Square of 15% (see appendix 6 for a description of the 1990-92 explanatory variables). However, this improvement is mainly due to the introduction of a new array of explanatory variables relating to the strategy of the firm that were not available in the 1985-90 survey.

We have also computed similar models for 1985-90 and 1990-92 with dummies for sectors. Some of the dummies were significant but neither the sign nor the significance of the other estimated coefficients were modified by their introduction. As a consequence we have preferred lighter models without dummies.

For simplicity in comments, we will only discuss results reported in table 7 (Exogenous variables from the 1990-92 period).

Table 6: The determinants of the «consistency» of the innovative behaviour between 1985-1990 and 1990-1992.Exogenous variables from 1985-90.

The determinants of the «consistency» of the innovative behaviour between 1985-1990 and 1990-1992.. Exogenous variables from 1985-90.

- **Endogenous variable** : the «consistency» of the innovative behaviour between 1985-90 and 1990-92 (0 if non consistent, 1 if consistent).
- **Exogenous variables** from 1985-90. No dummies for sectors.
- **Population** : 1395 innovative firms in 1985-90 AND in 1990-92.
- **Estimation** of the probability of consistency at the firm level: maximum likelihood estimation of a binomial logit model. Sample weights are included.

See ***appendix 2*** for a full description of the explanatory variables **Lagged explanatory variables from 1985-90.**		**Endogenous variable Consistency of the innovative behaviour**. Different slopes are simultaneously estimated depending on the initial type of innovation in 85-90. **Initial type of innovation (sub-populations)**		
		Product innovator in 1985-90 (k=1)	Process innovator in 1985-90 (k=2)	Product & process innovator in 1985-90 (k=3)
	constant	-0,3316	-4,5113***	0,0154
Demand conditions				
Past market share evolution(1987-90)	LDPM	-0,2436	0,0671	-0,0889
External sources of technological knowledge in 1985-90				
Upstream activities	UP	-0,1621	0,3198*	0,1408**
Downstream activities	DOWN	0,1146	-0,0807	0,1608*
Science	SCI	-0,0266	-0,0138	0,1847**
Subcontractors	STT	-0,1155	-0,2917*	0,167**
Market structure in 1987				
Concentration level (Herfindhal index)	LH87	0,2001	0,0163	-0,0951
Percentage of innovative firms in the sector in 1985-90	LPCI	0,0182	-3,457***	1,2292***
Characteristic of the firm in 1987				
Market share in 1987	LPM87	-0,1698**	-0,329***	0,1836****
Concentration index in 1987	LDIV87	0,3247	-0,726	-0,2431
Technological organisation in 1985-90				
Relative importance of research in laboratory and non-laboratory research	L_F	-0,0163	0,165	-0,00807
Relative importance of research inside the firm and research in the consortium	E_G	0,0549	-0,2337*	0,1338***
Sectoral appropriability conditions in 1990-92				
Efficiency of patent for product by comparison to process	BRV	-0,1922	-1,2464*	0,2609
Efficiency of secret for product by comparison to process	SEC	0,466	-2,4322**	0,1423
Efficiency of complexity for product by comparison to process	CPX	-0,7243	1,7998*	-0,4876
Efficiency of time advance for product by comparison to process	TIM	0,5693	0,8049	-0,0489

Well predicted 59%		
Initial	-2LogL=	1926
Final	-2LogL=	1782
Gain :	144, 48df	p=0,00001
Pseudo R Square (1-L0/L1) =	7.4%	

Table 7: The determinants of the «consistency» of the innovative behaviour between 1985-1990 and 1990-1992. Exogenous variables from 1990-92.

The determinants of the «consistency» of the innovative behaviour between 1985-1990 and 1990-1992.. Exogenous variables from 1990-92.

- **Endogenous variable** : the «consistency» of the innovative behaviour (0 if non consistent, 1 if consistent).
- **Explanatory variables** from 1990-92 (no lag). No dummies for sectors.
- **Estimation** of the probability of consistency: maximum likelihood estimation of a binomial logit model. Sample weights included.
- **Population** : 1390 innovative firms in 1985-90 AND 1990-92

See ***appendix 6*** for a full description of the explanatory variables		**Endogenous variable** **Consistency of the innovative behaviour.** Different slopes are simultaneously estimated depending on the initial type of innovation in 85-90.		
		Initial type of innovation in 1985-90 (sub-populations)		
		Product innovator in 1985-90	process innovator in 1985-90	product & process innovator in 1985-90
	INTERCPT	1,7731	-4,7228**	-0,5839
Demand conditions				
Past market share evolution(1987-90)	**DPM1**	-0,4005	0,2453	-0,1325
Sectoral appropriability conditions[2] in 1990-92				
Efficiency of patent for product by comparison to process	**BRV**	0,1261	-0,6384	0,3713*
Efficiency of secret for product by comparison to process	**SEC**	1,4598*	-4,1915***	0,5923
Efficiency of complexity for product by comparison to process	**CPX**	-1,9173**	3,0595**	-1,0264**
Efficiency of time advance for product by comparison to process	**TIM**	0,4175	0,5267	-0,2856
External origins of the technological knowledge in 1990-92				
Upstream activities	**UP**	0,0877	0,3443	-0,0619
Downstream activities	**DOWN**	0,041	-0,4107**	-0,00091
Competitors	**HORI**	0,0915	0,0433	-0,0651
Science	**SCI**	0,1489	-0,6764	0,2542**
Subcontractors	**STT**	0,2273	0,00195	-0,0888
General information	**IGAL**	-0,0542	0,1482	0,1621
Technical information	**ITEC**	-0,1484	0,2959	-0,0193
French sources	**FR**	-0,8336	-1,0115	0,5854
Market structures in 1990				
Concentration level (Herfindhal index)	**LH90**	0,3774**	0,024	-0,0375
Percentage of innovative firms in the sector	**LPCI90**	0,4274	-1,8887*	0,7328**
Microeconomic characteristics of the firm in 1990				
Market share in 1990	**LPM**	-0,1756*	-0,5717***	0,1494***
Concentration index in 1990	**LDIV**	0,66	0,676	-0,1277
Strategy of the firm in 1990-92				
Relative importance of research in laboratory and non-laboratory research	**L_F**	0,0213	-0,3019	0,0717
Relative importance of research inside the firm and research in the consortium	**E_G**	-0,0511	-0,2434	-0,0925
Marketing	**MKT**	0,4284**	-1,222****	0,2823***
Flexibility	**FLEX**	-0,4258***	0,5345**	0,2372***
Cost	**COST**	-0,161	-0,2836	0,0576
Quality	**QUAL**	-0,3789**	0,257	0,0663

Well predicted 65%		
Initial	-2LogL=	1926
Final	-2LogL=	1630
Gain :	296, 72df	p=0,00001
Pseudo R Square (1-L0/L1)=	15.36%	

[2] The simultaneous introduction of Appropriability variables and Strategy variables leads to a high multicolinearity in the model. That is the reason why estimated coefficients associated with sectoral appropriability conditions in this table (table 7) are so different from estimated coefficients reported in table 6. We have checked that when we suppress Sectoral appropriability conditions, estimated coefficients associated to Strategy variables are not too much modified.

		predicted		
		Consistency	**Change**	
Observed	**Consistency**	570	275	845
	Change	210	335	545
		780	610	1390

		predicted		
		Consistency	**Change**	
Observed	**Consistency**	0,4100719	0,197841727	
	Change	0,1510791	0,241007194	
				1

Do the determinants of the consistency of the innovative behaviour differ according to the initial type of innovation?

Looking carefully at the two former tables (tables 6 and 7) it is obvious that for each sub-population (defined by its initial type of innovation) the determinants of the consistency of the innovative behaviour greatly vary; factors of consistency are all specific. Let's now comment results for each sub-population.

Initially product innovator

The consistency of the behaviour of product innovation seems to be the most difficult to explain. Using explanatory variables from 1985-90 only one of them has a significant (negative) estimated coefficient: Market share in 1987. However, using explanatory variables from 1990-92 estimated coefficients tend to be more significant:

- **Sectoral appropriability conditions** (a higher efficiency of the complexity for the protection of product innovation in comparison to its efficiency for the protection of process innovation) leads to lower probability of consistency in the innovative behaviour of product innovators.
- **Market structure**. Higher concentration level would increase the probability of consistency. This result is striking because we had observed earlier that the concentration index had no significant impact on the probability of continuity for initially product innovators.
- A higher **market share** would tend to induce lower probability of consistency.
- The **marketing strategy** would be a major and positive explanatory variable of the consistency of the product innovation behaviour. On the contrary, goals of flexibility increase and quality improvement would reduce the probability of consistency in product innovation. Interestingly, the cost-reduction goal has no significant impact!

Initially process innovator

This sub-population is the smallest: we have only 170 observations.

- Concerning **appropriability conditions** at the sectoral level, estimated coefficients are opposed to those obtained for product innovators. Secret for product leads to a decrease in the probability of consistency of the process innovation behaviour whereas complexity of products increases the probability of consistency.
- No one of the external source of technological knowledge lead to a significant increase in the probability of consistency. However, **downstream sources** of technological knowledge reduce significantly this probability.
- **Market share** would be negatively related to the probability of consistency in process innovation.
- Higher **sectoral opportunity** conditions (LPCI) lead to lower probability of consistency in process innovation (that is mainly the case with exogenous variables

from 1985-90). It means that process innovators are more consistent in sectors with low technological opportunities.

- Strategies of firm would have also a significant impact. Goal of sale enhancement has a significant and negative impact while the goal of **flexibility increase** lead to a higher probability of consistency in process innovation.

Initially product & process innovator

Next, turning now to product & process innovators, we do not obtain mean results (mean of product and process coefficients). On the contrary, we observe specific determinants.

- Concerning sectoral appropriability conditions, **patent protection** of product may have a small and positive impact. In contrast, a higher **complexity of product** innovation would lead to lower probability of consistency in product & process innovation.
- The only significant and positive external source of knowledge would be the **link to science**.
- Market share would have a significant and positive impact on the consistency of the innovative behaviour. We find an intuitive result: **large firms** are more consistent in their innovative behaviour than small firms and develop more easily product & process innovations in the same time.
- Whereas estimated coefficients associated with sale enhancing and flexibility strategies are opposed for product and process innovators, that is not the case for product & process innovators. Both higher **goals of sale enhancement and flexibility increase** lead to higher probability of consistency in product & process innovation.

The explanation of the consistency of the innovative behaviour seems very difficult. First of all, we can not identify general factors of continuity. Second, for each sub-population we clearly identify specific and significant factors of continuity but we do not see any obvious explanation[3]. Maybe the main point of this analysis is to show that the consistency of the innovative behaviour is not mainly driven by the origin of the external sources of technological knowledge (excepting maybe for product & process innovators), nor by the organisational structure of the firm (L_F and E_G) but mainly by the current technological strategy of the firm in terms of sales-enhancement and flexibility increase.

[3] Suggestions of interpretation would be welcome.

IV Conclusions

In this paper, we have tried to check whether it was possible to identify empirically different technological trajectories for product, process, product & process innovators. We have defined a trajectory with two simple indicators: the "**continuity**" of the technological behaviour measures the *innovativeness of the trajectory* while the "**consistency**" of the innovative behaviour tries to measure the *specificity of the trajectory*.

- **The "continuity" of the innovative behaviour** differs widely according to the initial type of innovation: highest continuity for product & process innovators, lowest for process innovators. Whatever the initial type of innovation (product, process, product & process innovations), the probability of continuity is positively influenced by a number of factors:
    - the past evolution of the market share,
    - the links with external suppliers of technology,
    - the relative importance of research in the firm and in the consortium,
    - the sectoral efficiency of the complexity for the appropriation of product innovation in comparison to process innovation.

  However, other factors are specific to each sub-population of innovator. They show that despite general patterns, different technological dynamics may be at work depending on the initial type of innovation.

- Turning to **the "consistency" of the innovative behaviour**, we surprisingly obtain a similar rate of consistency (53-54%) for each type of innovator. This phenomenon could suggest that the 3 sub-populations are homogenous in term of sensitivity to the exogenous variables. However, after computation of a logit model, we obtain quite heterogeneous estimated coefficients for each sub-population. Despite homogenous aggregate results, in each sub-population, the consistency of the innovative behaviour does not seem to be explained by the same explanatory variables.

Using these two indicators, we clearly see that product, process, product & process innovators tend to follow distinct technological trajectories in terms of continuity and consistency. They also show that these technological trajectories are not determined by the same explanatory variables. However, these results are still difficult to interpret in details. An important work has to be done in this direction.
Two more specific conclusions can nevertheless be proposed:

- the traditional explanatory variables of the innovative behaviour of firm (external sources of technological knowledge) are not the only and major explanatory variables of the continuity and of the consistency of the innovative behaviour for product and process innovators. These traditional variables remain nevertheless relevant to explain product & process innovators' continuity and consistency.
- the cost-reducing *versus* sale enhancing trade-off does not seems relevant to explain the probability of consistency in product and process innovations (table 7). The trade-off would be more in terms of "sale enhancing product innovation" *versus* "flexibility increasing process innovation".

Despite these encouraging results a important work remain to be done maybe in the direction of more accurate measures of the characteristics of the technological trajectories that could help us to develop an easier explanation of the phenomenon.

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Appendixes

Appendix 1: Definitions of the type of innovations in different surveys

For the 1991 survey product and process innovations are identified by the answers to the following questions:

During the past five years the firm has:

Product innovations
- substantially improved existing products from a technological point of view : 0/1 (U1)
- introduced on the market a new product that is technologically innovating:
  - 1 / new products for the market : 0/1 (U2)
  - 2 / new products for the firm but already on the market : 0/1 (U3)

Process innovations
- been the first to develop : 0/1 (U4)
- substantially improved the production process from a technological point of view: 0/1 (U5)

In our computations for 1985-90 we have used the following definitions for product, process and product & process innovations:

```
if (u1=0 and u2=0 )    and (u4=0 and u5=0) then Non innovator;
if (u1=1 or  u2=1)     and (u4=0 and u5=0) then Product innovator;
if (u1=0 and u2=0)     and (u4=1 or  u5=1) then Process innovator;
if (u1=1 or  u2=1)     and (u4=1 or  u5=1) then Product & process innovator
```

For the 1990-92 CIS survey and the apporpriability surveys, the type of innovation is identified using the following questions:

During the past three years (1990, 1991, 1992), has your firm developed or introduced:
- 1 / product innovation? 0/1 (Q110)
- 2 / process innovation? 0/1 (Q120)

In our computations for 1990-92 we have used the following definitions for product, process and product & process innovations:

```
if q110=0 and q120=0 then Non innovator;
if q110=1 and q120=0 then Product innovator;
if q110=0 and q120=1 then Process innovator;
```

if q110=1 and q120=1 then Product & process innovator.

Appendix 2: Description of the 1985-90 variables used to explain the "continuity" and "consistency" of the innovative behaviour between 1985-90 and 1990-92

Name	*Notation*	*Definition of the variable*	*Statistical source*
Sources of technological knowledge			
Upstream activities	Up	W7 ~ "*Innovations in your firm are due to the innovative use of investment goods (process, machines, ...)*"	SESSI's 1990 survey
Downstream activities	Down	V1 ~ "*Innovation is determined by the market (links with suppliers or competitors)*"	SESSI's 1990 survey
Science	SCI	V2 ~ " *Innovation is determined by the own dynamics of the technology*"	SESSI's 1990 survey
Providers of technological services	STT	(W4+W6)/2 with W4 ~ "*The introduction of innovations comes from a R&D bought outside (public/private research institutions, customers, ...)* W6 ~ "*The introduction of innovations comes from patents, technical know how, ... bought outside the firm*".	SESSI's 1990 survey
Market structure			
Concentration index in 1987	LH87	log(weighted mean concentration level (measured by the Herfindahl index) a firm meets given its diversification pattern by branch).	EAE 1987
Intensity of the technological competition in 1985-90	LPCI 85-90	log(percentage of innovative firms in the sector over 1985-90 (NAP90))	SESSI's 1990 survey
Firms' characteristics			
Market share in 1987	LMS 87	log(market share in 1990 using branch data. Weighted means of each firm's market share on the whole set of branches in which it operates).	EAE 1987
Concentration in 1987	LCON 87	log(Herfindahl index calculated over the different branches in which a firm operates)	EAE 1987
Strategy of the firm			
Relative importance of research in laboratory and non-laboratory research	L_F	max(w1,w2)-w3 The difference between LAB=max(W1,W2) and FLOR=W3 (L_F=(LAB-FLOR)) as sources of technological knowledge W1 ~ "*Innovations result from a permanent and organised activity of R&D inside the firm*" W2 ~ " *Innovations result from a permanent and organised activity of R&D inside the consortium (if the firm belong to a consortium)*" W3 ~ " *Innovations result from an activity of technical research and methods inside the firm* including non-permanent research.	SESSI's 1990 survey
Relative importance of research inside the firm and research in the consortium	E_C	The difference between the mean score of ETS=W1 and CON=W2 (E_C=(ETS-CON)) as sources of technological knowledge	SESSI's 1990 survey
Sectoral appropriability conditions			
Efficiency of patent for product in comparison to process	PAT	Sectoral mean score obtained by (AQ21a , AQ22a) minus (AQ21b , AQ22b)	SESSI 's appropriability survey
Efficiency of secret for product in comparison to process	SEC	Sectoral mean score obtained by (AQ23a) minus (AQ23b)	SESSI 's appropriability survey
Efficiency of complexity for product in comparison to process	CPX	Sectoral mean score obtained by (AQ31a) minus (AQ31b)	SESSI 's appropriability survey
Efficiency of time advance for product in comparison to process	TIM	Sectoral mean score obtained by (AQ32a , AQ33a) minus (AQ32b , AQ33b)	SESSI 's appropriability survey

Appendix 3 : The evolution of the innovative behaviour between 1985-90 and 1990-92. Descriptive statistics.

Weighted frequency
Percentage
Row percentage
Col. Percentage

Weighted by survey rates in 1990-92 (CIS survey)

		Type of innovation in 1990-1992				
		No innovation	**Product innovation**	**Process innovation**	**Product & process innovation**	**Total**
Type of innovation in 1985-1990	**No innovation**	7585 ,2	457 ,59	657 ,36	476 ,94	**9177 ,1**
		32 ,47	1 ,96	2 ,81	2 ,04	**39 ,28**
		82 ,65	4 ,99	7 ,16	5 ,20	**100**
		53 ,03	16 ,10	29 ,29	12 ,01	
	Product innovation	1372 ,9	838 ,42	147 ,48	565 ,58	**2924 ,3**
		5 ,88	3 ,59	0 ,63	2 ,42	**12 ,52**
		46 ,95	**28 ,67**	5 ,04	19 ,34	**100**
		9 ,60	29 ,50	6 ,57	14 ,24	
	Process innovation	1803 ,9	132 ,16	576 ,73	348 ,48	**2861 ,3**
		7 ,72	0 ,57	2 ,47	1 ,49	**12 ,25**
		63 ,05	4 ,62	**20 ,16**	12 ,18	**100**
		12 ,61	4 ,65	25 ,70	8 ,78	
	Product & process innovation	3543	1414 ,4	862 ,44	2579 ,4	**8399 ,2**
		15 ,17	6 ,05	3 ,69	11 ,04	**35 ,95**
		42 ,18	16 ,84	10 ,27	**30 ,71**	**100**
		24 ,77	49 ,76	38 ,43	64 ,97	
	Total	**14304 ,9**	**2842 ,57**	**2244 ,01**	**3970 ,42**	**23362**
		61 ,23	12 ,17	9 ,61	17 ,00	100 ,00

Raw frequency
Percentage
Row percentage
Col. Percentage

Raw data. No weight used

		Type of innovation in 1990-1992				
		No innovation	**Product innovation**	**Process innovation**	**Product & process innovation**	**Total**
Type of innovation in 1985-1990	**No innovation**	1135	73	100	82	1390
		29 ,62	1 ,91	2 ,61	2 ,14	36 ,27
		81 ,65	5 ,25	7 ,19	5 ,90	100
		52 ,02	15 ,11	28 ,17	10 ,10	
	Product innovation	205	132	24	103	464
		5 ,35	3 ,44	0 ,63	2 ,69	12 ,11
		44 ,18	**28 ,45**	5 ,17	22 ,20	100
		9 ,40	27 ,33	6 ,76	12 ,68	
	Process innovation	283	21	87	62	453
		7 ,39	0 ,55	2 ,27	1 ,62	11 ,82
		62 ,47	4 ,64	**19 ,21**	13 ,69	100
		12 ,97	4 ,35	24 ,51	7 ,64	
	Product & process innovation	559	257	144	565	1525
		14 ,59	6 ,71	3 ,76	14 ,74	39 ,80
		36 ,66	16 ,85	9 ,44	**37 ,05**	100
		25 ,62	53 ,21	40 ,56	69 ,58	
	Total	2182	483	355	812	**3832**
		56 ,94	12 ,60	9 ,26	21 ,19	100 ,00

Appendix 4: Descriptive statistics concerning the continuity and the consistency

	Initially product innovator				**Initially process innovator**				**Initially product & process innovator**			
	Continuity=0		Continuity=1		Continuity=0		Continuity=1		Continuity=0		Continuity=1	
Explanatory variables calculated over 1985-90	Mean	Variance	Mean	Variance	Mean	Variance	Mean	Variance	Mean	Variance	Mean	Variance
LDPM	-0,10	1,69	-0,06	0,88	-0,07	0,94	0,02	1,01	-0,07	1,47	0,02	1,06
UP	1,04	8,33	0,91	7,01	1,78	7,71	2,03	6,33	1,72	7,32	1,68	5,47
DOWN	2,42	5,44	2,49	4,36	2,19	6,43	2,23	6,50	2,26	4,91	2,55	2,89
SCI	1,41	7,01	1,51	6,08	1,62	6,90	1,77	7,13	1,68	6,88	1,95	4,47
STT	0,63	5,89	0,77	5,65	0,58	4,89	0,76	6,54	0,76	5,77	0,89	4,93
LH87	-3,86	8,00	-3,42	8,12	-4,24	10,08	-3,93	10,26	-3,92	8,26	-3,46	6,37
LPCI	-0,55	0,63	-0,43	0,21	-0,59	0,39	-0,55	0,36	-0,56	0,41	-0,47	0,21
LPM87	-6,47	14,74	-6,25	16,99	-6,72	19,98	-6,60	16,15	-6,67	17,19	-5,81	16,97
LDIV87	-0,15	0,47	-0,16	0,48	-0,10	0,36	-0,10	0,38	-0,13	0,44	-0,18	0,46
L_F	-0,25	16,16	-0,01	17,56	-0,57	11,16	-0,74	12,99	-0,36	13,53	-0,12	11,90
E_G	0,25	12,68	0,81	16,39	0,07	6,78	0,31	10,63	0,44	11,71	1,08	12,21
BRV	0,83	2,59	1,10	2,07	0,71	1,60	0,79	2,07	0,82	2,10	1,01	1,80
SEC	-0,29	1,48	-0,16	1,65	-0,52	0,79	-0,51	1,29	-0,41	1,25	-0,23	1,20
CPX	0,10	1,36	0,29	1,49	-0,13	0,83	-0,09	1,45	0,00	1,39	0,20	1,20
TIM	0,90	2,51	1,10	2,05	0,69	1,83	0,73	2,19	0,80	2,24	0,99	1,65

	Initially product innovator				**Initially process innovator**				**Initially product & process innovator**			
	consistency=0		consistency=1		consistency=0		consistency=1		consistency=0		consistency=1	
Explanatory variables calculated over 1985-90	Mean	Variance	Mean	Variance	Mean	Variance	Mean	Variance	Mean	Variance	Mean	Variance
LDPM	-0,04	1,00	-0,08	0,78	0,02	1,32	0,03	0,72	0,03	1,47	0,01	0,76
UP	1,05	6,96	0,79	6,92	1,92	5,73	2,12	6,85	1,59	6,40	1,76	4,76
DOWN	2,45	3,98	2,52	4,74	2,34	5,64	2,13	7,26	2,48	3,93	2,60	2,12
SCI	1,52	6,30	1,50	5,93	1,71	7,00	1,83	7,29	1,85	5,79	2,04	3,46
STT	0,82	5,06	0,72	6,22	0,78	6,88	0,75	6,28	0,79	5,21	0,97	4,66
LH87	-3,55	8,05	-3,32	8,09	-3,73	9,54	-4,09	10,68	-3,53	7,07	-3,41	5,85
LPCI	-0,44	0,25	-0,42	0,16	-0,47	0,16	-0,61	0,50	-0,49	0,33	-0,45	0,11
LPM87	-6,04	16,25	-6,43	17,36	-6,36	16,98	-6,80	14,96	-6,11	16,68	-5,54	16,51
LDIV87	-0,18	0,46	-0,15	0,49	-0,10	0,37	-0,10	0,39	-0,16	0,40	-0,20	0,49
L_F	0,00	15,84	-0,03	19,35	-0,76	11,72	-0,73	14,35	-0,18	15,04	-0,06	9,65
E_G	0,69	15,90	0,92	16,83	0,44	10,43	0,19	10,76	0,91	13,54	1,22	11,09
BRV	1,06	2,10	1,14	2,04	0,95	1,85	0,65	2,03	0,97	2,18	1,04	1,51
SEC	-0,22	1,53	-0,11	1,74	-0,40	1,38	-0,61	1,08	-0,23	1,32	-0,23	1,11
CPX	0,25	1,44	0,33	1,54	0,00	1,56	-0,17	1,28	0,20	1,35	0,19	1,10
TIM	1,00	2,19	1,18	1,84	0,86	2,13	0,63	2,11	0,98	2,08	1,00	1,35

Appendix 5 : The determinants of the «continuity» of the innovative behaviour with dummies for sectors

When we add dummies for sectors we do not include in the model Sectoral appropriability conditions and measures of the Market structure.

The determinants of the «continuity» of the innovative behaviour between 1985-1990 and 1990-1992. Exogenous variables from 1985-90. With dummies for sectors. Estimation: maximum likelihood estimation of a binomial logit model. Sample weights included (cofred). Population: ia ne 0

	Endogenous variable ==>	Continuity of the innovative behaviour. Different slopes are simultaneously estimated in function of the initial type of innovation in 85-90.		
	Initial type of innovation ==>	Product innovator in 1985-90	process innovator in 1985-90	product & process innovator in 1985-90
	constant	0,5077	-0,6561	0,4711
Demand Conditions				
Past market share evolution(1987-90)	LDPM	0,3931*	0,5297**	0,388***
External sources of technological knowledge				
Upstream activities	UP	-0,1036	0,2315**	-0,1*
Downstream activities	DOWN	0,00368	-0,099	0,3938****
Science	SCI	0,0488	0,0278	0,2582****
Subcontractors	STT	0,2071**	0,2137**	0,1015*
Market structure				
Concentration level (Herfindhal index)	LH87			
Percentage of innovative firms in the sector	LPCI			
Characteristic of the firm				
Market share in 1990	LPM87	0,1436**	0,0777	0,3063****
Concentration index in 1990	LDIV87	-0,1309	0,0841	0,00757
Strategy of the firm				
Relative importance of research in laboratory and non-laboratory research	L_F	0,0188	-0,1527**	-0,0134
Relative importance of research inside the firm and research in the consortium	E_G	0,1996***	0,2538***	0,2429****
	20 Dummies for sectors. 7 sectors have significant estimated parameters.			

Initial	-2LogL=	3385
Final	-2LogL=	2936
Gain :	448 with 50 DF	(p=0,0001)
Adjusted R Square (1-L0/L1) =	13,26	

		predicted	
		continuity	**Death**
Observed	**continuity**	999	406
	Death	396	641

		predicted	
		continuity	**Death**
Observed	**continuity**	0,41026694	0,1667351
	Death	0,162628337	0,2632444

Appendix 6: Description of the 1990-92 explanatory variables used to explain the consistency of the innovative behaviour

	Name	*Notation*	*Definition of the variable*	*Statistical source*
Demand conditions				
	Market share evolution	LDpm	log(PM90/PM87)	EAE 1990 and 1987
Sectoral appropriability conditions				
	Efficiency of patent for product in comparison to process	PAT	Sectoral mean score obtained by (AQ21a , AQ22a) minus (AQ21b , AQ22b)	SESSI 's appropriability survey
	Efficiency of secret for product in comparison to process	SEC	Sectoral mean score obtained by (AQ23a) minus (AQ23b)	SESSI 's appropriability survey
	Efficiency of complexity for product in comparison to process	CPX	Sectoral mean score obtained by (AQ31a) minus (AQ31b)	SESSI 's appropriability survey
	Efficiency of time advance for product in comparison to process	TIM	Sectoral mean score obtained by (AQ32a , AQ33a) minus (AQ32b , AQ33b)	SESSI 's appropriability survey
Sources of technological knowledge				
	Relative importance of research in laboratory and non-laboratory research	L_F	The difference between the mean score of LAB=(Q311+Q321)/2 and FLOR=(Q312+Q322)/2 (L_F=(LAB-FLOR)) as sources of technological knowledge	SESSI 's CIS survey
	Relative importance of research inside the firm and research in the consortium	E_C	The difference between the mean score of ETS=(Q311+Q312)/2 and CON=(Q321+Q322)/2 (E_C=(ETS-CON)) as sources of technological knowledge	SESSI 's CIS survey
	Upstream activities	Up	Mean score obtained by Q344 Q345 about suppliers of material and components and suppliers of equipment as sources of technological knowledge.	SESSI 's CIS survey
	Downstream activities	Down	Mean score obtained by Q346 about customers as sources of technological knowledge	SESSI 's CIS survey
	Competitors	HORI	Mean score obtained by Q347 (competitors as sources of technological knowledge)	SESSI 's CIS survey
	Science	Science	Mean score obtained by Q331, Q332 (public laboratories, universities as sources of technological knowledge)	SESSI 's CIS survey
	Providers of technological services	SSTT	Mean score obtained by Q341, Q342, Q343 (centres techniques de profession, prestataires de service de R&D, sociétés de consultants)	SESSI 's CIS survey
	General information	IGAL	Mean score obtained by Q352, Q353 (meetings, publications, fair, exhibitions as sources of technological knowledge)	SESSI 's CIS survey
	Technical information	ITECH	Score obtained by Q351 (data bases, patents, patterns as sources of technological knowledge)	SESSI 's CIS survey
	National system of innovation (French sources)	NSI	Mean score obtained by French sources of knowledge for the questions [Q41a, , Q42a, Q43a, , Q44a, Q45a, Q46a, Q47a, Q48a, Q49a, Q410a, Q411a, Q412a]	SESSI 's CIS survey
Market structure				
	Concentration in 1990	LH90	log(weighted mean concentration level (measured by the Herfindahl index) a firm meets according its diversification pattern by branch).	EAE 1990
	Intensity of technological competition	LPCI 90-92	log(percentage of innovative firms in the sector over 1990-92 (NAF in 24 sectors))	SESSI 's CIS survey
Firms' characteristics				
	Market share in 1990	LPM90	log(market share in 1990 using branch data. Weighted means of each firm's market share on the whole set of branches in which it operates).	EAE 1990
	Diversification in 1990	LCON	log(Herfindahl index calculated over the different branches in which a firm operates)	EAE 1990
	Technological past	PAST	1 if the firm declares an innovation (product or process or product & process) in 1985-90, 0 otherwise	SESSI's 1990 survey
Strategy				
	Marketing	Mrkt	Mean score obtained by Q211 Q213 Q214 about obsolescence, range of products, exploration of new products.	SESSI 's CIS survey
	Flexibility	Flex	Mean score obtained by Q221 Q226 about the flexibility of the production and the reduction of the product conception cycle.	SESSI 's CIS survey
	Quality	Qual	Mean score obtained by Q212 Q225 about improvement in product quality and rejects reduction.	SESSI 's CIS survey
	Cost	Cost	Mean score obtained by Q222 Q223 Q224 about the reduction in labour costs, energy costs, consumption of materials	SESSI 's CIS survey

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