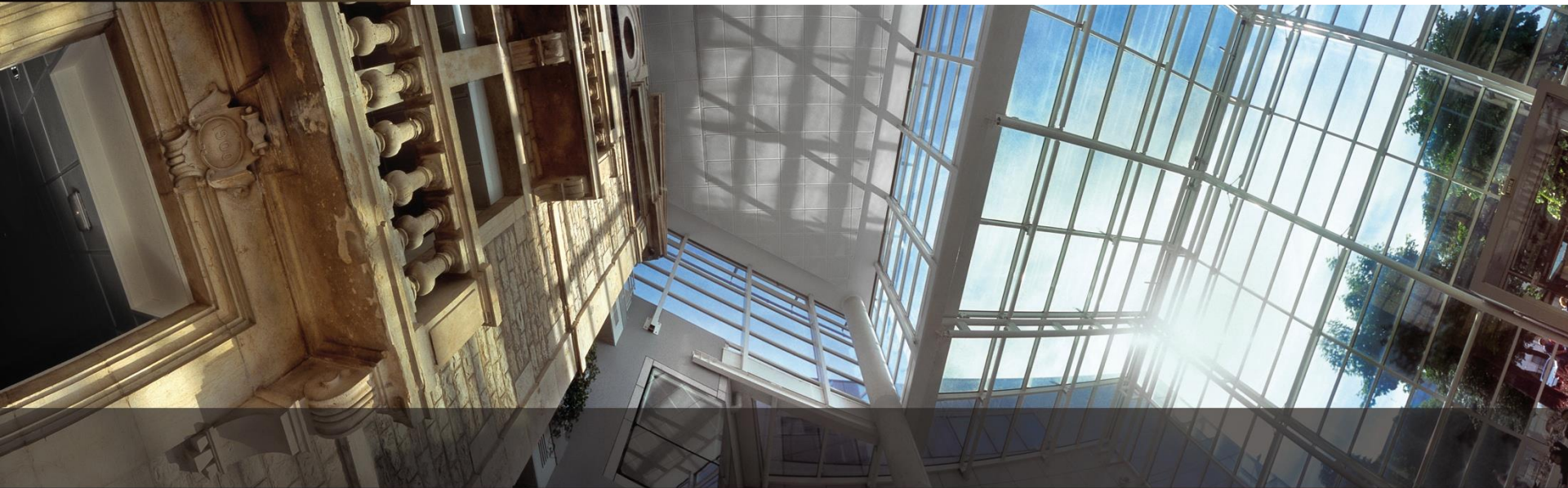


The Process of Innovation: Obstacles and Complementarities



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The Process of Innovation: Obstacles and Complementarities

1. The process of innovation
2. Innovation measures and CIS - Community Innovation Survey
3. Obstacles to Innovation
 - 3.1. Obstacles to innovation – Study #1 (RP, France, 2004)
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4. The Fateful Triangle: Complementarities in Performance between Product, Process and Organizational Innovation (RP, France, UK 2016)

1. The process of innovation

Oslo Manual (2005) classifies four main forms of innovation:

➤ **Product, Process, Organizational and Marketing** innovations

Innovation is defined

as **major changes**

aimed at enhancing your **competitive position,**

your **performance,**

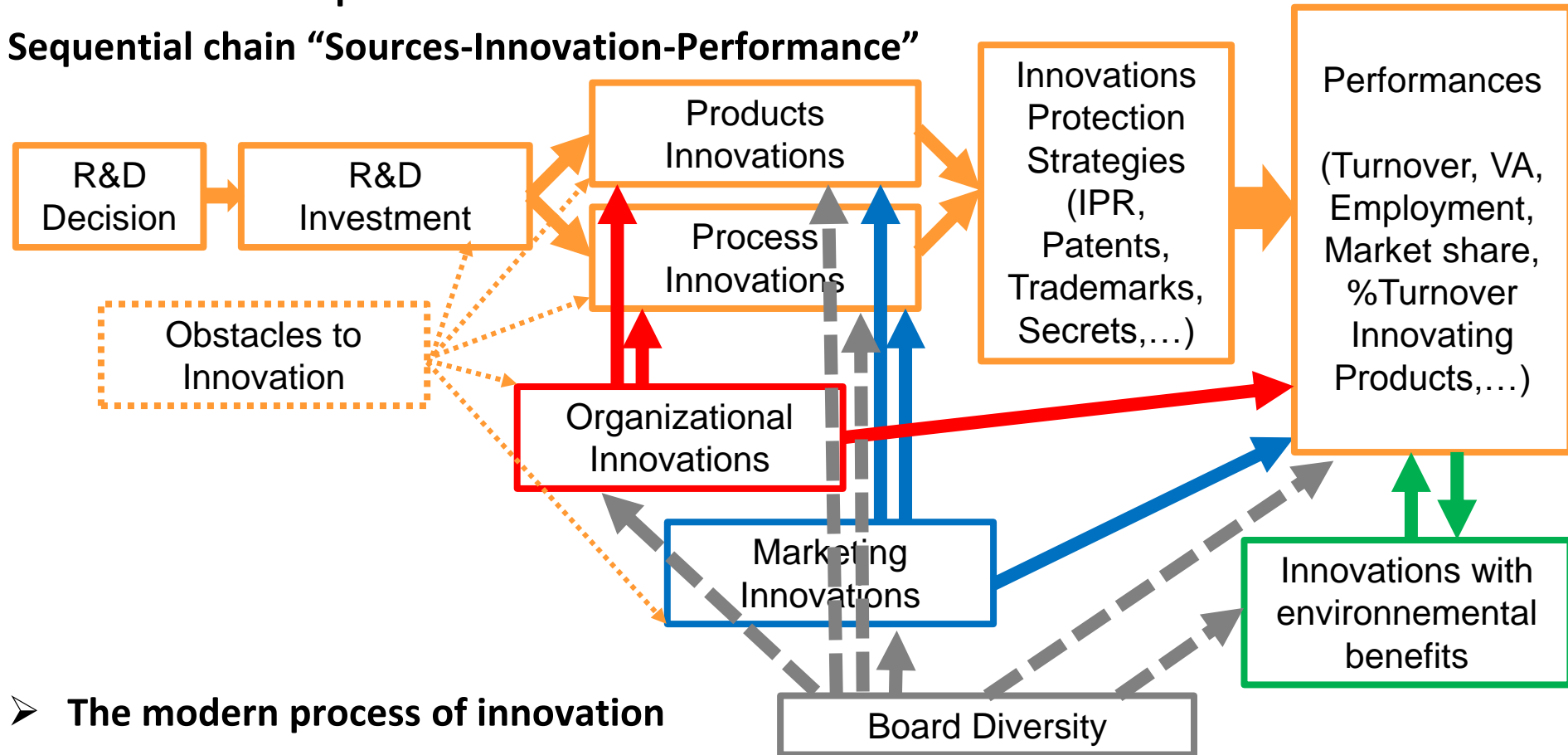
your **know-how**

or your **capabilities** for future enhancements

1. The process of innovation

➤ The traditional process of innovation

Sequential chain “Sources-Innovation-Performance”



➤ The modern process of innovation

- Integration of the Organizational Innovations and Marketing Innovations
- Implications for environment, CSR, and Sustainable Development

➤ Board diversity and innovation

1. The process of innovation

Oslo Manual (2005) classifies four main forms of innovation:

➤ **Product, Process, Organizational and Marketing** innovations

❑ **Product and Process innovations**
within the topic of **Technological Innovations**

- Demand pull
- and/or Technology push

Obstacles to
Innovation

❑ **Organizational and Marketing innovations**
within the topic of **Management Innovations**
or **Non-Technological Innovations**

- Understanding of organizational innovations
- Potential source of competitive advantage

The traditional
process
of innovation

The modern
process
of innovation

2. Innovation measures and CIS - Community Innovation Survey

French Community Innovation Survey (CIS) since 1990 (3 year period)

INSEE - National Statistical Office in France (20 000 firms - 8th wave in 2010-2012)

- **Innovation 1991 – Appendix of EAE "Firm Annual Survey" (1986-90)**
- **CIS1 (1990-92)**
- **CIS2 (1994-96)**
- **CIS3 (1998-00)**
- **CIS4 (2002-04)**
- **CIS5 (2004-06) "Overlapping data" with three years' CIS length Eurostat requirement**
- **CIS6 (2006-08)**
- **CIS7 (2008-10)**
- **CIS8 (2010-12)**
- **CIS9 (2012-14) Available December 2016**
- **CIS10 (2014-16) Survey validated during Summer 2016**



*Enquête communautaire sur
l'innovation 2012*

SIREN : xxx xxx xxx



Since 2005, I am Representative of the Scientific Community within Design Committee for the French Community Innovation Survey CIS, INSEE, Paris, France.

2. Innovation measures and CIS - Community Innovation Survey

Community Innovation Survey (CIS) since 1990 (3 year period)

INSEE - National Statistical Office in France (20 000 firms - 8th wave in 2010-2012)

▪ General information (size, sales, sector...)

▪ *Product (good or service) innovations [2 types] (0,1)*

- *New to the market*
- *Only new to the firm*

"A **product innovation** is the market introduction of a **new** good or service or a **significantly** improved good or service with respect to its **capabilities**, such as **quality, user friendliness, software** or **subsystems**.

The innovation must be new to your enterprise, but it does not need to be new to your market.

It does not matter if the innovation was originally developed by your enterprise or by other enterprises."

2. Innovation measures and CIS - Community Innovation Survey

Community Innovation Survey (CIS) since 1990 (3 year period)

INSEE - National Statistical Office in France (20 000 firms - 8th wave in 2010-2012)

▪ General information (size, sales, sector...)

▪ *Product (good or service) innovations [2 types] (0,1)*


- New to the *market*
- Only new to the *firm*

▪ *Process innovations [3 types] (0,1)*

- New or significantly improved *methods* for the manufacture or production
- New or significantly improved *logistics systems* or *delivery* or *distribution*
- New or significantly improved *supports activities* for its processes

▪ *Innovation activity in progress or abandoned (0,1)*

 If at least one YES among three: Firm is defined as **technological innovative firms**

 If NO to these 3 questions go directly to questions on Org. and Mkg. Innovations

2. Innovation measures and CIS - Community Innovation Survey

Community Innovation Survey (CIS)

- Innovation activities and expenditures
- Sources of information and co-operation for innovation
- Effects of innovations
- Objectives of innovations

- Obstacles to innovation: projects or activities of innovation
 - *Abandoned during conception / Abandoned at the beginning / Delayed projects*
Only for firms with technological innovating activities (Product, Process or Project)
 - CIS 2, 3, 4, 5 and 7 for all firms
 - CIS 9 only for non-innovating firms

- Obstacles to innovation for all firms (*Financial, Knowledge, Market obstacles*)

- Environmental benefits of innovation
- Strategies to reach objectives of the firm
- Protection methods for innovation

2. Innovation measures and CIS - Community Innovation Survey

Community Innovation Survey (CIS)

▪ *Organizational Innovations [4 types] (0,1)*

- *New business practices in the organization of the work or of the company procedures*
- *New knowledge management systems to improve the use or exchange of information, knowledge and ability, within the company, or so as to collect information outside of the Company*
- *New organization methods for the workplaces in the company, for the purpose of a better distribution of responsibilities and decision-making*
- *New management models for external relations with other companies or public institutions*

2. Innovation measures and CIS - Community Innovation Survey

Community Innovation Survey (CIS)

▪ *Marketing Innovations [4 types] (0,1)*

- *Design: If the firm introduces significant modifications in the design of the product or in the packaging of the goods or services*
- *Product promotion: If the firm introduces new techniques or channels for the promotion of the product*
- *Product positioning: If the firm introduces new methods for the positioning of the product in the market or sales channels*
- *Establishing prices: If the firm introduces new methods for establishing the prices of the goods or services*

3. Obstacles to innovation

Studies on obstacles to innovation

using Community Innovation Survey (CIS):

- Mainly aimed at understanding their **impact on firm's attitude towards R&D activities and propensity/intensity of innovation**

(Arundel, 1997; Asso and Vito, 2010; Blanchard et al., 2012; Hyytinen and Toivanen, 2005; Mohnen and Röller, 2005; Mohnen et al., 2008; Savignac, 2008; Segarra-Blasco et al., 2007; Tiwari et al., 2008; Tourigny and Le, 2004; Mancusi and Vezzulli, 2010; Wziatek-Kubiak and Peczkowski, 2011)

- Minor attention has been paid to the **determinants of obstacles to innovation**

(Baldwin and Lin, 2002; D'Este et al., 2012; Galia and Legros, 2004; Hölzl and Janger, 2011; Iammarino et al., 2009; Mohnen and Rosa, 2000; Schneider and Veugelers, 2008; Tourigny and Le, 2004)

3. Obstacles to innovation

Obstacles to innovation:

- *Cost and Financial*
- *Knowledge*
- *Market*
- *Institutional*
- *Other reasons for not innovating*

(Oslo Manual, 2005)

Table 7.2. Factors hampering innovation activities

Relevant for:	Product innovations	Process innovations	Organisational innovations	Marketing innovations
Cost factors:				
Excessive perceived risks	*	*	*	*
Cost too high	*	*	*	*
Lack of funds within the enterprise	*	*	*	*
Lack of finance from sources outside the enterprise:				
Venture capital	*	*	*	*
Public sources of funding	*	*	*	*
Knowledge factors:				
Innovation potential (R&D, design, etc.) insufficient	*	*		*
Lack of qualified personnel:				
Within the enterprise	*	*		*
In the labour market	*	*		*
Lack of information on technology	*	*		
Lack of information on markets	*			*
Deficiencies in the availability of external services	*	*	*	*
Difficulty in finding co-operation partners for:				
Product or process development	*	*		
Marketing partnerships				*
Organisational rigidities within the enterprise:				
Attitude of personnel towards change	*	*	*	*
Attitude of managers towards change	*	*	*	*
Managerial structure of enterprise	*	*	*	*
Inability to devote staff to innovation activity due to production requirements	*	*		
Market factors:				
Uncertain demand for innovative goods or services	*			*
Potential market dominated by established enterprises	*			*
Institutional factors:				
Lack of infrastructure	*	*		*
Weakness of property rights	*			*
Legislation, regulations, standards, taxation	*	*		*
Other reasons for not innovating:				
No need to innovate due to earlier innovations	*	*	*	*
No need because of lack of demand for innovations	*			*

3.1. Obstacles to innovation – Study #1 (RP, France, 2004)

Community Innovation Survey (CIS)

Obstacles to innovation (1772 firms)

Obstacles	Description	Postponed projects (%)	Abandoned projects (%)	
OBS1	ECO RISK	Excessive perceived economic risk	21.3	18.7
OBS2	COSTS	Innovation costs too high	19.9	14.7
OBS3	FINANCING	Lack of appropriate source of finance	13.8	5.8
OBS4	RIGID ORG	Resistance of change in the firm (rigid organization)	16.6	3.3
OBS5	SKILLED	Lack of skilled personnel	21.2	3.4
OBS6	INFO TECH	Lack of information on technologies	17.0	5.5
OBS7	INFO MARK	Lack of information on markets	16.2	4.4
OBS8	INSTITUT	Legislation, regulations, norms, standards	14.2	3.7
OBS9	CUSTOMER	Lack of customer responsiveness to new products and processes	18.8	9.2
Met at least one obstacle		67.6 (1197)	39.3(696)	

Source: SESSI (1997).

CIS2 -1994-96: main obstacles are, compared to **financial constraints:**

➡ **Lack of skilled personnel**

➡ **Resistance of change in the firm (rigid organization)**

Galia, F. and Legros, D. (2004). Complementarities between Obstacles to Innovation: Evidence from France. *Research Policy*, Vol. 33, No. 8, pp. 1185-1199 [A+ Ranked Journal, CNRS List Ranked no. 1]..

3.1. Obstacles to innovation – Study #1 (RP, France, 2004)

Complementarities and innovation

Complementarities:

Intuitive ideas of **synergies**, **systems** effects and **mutual** reinforcement
i.e. “the whole is more than the sum of the parts”

Mathematical concept of lattices and qualitative variables (0,1)

Vienott (1989), Topkis (1998), Vives (1999), Amir (2004),
Milgrom and Roberts (1990, 1995), Athey and Stern (1998)

*A practice is more likely to be adopted at a higher level
if other practices are adopted at high level, too*

3.1. Obstacles to innovation – Study #1 (RP, France, 2004)

Empirical literature studying complementarities between various practices or strategies:

 **Three types of approaches** - Athey and Stern (1998):

- 1** - Testing the positive **correlation** between various practices **conditional** on a certain number of **common explanatory variables** (**CORR**)
 - 2** - Factor which has an effect on one variable will not be **correlated** with another variable unless the **variables are complementary** (**RED**)
 - 3** - Modeling **firm's objective function** by a set of regressors, including the interactions effects or clusters between several practices or strategies (**PROD**)
- + **3 ext.** - Theoretical concept of **supermodularity** within the mathematical concept of lattices (**SUPERMOD**)

3.1. Obstacles to innovation – Study #1 (RP, France, 2004)

- Multivariate probit model: 9 equations estimating the 9 obstacles to innovation

Table 4
Multivariate probit model of obstacles to innovation in postponed projects (1772 firms)

	ECO RISK	COSTS	FINANCING	RIGID ORG	SKILLED	INFO TECH	INFO MARK	INSTITUT	CUSTOMER
Intercept	-0.900***(0.146)	-0.821***(0.151)	-1.182***(0.163)	-1.380***(0.165)	-0.908***(0.151)	-1.264***(0.172)	-1.312***(0.162)	-1.289***(0.170)	-1.117***(0.157)
Nb empl. (log)	0.011(0.032)	-0.020(0.032)	0.022(0.036)	0.040(0.035)	-0.023(0.031)	-0.001(0.034)	0.015(0.034)	-0.019(0.034)	-0.003(0.033)
Med. low tech.	-0.184** (0.090)	0.038(0.095)	-0.019(0.106)	-0.070(0.099)	0.069(0.091)	0.019(0.101)	0.063(0.099)	0.182(0.116)	-0.032(0.094)
Med. high tech.	-0.098(0.100)	0.154(0.103)	0.162(0.111)	0.042(0.106)	0.039(0.101)	0.091(0.106)	0.228** (0.106)	0.475*** (0.122)	0.065(0.101)
High tech.	-0.185(0.140)	0.041(0.142)	0.072(0.159)	-0.315** (0.157)	-0.243* (0.151)	-0.083(0.146)	-0.051(0.151)	0.587*** (0.151)	-0.394*** (0.154)
French group	-0.086(0.104)	-0.215** (0.105)	-0.337*** (0.117)	-0.050(0.119)	-0.015(0.104)	0.029(0.115)	0.064(0.111)	-0.307** (0.120)	0.019(0.107)
Foreign group	-0.087(0.110)	-0.344*** (0.107)	-0.438*** (0.117)	0.107(0.117)	0.127(0.106)	-0.012(0.113)	-0.085(0.112)	-0.206* (0.116)	0.123(0.107)
Internal R&D	0.213** (0.097)	0.102(0.097)	0.169(0.113)	0.258** (0.112)	0.100(0.099)	0.135(0.105)	0.161(0.114)	0.271** (0.118)	0.124(0.105)
External R&D	-0.169** (0.084)	-0.058(0.086)	-0.134(0.093)	-0.038(0.090)	-0.020(0.083)	0.202** (0.085)	0.027(0.089)	0.080(0.095)	0.118(0.086)
Training	0.179** (0.077)	0.094(0.082)	0.110(0.092)	0.029(0.086)	0.205*** (0.077)	0.028(0.083)	-0.032(0.084)	-0.067(0.091)	0.016(0.082)
Cooperation	0.084(0.079)	0.222*** (0.083)	0.112(0.091)	0.038(0.084)	0.088(0.079)	0.189** (0.081)	0.074(0.086)	0.011(0.088)	0.161** (0.083)

- Estimate of the disturbance covariance matrix

Table 5
Estimate of the disturbance covariance matrix—obstacles to innovation in postponed projects (1772 firms)

	ECO RISK	COSTS	FINANCING	RIGID ORG	SKILLED	INFO TECH	INFO MARK	INSTITUT
ECO RISK	1							
COSTS	0.37(0.044)	1						
FINANCING	0.29(0.051)	0.44 (0.045)	1					
RIGID ORG	0.10(0.052)	0.11 (0.053)	0.36 (0.052)	1				
SKILLED	0.12(0.049)	0.14 (0.049)	0.34 (0.050)	0.46 (0.043)	1			
INFO TECH	-0.02 ^{n.s.} (0.053)	0.16 (0.052)	0.19 (0.056)	0.39 (0.047)	0.49 (0.041)	1		
INFO MARK	0.17(0.051)	0.10 (0.052)	0.21 (0.056)	0.41 (0.046)	0.33 (0.047)	0.41 (0.047)	1	
INSTITUT	0.18(0.054)	0.19 (0.055)	0.25 (0.058)	0.42 (0.050)	0.28 (0.052)	0.37 (0.052)	0.50 (0.046)	1
CUSTOMER	0.23(0.048)	0.16 (0.051)	0.15 (0.054)	0.27 (0.049)	0.19 (0.048)	0.29 (0.048)	0.49 (0.042)	0.38 (0.049)

Between parentheses are standard deviation. Correlation coefficients in bold indicate higher values of correlation. Source: SESSI (1997).

3.1. Obstacles to innovation – Study #1 (RP, France, 2004)

- Multivariate probit model: 9 equations estimating the 9 obstacles to innovation

Table 6
Multivariate probit model of obstacles to innovation in abandoned projects (1772 firms)

	ECO RISK	COSTS	FINANCING	RIGID ORG	SKILLED	INFO TECH	INFO MARK	INSTITUT	CUSTOMER
Intercept	-1.624***(0.160)	-1.357***(0.163)	-1.414***(0.210)	-1.967***(0.297)	-1.917***(0.246)	-1.855***(0.244)	-1.757***(0.271)	-1.660***(0.279)	-1.752***(0.185)
Nb empl. (log)	0.112***(0.032)	0.024(0.035)	-0.046(0.050)	0.015(0.068)	0.030(0.047)	0.023(0.050)	-0.006(0.062)	-0.055(0.063)	0.094***(0.039)
Med. low tech.	-0.187***(0.096)	-0.146(0.103)	-0.043(0.149)	-0.187(0.181)	-0.062(0.161)	-0.213(0.158)	-0.014(0.158)	0.078(0.205)	-0.006(0.120)
Med. high tech.	-0.079(0.105)	0.056(0.109)	-0.006(0.157)	0.013(0.187)	-0.195(0.198)	-0.158(0.172)	-0.071(0.171)	0.113(0.221)	-0.006(0.129)
High tech.	-0.104(0.137)	-0.077(0.149)	-0.037(0.222)	0.109(0.270)	-0.125(0.252)	-0.186(0.199)	-0.033(0.250)	0.533****(0.247)	-0.034(0.174)
French group	0.088(0.108)	-0.003(0.117)	0.079(0.156)	0.046(0.210)	0.049(0.184)	0.176(0.164)	0.074(0.208)	0.027(0.198)	-0.003(0.141)
Foreign group	-0.006(0.113)	-0.013(0.123)	-0.125(0.161)	0.073(0.228)	0.108(0.187)	0.040(0.181)	0.144(0.197)	-0.127(0.213)	-0.120(0.136)
Internal R&D	0.172(0.110)	0.266***(0.114)	0.027(0.146)	0.065(0.193)	-0.080(0.182)	0.114(0.167)	0.008(0.184)	-0.085(0.175)	-0.094(0.134)
External R&D	0.025(0.089)	0.026(0.088)	0.133(0.127)	0.027(0.166)	0.310***(0.148)	0.102(0.124)	-0.009(0.141)	-0.035(0.180)	-0.037(0.108)
Training	-0.082(0.083)	0.047(0.086)	-0.051(0.121)	-0.152(0.168)	-0.037(0.163)	-0.096(0.127)	-0.029(0.141)	0.023(0.140)	0.049(0.102)
Cooperation	0.132(0.085)	-0.024(0.086)	0.116(0.129)	0.078(0.169)	-0.170(0.154)	0.163(0.132)	0.063(0.173)	0.259****(0.153)	0.060(0.105)

- Estimate of the disturbance covariance matrix

Table 7
Estimate of the disturbance covariance matrix—obstacles to innovation in abandoned projects (1772 firms)

	ECO RISK	COSTS	FINANCING	RIGID ORG	SKILLED	INFO TECH	INFO MARK	INSTITUT
ECO RISK	1							
COSTS	0.48 (0.044)	1						
FINANCING	0.34 (0.070)	0.53 (0.062)	1					
RIGID ORG	0.28 (0.085)	0.25 (0.096)	0.61 (0.081)	1				
SKILLED	0.15 ^{n.s.} (0.095)	0.42 (0.081)	0.38 (0.094)	0.49 (0.011)	1			
INFO TECH	0.16 (0.080)	0.29 (0.074)	0.32 (0.092)	0.40 (0.011)	0.54 (0.085)	1		
INFO MARK	0.29 (0.076)	0.27 (0.084)	0.31 (0.011)	0.35 (0.013)	0.40 (0.099)	0.36 (0.011)	1	
INSTITUT	0.36 (0.076)	0.43 (0.078)	0.35 (0.011)	0.49 (0.014)	0.38 (0.012)	0.45 (0.093)	0.40 (0.013)	1
CUSTOMER	0.38 (0.054)	0.33 (0.059)	0.25 (0.077)	0.28 (0.010)	0.23 (0.094)	0.20 (0.088)	0.35 (0.083)	0.52 (0.077)

Between parentheses are standard deviation. Correlation coefficients in bold indicate higher values of correlation. *Source*: SESSI (1997).

3.1. Obstacles to innovation – Study #1 (RP, France, 2004)

F. Galia, D. Legros / Research Policy 33 (2004) 1185–1199

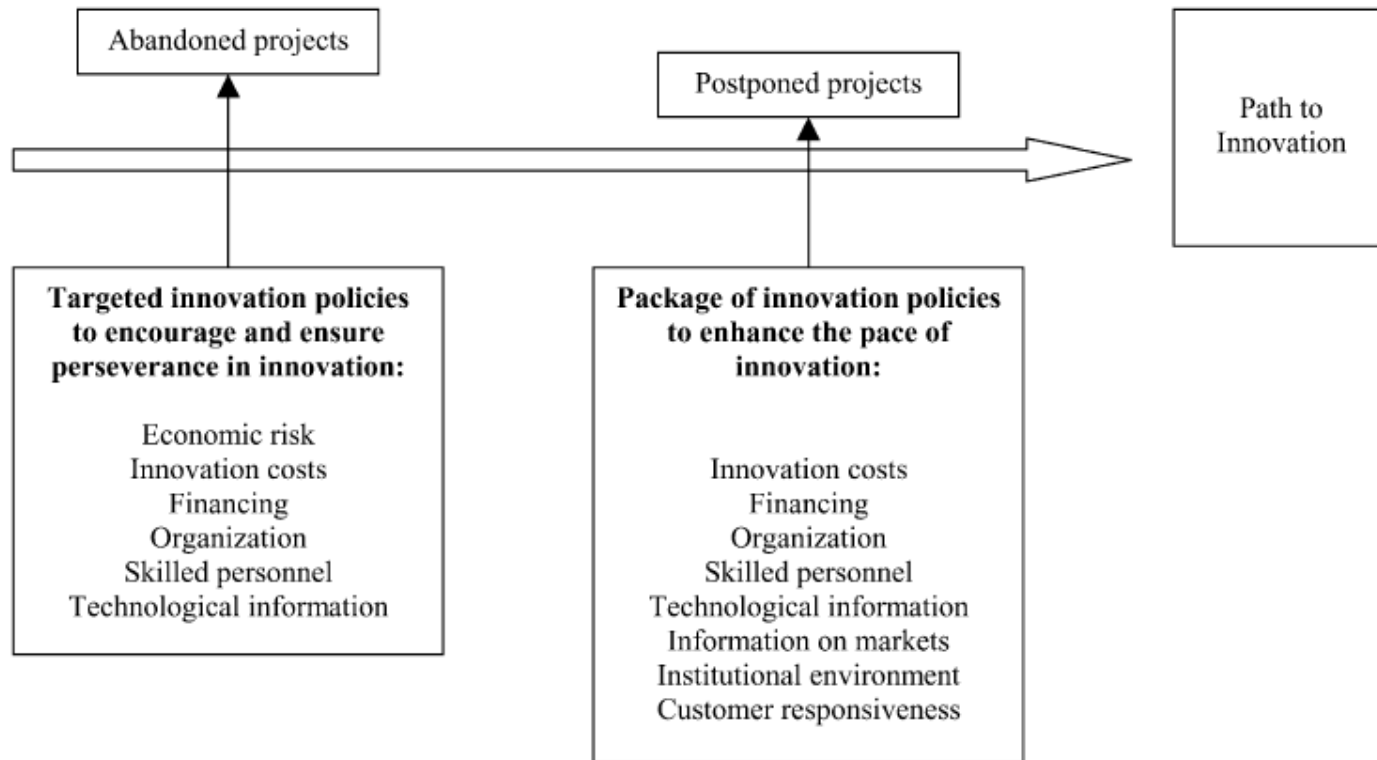


Fig. 1. Innovation policies on the path to innovation.

Economic and managerial implications of complementarities between obstacles

- **Futile to combat them individually and separately**
- **Synergies in a coherent manner**

3.2. Obstacles to innovation – Study #2 (ICBM, France and Italy, 2015)

Different types of obstacles:

- **Revealed barriers** to innovation: reflects the degree of difficulty of the innovation process and the learning experience consequent on the firm engaging in innovation activity
- **Deterring barriers** to innovation: encompasses the obstacles that prevent firms from committing to innovation

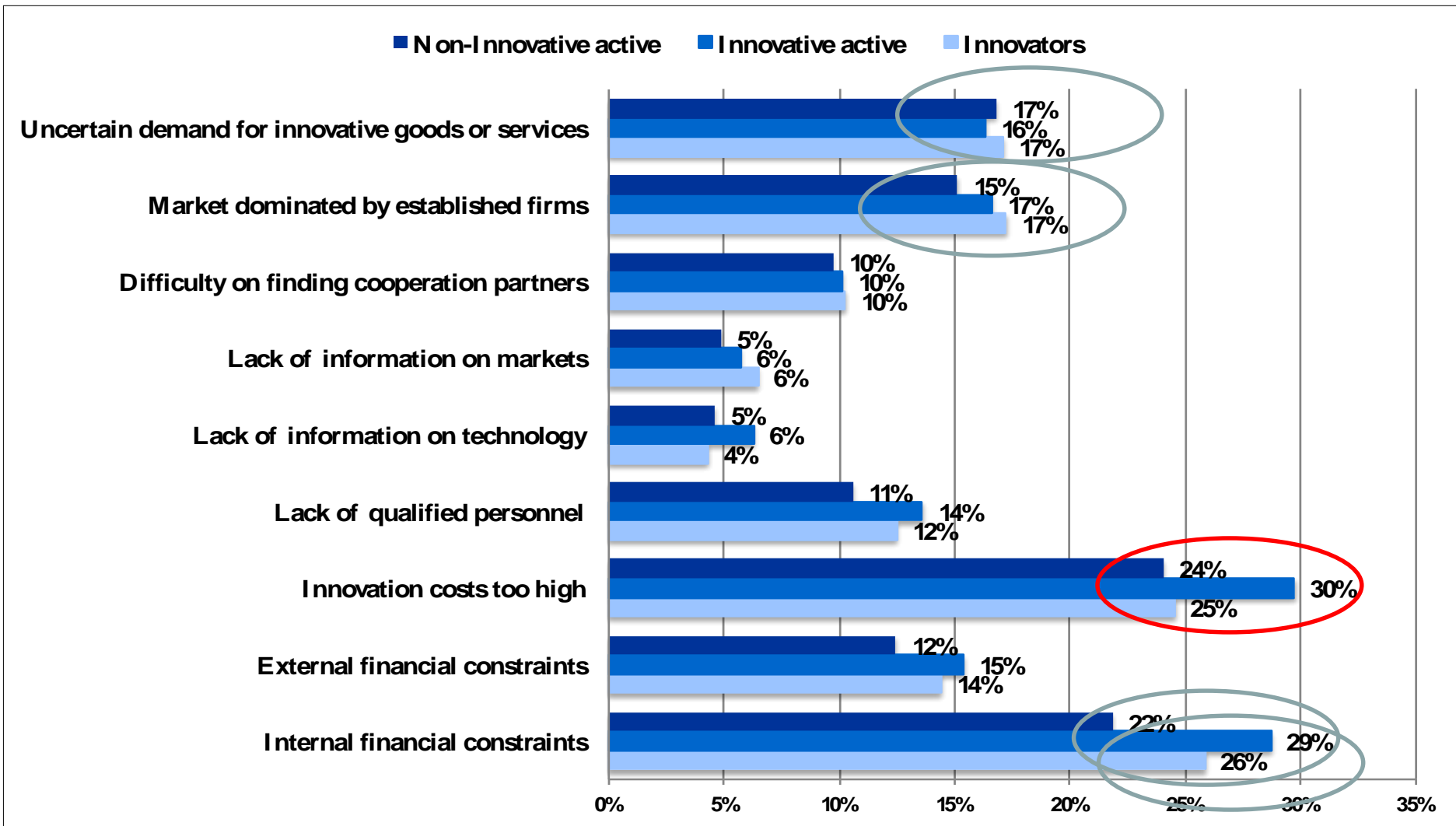
D'Este, P., Iammarino, S., Savona, M., and von Tunzelmann, N. (2012) What hampers innovation? Revealed barriers versus deterring barriers. *Research Policy* 41(2), 482–488.

Determinants of obstacles to innovation within innovation profiles:

- **Innovators**: firms that introduce product or process innovation (6364 firms, 30.7%)
- **Innovative active**: firms engaged into innovation activities but without reaching the expected output (1063 firms, 5.1%)
- **Non-innovative active**: firms not involved in innovation activities (13320 firms, 64.2%)

Galia, F., Mancini S. and Morandi, V. (2015), Obstacles to Innovation and Firms Innovation Profiles: Are Challenges Different for Policy Makers?, *ICBM – 1st International Conference on Business Management*, 2-3 June 2015, Valencia, Spain.

3.2. Obstacles to innovation – Study #2 (ICBM, France and Italy, 2015)



3.2. Obstacles to innovation – Study #2 (ICBM, France and Italy, 2015)

CIS4 in France and Italy: “L’Innovation” - Community Innovation Survey (CIS)

2002-2004 - 20,747 manufacturing and services sectors firms

Predominant impediments for each innovative profile:

- **internal financial constraints**
- innovation **costs** too high
- **market dominated** by established firms
- **uncertain demand** for innovative goods or services

The only evident difference among innovation profiles:

- **economic barriers perceived by *Innovative-active* firms**
- suggests that the high costs involved in innovation projects and the lack of internal financial resources have an high probability to delay or giving up the innovation development

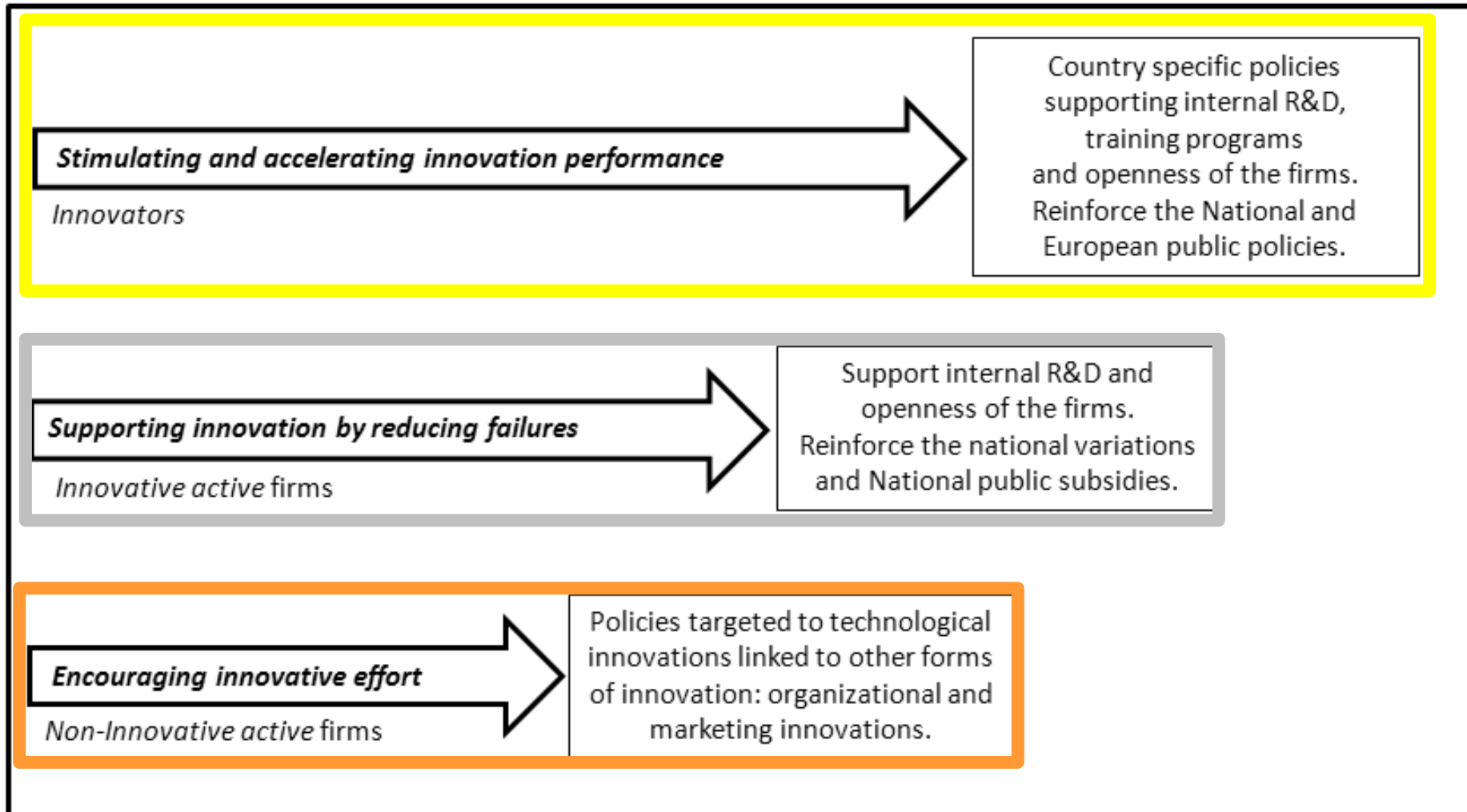
3.2. Obstacles to innovation – Study #2 (ICBM, France and Italy, 2015)

- **Multivariate probit models** explaining obstacles to innovation that allow taking into account the **possible interdependence** between the perception of different types of obstacles

Dependent variables:

- Types of innovation activities: Internal R&D, External R&D, Equipment, Knowledge, Training, Marketing, Cooperation
- Sources of information (9 types)
- Ability to appropriate the results of innovative activities
- Public financial support: National, EU
- Wider innovation: Organizational, Marketing
- Size
- High growth
- Group membership
- Industry dummies
- Competition
- International and/or national market
- Country specific effect (impact of national innovation system)

3.2. Obstacles to innovation – Study #2 (ICBM, France and Italy, 2015)



3.2. Obstacles to innovation – Study #2 (ICBM, France and Italy, 2015)

Pro-innovation public policies should take into account that the **causes** of the **perception of obstacles vary across innovation profiles**

Thus, both to stimulate the **involvement of *Non-innovative active*** firms in innovation activities, to **enhance innovative efforts** of the other firms and to **help firms in introducing innovation**, **pro-innovation policies** should aim:

- First: **reducing economic and financial obstacles**
- Secondly: **helping firms in facing market-related obstacles**

Nature of the most perceived obstacles is similar across the three innovation profiles (*Innovators, Innovative active* and *Non-innovative active*):

- internal financial constraints, innovation costs too high, market dominated by established firms and uncertain demand for innovative goods or services
- Hampering effect of **innovation costs** is more evident for ***Innovative active* firms**

3. Obstacles to innovation: Conclusion

- Better understanding of the factors hampering innovation and the determinants of these obstacles in order to suggest how innovation could be stimulated or facilitated
- **Nature of the most perceived obstacles seems to be similar across the firms' innovation profiles**: internal financial constraints, innovation costs too high, market dominated by established firms and uncertain demand for innovative goods or services
- Hampering effect of **innovation costs** is more evident for ***Innovative active firms***
- However, the **drivers of the perception of obstacles vary** across different **types of obstacle** and, at the same time, vary across **innovation profiles**
- Thus, public policies aimed at **supporting innovation development** may **differ from** the ones targeted to **encourage innovation activities**

3. Obstacles to innovation: Conclusion

Next steps:

- panels of CIS data avoiding overlapping of data period
- international comparison including France and Italy
- disaggregated analysis of sectors (manufacturing / services)
- link information focused on obstacles to innovation and cooperation

4. The Fateful Triangle: Complementarities in Performance between Product, Process and Organizational Innovation

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The fateful triangle: Complementarities in performance between product, process and organizational innovation in France and the UK[☆]



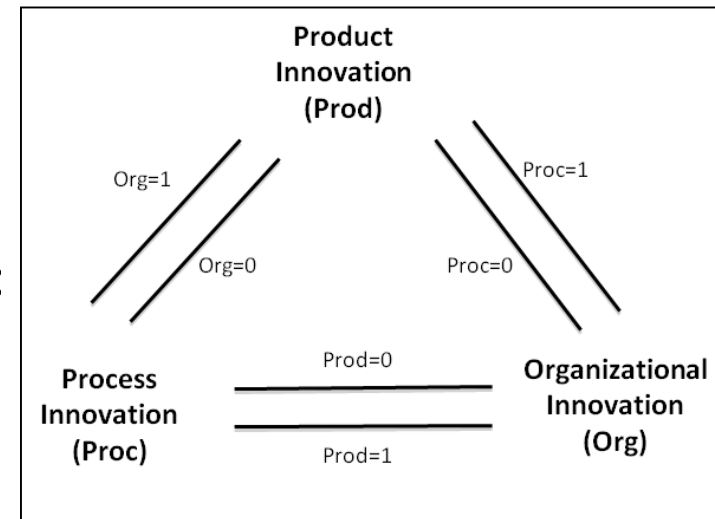
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➤ Explore the **triangle** of relationships between:

➤ **Product innovation**

➤ **Process innovation**

➤ and **Organizational innovation**

Ballot, G., Fakhfakh, F., Galia, F. and Salter, A. (2016). "The Fateful Triangle: Complementarities in Performance between Product, Process and Organizational Innovation in France and the UK", *Research Policy*, Vol. 44, No. 1, pp. 217-232 [A+ Ranked Journal, CNRS List Ranked no. 1].

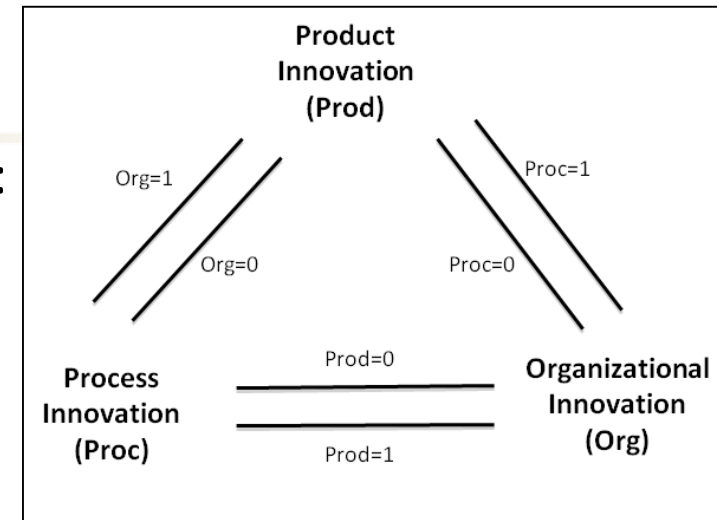
4. The Fateful Triangle

➤ Explore the **triangle** of relationships between:

➤ **Product innovation**

➤ **Process innovation**

➤ and **Organizational innovation**



➤ Examine the **complementarities-in-performance**: the **effects of** complementarities and substitutions between these forms of innovation on the **performance** of the firms

➤ Implement a **new testing procedure** for complementarity: **conditional vs. unconditional** tests

➤ **Test if the triangle depends on:**

○ **National context**: France and the UK

○ **Size** of firms

○ **Capabilities** of firms (R&D)

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4. The Fateful Triangle: Complementarities in Performance between Product, Process and Organizational Innovation

Motivation

➤ Results should bring some light on:

- **Theoretical issues:** the firm according to Milgrom & Roberts (1990) benefits from having certain complementary practices
- Is this prediction **supported by the data** (*i.e.* all innovation forms complementary)?
- If not, are there **partial complementarities**?
- **Foundations for the theory:** new products may require new processes and new methods of management, marketing... (Damanpour & Evan, 1984; Damanpour, 1991; Freeman & Soete, 1997; Birkinshaw, Hamel & Mol, 2008; Mol & Birkinshaw, 2009)...

4. The Fateful Triangle: Complementarities in Performance between Product, Process and Organizational Innovation

Empirical literature studying complementarities between various practices or strategies:

 **Three types of approaches** - Athey and Stern (1998):

- 1 - Testing the positive **correlation** between various practices **conditional** on a certain number of **common explanatory variables** (**CORR**)
 - 2 - Factor which has an effect on one variable will not be **correlated** with another variable unless the **variables are complementary** (**RED**)
 - 3 - Modeling **firm's objective function** by a set of regressors, including the interactions effects or clusters between several practices or strategies (**PROD**)
- + **3 ext.** - Theoretical concept of **supermodularity** within the mathematical concept of lattices (**SUPERMOD**)

4. The Fateful Triangle: Complementarities in Performance between Product, Process and Organizational Innovation

Innovation and complementarities literature

Two axes of economic/management literature on sources of innovation and the effects of innovation on firm performance

➤ First axis: Sequential chain “Sources-Innovation-Performance”

Long history of econometric studies on the effects of **R&D** on *technological innovation* and the two main forms: **product** and **process**

Mairesse & Mohnen (2005) for a survey, Crépon-Duguet-Mairesse (1998), Leiponen (2000)...

Recent extensions on organizational and marketing innovation: Mol & Birkinshaw (2009), Schmidt & Rammer (2007)

4. The Fateful Triangle: Complementarities in Performance between Product, Process and Organizational Innovation

Innovation and complementarities literature

Two axes of economic/management literature on sources of innovation and the effects of innovation on firm performance

➤ Second axis: Complementarities and innovation

Complementarities:

Intuitive ideas of **synergies**, **systems** effects and **mutual** reinforcement
i.e. “the whole is more than the sum of the parts”

Mathematical concept of lattices and qualitative variables (0,1)

Vienott (1989), Topkis (1998), Vives (1999), Amir (2004),
Milgrom and Roberts (1990, 1995), Athey and Stern (1998)

*A practice is more likely to be adopted at a higher level
if other practices are adopted at high level, too*

4. The Fateful Triangle: Complementarities in Performance between Product, Process and Organizational Innovation

Two axes of economic/management literature on sources of innovation and the effects of innovation on firm performance

➤ **Second axis: Complementarities and innovation**

a) “Traditional” methods - *Complementarities-in-use*: two sets of activities are linked, the use of one practice often requires the use of other practices

Schmidt & Rammer (2007), Roper, Du, Love (2008), Evangelista & Vezzani (2010), Ballot et al. (2011)

b) Supermodularity theory and tests - *Complementarities-in-performance*: performance effects of the use of different practices in combination with one another

i) **General theory:** Milgrom & Roberts (1990,1995)

ii) Complementarities between **sources** of innovation with appropriate econometric tests of **supermodularity** and **submodularity**: Cassiman & Veughelers (2006), Mohnen & Röller (2005), Belderbos, Carre, Lokshin (2006)

iii) Complementarities between **forms** of innovation: Corrazin & Percival (2006), Percival & Corrazin (2008)

c) Trying to study the innovation chain *and* the complementarities in innovation forms: Polder, Leuwen, Mohnen, Raymond (2010, being revised)

4. The Fateful Triangle: Complementarities in Performance between Product, Process and Organizational Innovation

France and UK CIS4 - 2002-2004, Manufacturing firms

Total sample of firms

for the Heckman test

- ❑ **UK: 3627 firms**
- ❑ **France: 5691 firms**
- ❑ *Pooled: 9318 firms*

Sample of firms which innovate or try to

innovate used for the production functions of the innovation forms

- ❑ **UK: 2014 firms**
- ❑ **France: 3201 firms**
- ❑ *Pooled: 5215 firms*

Table 1: Definition of variables and descriptive statistics (firms with technological innovating activities – Product, Process or Project – and all firms¹)

<i>Name of variables</i>	<i>Description</i>	<i>Pooled</i> 5215 firms (9318 firms)	<i>UK</i> 2014 firms (3627 firms)	<i>France</i> 3201 firms (5691 firms)
Product innovation	If the firm introduces a product that is new-for-the-market (0,1)	50.74 % (28.40 %)	49.35% (27.40 %)	51.61% (29.03 %)
Process innovation	If the firm introduces a new process (0,1)	67.69 % (37.88 %)	55.16% (30.63 %)	75.57% (42.50 %)
Organizational innovation	If one of the following: new or significant improved organizational structure, system for managing knowledge, or marketing activities (0,1)	63.97 % (46.39 %)	60.43% (43.64 %)	66.20% (48.15 %)

4. The Fateful Triangle: Complementarities in Performance between Product, Process and Organizational Innovation

- Explore the forms of innovation and combinations (eight exclusive combinations (*Wijk*))

Table 2: Descriptive statistics of forms of innovations and the eight exclusive associated combinations

	<i>Pooled</i>	<i>UK</i>	<i>France</i>
Product innovation	2646 (50.74%)	994 (49.35%)	1652 (51.61%)
Process innovation	3530 (67.69%)	1111 (55.16%)	2419 (75.57%)
Organizational innovation	3336 (63.97%)	1217 (60.43%)	2119 (66.20%)
Product innovation only (W100)	374 (7.17%)	192 (9.53%)	182 (5.69%)
Process innovation only (W010)	637 (12.21%)	229 (11.37%)	408 (12.75%)
Organizational innovation only (W001)	395 (7.57%)	229 (11.37%)	166 (5.19%)
Product and process innovation (W110)	423 (8.11%)	137 (6.80%)	286 (8.93%)
Product and organizational innovation (W101)	471 (9.03%)	243 (12.07%)	228 (7.12%)
Process and organizational innovation (W011)	1092 (20.94%)	323 (16.04%)	769 (24.02%)
All forms of innovations (W111)	1378 (26.42%)	422 (20.95%)	956 (29.87%)
None (W000)	445 (8.53%)	239 (11.86%)	206 (6.44%)
Nb of firms with technological innovating activities (Product, Process and/or Project)	5215	2014	3201

Sources: CIS 4 (UK and France)

4. The Fateful Triangle: Complementarities in Performance between Product, Process and Organizational Innovation

Two approaches for testing complementarities:

- **4.1 Complementarities-in-use:** two sets of activities are linked, the use of one practice often requires the use of other practices (CORR and RED)
 - Identify the relatedness in the use of different practices
 - Find evidence that some practices are usually combined with others
 - **Descriptive statistics, trivariate probit, multinomial logit**
- **4.2 Complementarities-in-performance:** performance effects of the use of different practices in combination with one another (PROD and SUPERMOD)
 - Direct test of the economic value and performance
 - Mutual product of the joint use of practices produce economic benefits that are greater than the individual parts
 - **Heckman OLS regression on labour productivity as a performance function with test of the endogeneity of Wijk for supermodularity tests**

4. The Fateful Triangle: Complementarities in Performance between Product, Process and Organizational Innovation

➤ Qualitatives Variables: Mathematical concept of lattices

Vienott (1989), Topkis (1998), Vives (1999), Amir (2004), Milgrom and Roberts (1995), Athey and Stern (1998)

➤ The theory of supermodularity based on Topkis (1978) lattice theory allows for the discreteness of the factors/strategies, notably taking binary values (present (1), absent (0)).

➤ **Supermodularity**: performance function $f(x_1, x_2)$

➤ Case of two types of innovation: Product (x_1) and Process (x_2):


$$f(1,1) - f(0,1) > f(1,0) - f(0,0)$$

Introducing Product innovation (x_1) is more efficient-productive when Process innovation (x_2) is introduced simultaneously

➤ $f(x_1, x_2)$ is supermodular

➤ Two practices: only one inequality constraint

4. The Fateful Triangle: Complementarities in Performance between Product, Process and Organizational Innovation

➤ Case of **three types of innovation**:

Product (x1), Process (x2) and Organization (x3):

- Set of eight exclusive combinations **$W1i1j1k$** from W000 to W111 where $1_i=1$ if the firm introduces a **product** innovation; zero otherwise, $1_j=1$ if the firm introduces a **process** innovation; zero otherwise, and $1_k=1$ if the firm introduces an **organizational** innovation; zero otherwise

➤ **Supermodularity**: performance function **$f(x1,x2,x3)$**

- Testing complementarity between Product (x1) and Process (x2)
NOT only one inequality constraint,

➡ but **TWO inequality constraints**

$f(1,1,0) - f(0,1,0) > f(1,0,0) - f(0,0,0)$ when ORG is absent

$f(1,1,1) - f(0,1,1) > f(1,0,1) - f(0,0,1)$ when ORG is present

4. The Fateful Triangle: Complementarities in Performance between Product, Process and Organizational Innovation

- Testing **complementarity** between Product (x1) and Process (x2)
NOT only one inequality constraint, but TWO inequality constraints

$$f(1,1,0) - f(0,1,0) > f(1,0,0) - f(0,0,0) \text{ when ORG is absent}$$

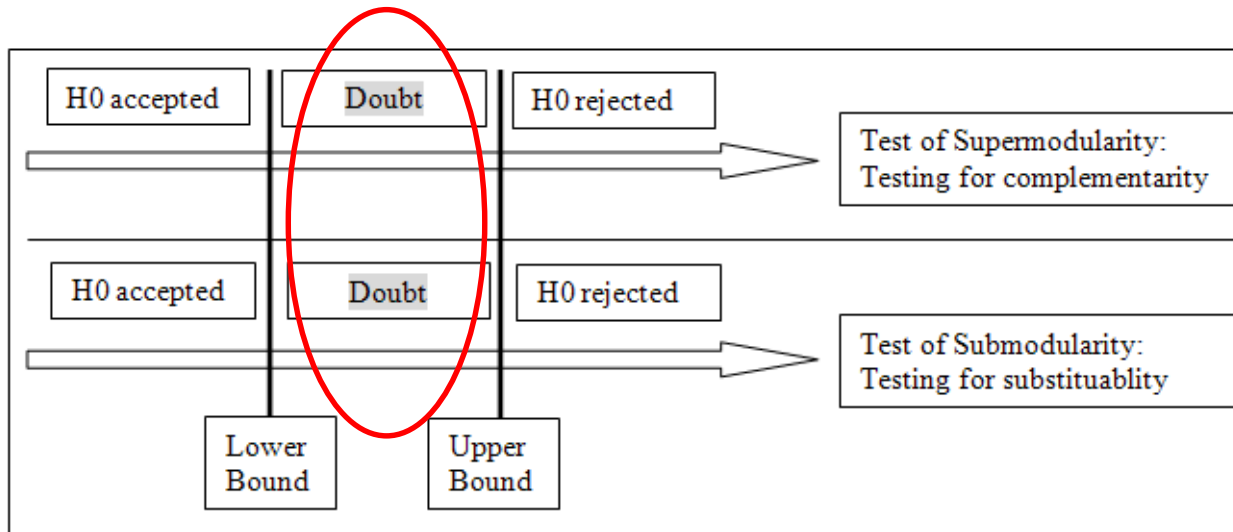
$$f(1,1,1) - f(0,1,1) > f(1,0,1) - f(0,0,1) \text{ when ORG is present}$$

- Testing **substituability** is replacing '>' by '<'
- Testing these **two inequality constraints together**:
unconditional complementarity (Kodde & Palm, 1986),
but can lead to inconclusive interpretations
- We then **introduced a more detailed approach** than the literature:
Testing these two inequality constraints individually:
conditional complementarity

4. The Fateful Triangle: Complementarities in Performance between Product, Process and Organizational Innovation

- **Unconditional complementarity tests** (Kodde & Palm, 1986) can lead to inconclusive interpretations

Appendix 1: Testing complementarity and substitutability of the 7 possible cases of interpretation (Kodde-Palm LR tests)



Critical values for two constraints:

at 5% level: lower bound (df=1) = 2.706 and upper bound (df=2) = 5.138

at 1% level: lower bound (df=1) = 5.412 and upper bound (df=2) = 8.273

We accept H0 if LR statistic is smaller than the lower bound. We reject H0 if this LR statistic is larger than the upper bound. If this statistic is between the bounds, the outcome is within the doubt region.

4. The Fateful Triangle: Complementarities in Performance between Product, Process and Organizational Innovation

- **Unconditional complementarity tests** (Kodde & Palm, 1986) can lead to inconclusive interpretations

	Test of Supermodularity: Testing for complementarity	Test of Submodularity: Testing for substitutability	Interpretation
Case 1	H0 accepted	H0 rejected	Strict complementarity (Strict COMPL.)
Case 2	H0 rejected	H0 accepted	Strict substitutability (Strict SUBST.)
Case 3	H0 accepted	Doubt	Weak complementarity (Weak COMPL.)
Case 4	Doubt	H0 accepted	Weak substitutability (Weak SUBST.)
Case 5	H0 accepted	H0 accepted	Inconclusive
Case 6	H0 rejected	H0 rejected	Inconclusive
Case 7	Doubt	Doubt	Inconclusive

4. The Fateful Triangle: Complementarities in Performance between Product, Process and Organizational Innovation

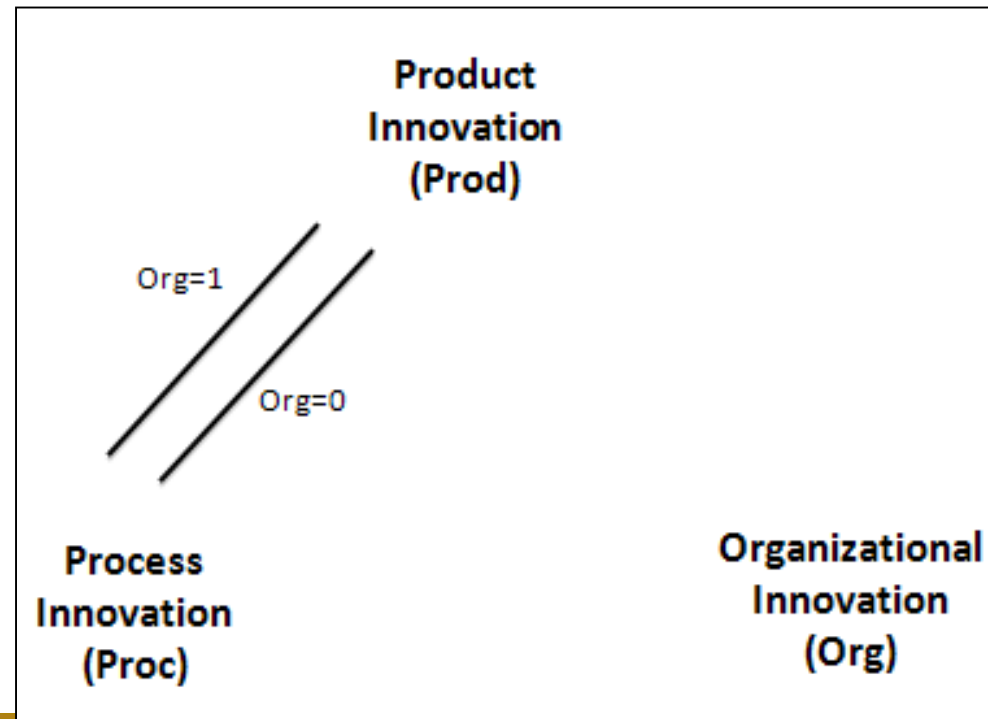
- Case of **three types of innovation**:

Product (x1), Process (x2) and Organization (x3)

- Testing **unconditional** and **conditional** complementarity between Product (x1) and Process (x2):

TWO inequality constraints:

- when Organization (x3) is absent (Org=0)
- when Organization (x3) is present (Org=1)

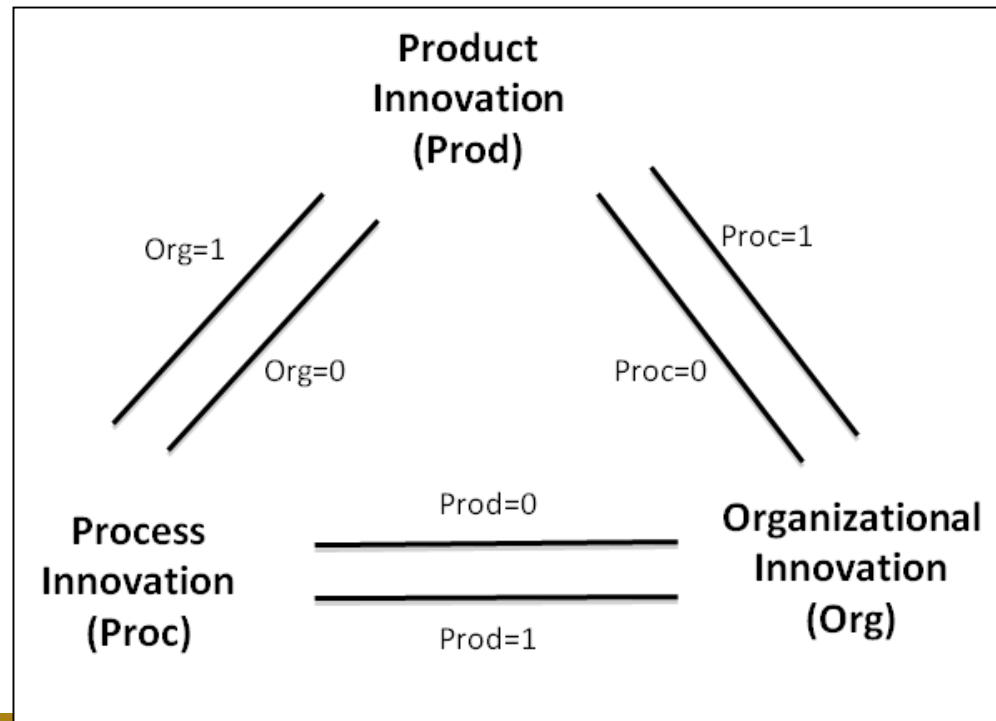


4. The Fateful Triangle: Complementarities in Performance between Product, Process and Organizational Innovation

➤ Testing for the **THREE couples** (pair-wise tests):

- Product and Process
- Product and Organization
- Process and Organization

➤ Testing **SIX inequality constraints**



4. The Fateful Triangle: Complementarities in Performance between Product, Process and Organizational Innovation

Results: *Complementarities-in-use*

Trivariate probit: main results

- **Size** has a positive effect on **process** and **organizational** innovations, no effect on product (**economies of scale**)
- **Internal R&D** has a positive effect on **product innovation**, negative on process for FR, and positive on organizational innovation in UK only
- **Training** has no effect on product, and a positive effect on process and organizational innovations.
- **Cooperation, openness** have always a **positive** effect
- **Informal appropriability** has always a **positive** effect, confirming many enquiries about its higher protection than formal protection.

4. The Fateful Triangle: Complementarities in Performance between Product, Process and Organizational Innovation

Trivariate probit: similarities and differences between Countries

- **UK:** complementarity between process and organizational innovation
 - and also between product and organizational innovation
 - no relation between product and process innovation

- **France:** complementarity between process and organizational innovation
 - no relation between product and organizational innovation
 - substitution between product innovation and process innovation

Correlations of residuals	UK		France	
Product / Process	0,019	0,54	-0,062**	-2,06
Product / Organization	0,079**	2,12	0,034	1,13
Process / Organization	0,185***	4,96	0,265***	8,18
Nb of observation	2014		3201	

Sources: CIS 4 (UK and France), Industry dummies are not reported.

Significance levels at *** 1%, ** 5% and * 10%.

4. The Fateful Triangle: Complementarities in Performance between Product, Process and Organizational Innovation

Multivariate probit: eight exclusive innovation combinations (Wijk)

- The number of significant factors increases in the number of different forms of innovation done simultaneously
- firms need a **more systematic use of the diverse possible strategies** when the aim is innovation in all forms
 - **Size** becomes a positive factor only when the firm innovates in the 3 forms
 - **R&D** is the most often positive & significant factor, except for process only
 - **Training** always increases innovation except when there is only product innovation, (or Prod combined with Org in UK)
 - **Cooperation** always enhances the probability of innovation mainly in UK, but less in France
 - **Sources (Openness):** positive only when Org Innov
 - **Intellectual protection, formal or not,** increases the probability of innovating, although much less in UK
 - **Financial, knowledge and market obstacles to innovation** no influence, except financial in UK

4. The Fateful Triangle: Complementarities in Performance between Product, Process and Organizational Innovation

Results: *Complementarities-in-performance*

Performance is regressed on the eight combinations of innovations and control variables

Table 3: Exclusive innovation combinations and performance. Dependent variable: Log of sales per employee (2004 in Euro)

	<i>UK</i>		<i>France</i>	
	Coef.	<i>z</i>	Coef.	<i>z</i>
W000	0,843***	7.71	0,758***	5.35
W100	0,813***	7.45	0,723***	5.16
W010	0,876***	7.97	0,759***	5.23
W001	0,866***	7.80	0,734***	5.16
W110	0,903***	8.00	0,773***	5.33
W101	0,878***	8.00	0,789***	5.47
W011	0,880***	8.07	0,758***	5.31
W111	0,886***	7.93	0,775***	5.43

4. The Fateful Triangle: Complementarities in Performance between Product, Process and Organizational Innovation

Results: *Complementarities-in-performance*

- **Size** has no influence
- **R&D** has a positive effect on performance, which can be interpreted as an “absorptive capacity” effect (Cohen-Levinthal,1990) since innovations are controlled for
- **Financial** and **knowledge obstacles** have the right negative sign but are significant only for France, while the **market obstacles** are always significant (less rent from innovations)
- **Appropriability methods** have no effect on performance, but these have normally been captured in the innovation equations

4. The Fateful Triangle: Complementarities in Performance between Product, Process and Organizational Innovation

Unconditional complementarity tests (Kodde & Palm, 1986) lead mostly to inconclusive interpretations

➤ Only two cases of conclusive interpretations

	<i>UK</i>	<i>France</i>
Supermodularity	1.108*** (H0 accepted)	0.977*** (H0 accepted)
Submodularity	0.008*** (H0 accepted)	0.610*** (H0 accepted)
PROD / PROC	Inconclusive	Inconclusive
Supermodularity	0.622*** (H0 accepted)	1.873*** (H0 accepted)
Submodularity	0.145*** (H0 accepted)	0.000*** (H0 accepted)
PROD / ORG	Inconclusive	Inconclusive
Supermodularity	0.000*** (H0 accepted)	0.222*** (H0 accepted)
Submodularity	2.251*** (H0 accepted)	1.622*** (H0 accepted)
PROC / ORG	Inconclusive	Inconclusive
5%	Lower bound : 2.706	Upper bound : 5.138

4. The Fateful Triangle: Complementarities in Performance between Product, Process and Organizational Innovation

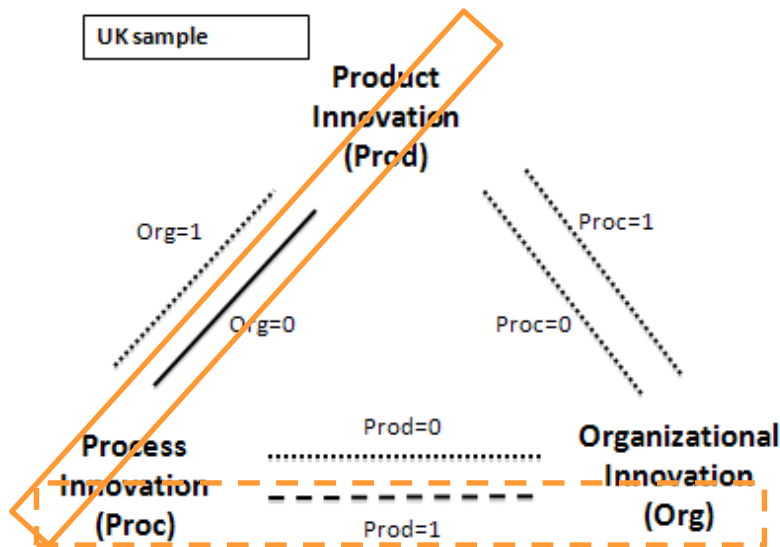
Unconditional complementarity tests by sub-samples:

- Lead **mostly to inconclusive interpretations**
- Only two cases /24 of conclusive interpretations
- SME: all tests are inconclusive
- Large firms: weak substitutability between PROC / ORG in UK
- Low R&D: all tests are inconclusive
- High R&D: all tests are inconclusive
- We then implement a more detailed approach than the literature: **Conditional complementarity**

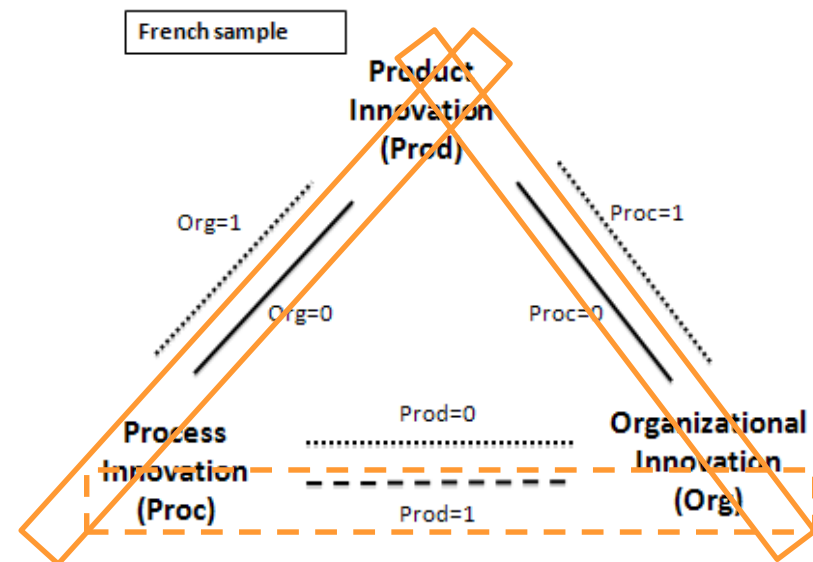
4. The Fateful Triangle: Complementarities in Performance between Product, Process and Organizational Innovation

Conditional complementarities comparing France and UK:

- Similar results on **conditional complementarities** between **product** and **process** when organizational innovation is absent
- Only for **French firms**, **product** and **organizational** innovations are **conditional complements** when firms do **not** introduce **process** innovation
- **Conditional substitution** effect in both countries between **process** and **organization** when product is introduced




— Complementarity
 - - - Substitutability
 No relation



— Complementarity
 - - - Substitutability
 No relation

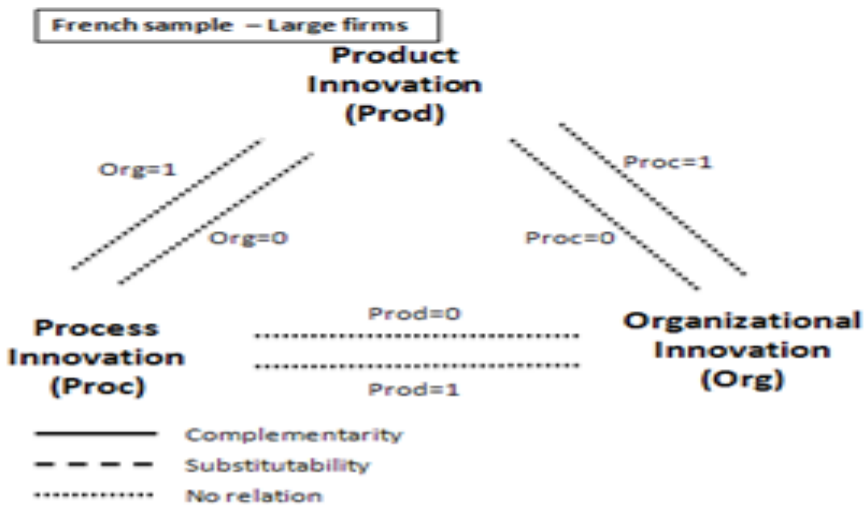
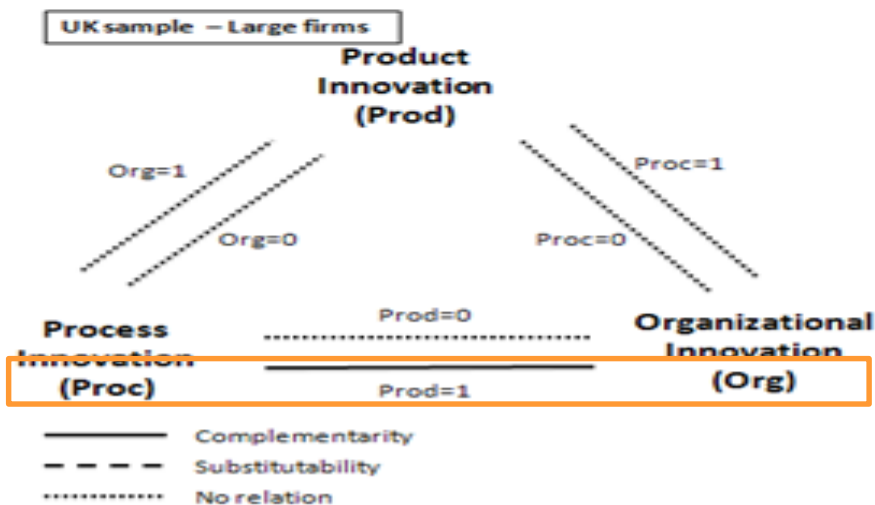
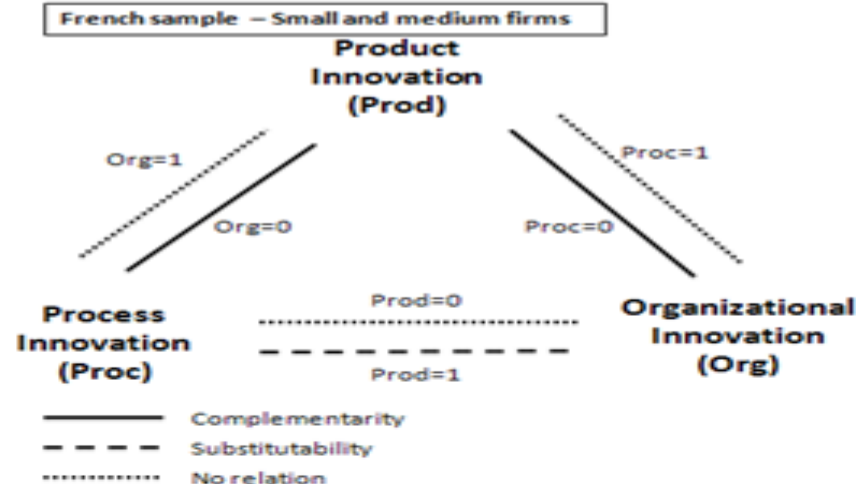
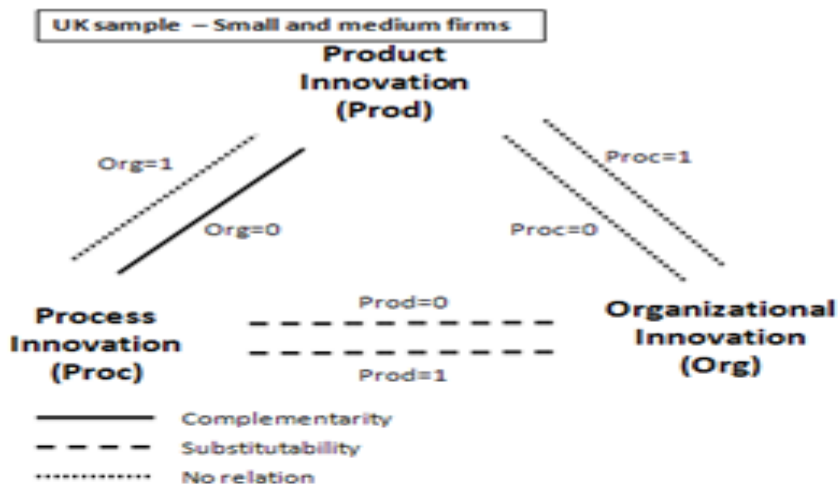
4. The Fateful Triangle: Complementarities in Performance between Product, Process and Organizational Innovation

First lessons comparing France and UK:

1. **French firms** can only choose between **two strategies** - “technological strategy” (Product-Process) and “structure oriented strategy” (Product-Organization), but the estimated returns are likely to be higher for none of the two. **UK firms** must choose the **“technological” (Product-Process) strategy**.
2. Strategies are then **Country dependent**. Contingency theory applies: there is **no unique best strategy**
 **Strong strategic implications for French and UK managers**
4. This suggests further **sample splits**

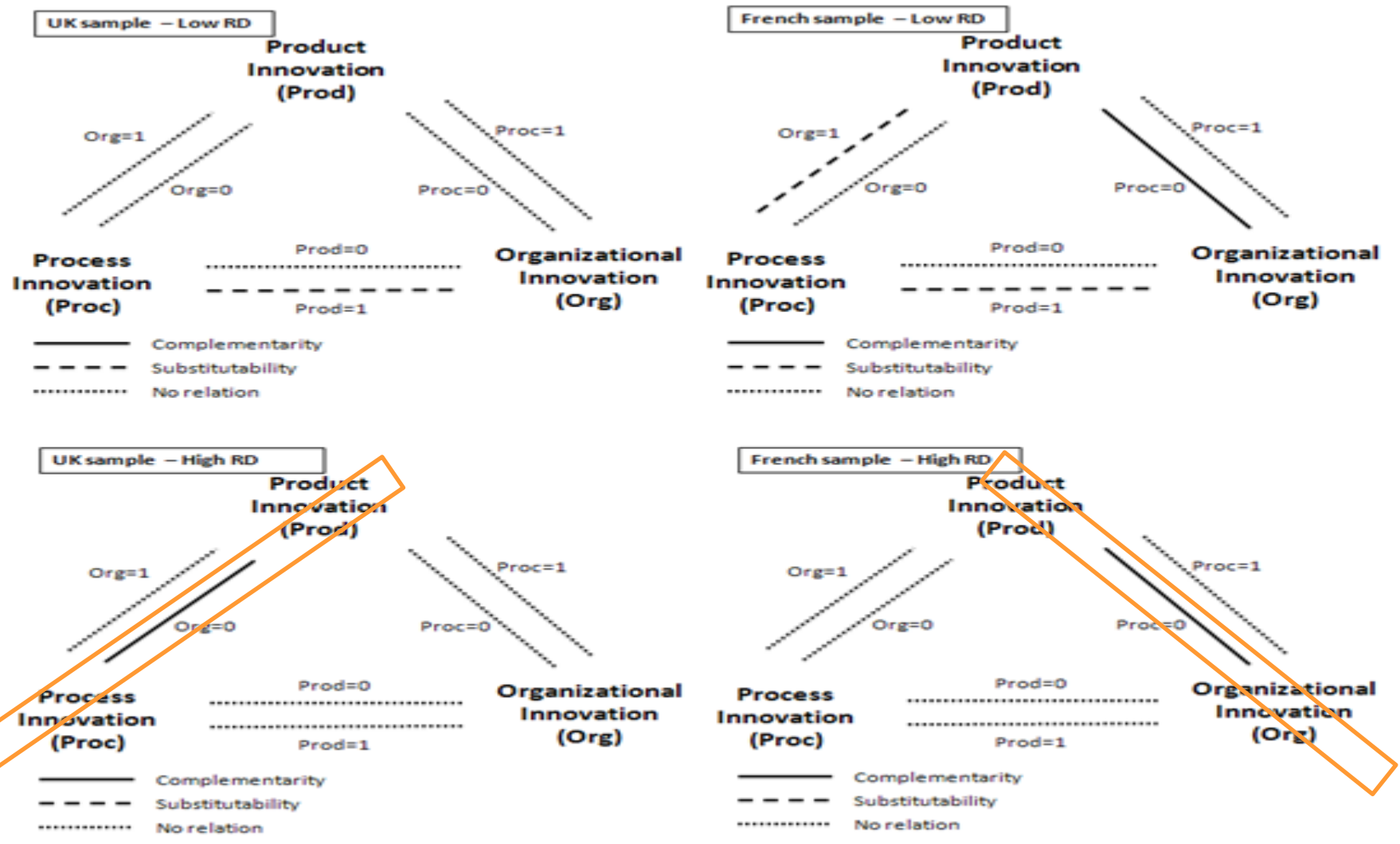
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Sample split according to size: small-medium versus large firms



4. The Fateful Triangle: Complementarities in Performance between Product, Process and Organizational Innovation

Sample split on “capabilities”: high-tech / low-tech firms



4. The Fateful Triangle: Complementarities in Performance between Product, Process and Organizational Innovation

Lessons from the size slipt:

- SMEs have to **choose** clearly between the "**technological strategy**" and the "**structure-oriented strategy**", for cost reason
- **Large UK** firms should choose an **product-process-organization strategy** benefiting from economies of scale

Lessons from the “capabilities” slipt:

1. **High Tech firms** benefit more from complementarities than Low Tech firms: logical in the context of the competition by innovation
2. French firms and UK firms should choose different strategies:
 - “**Structure oriented strategy**” (Product-Organization) for French firms
 - “**Technological strategy**” (Product-Process) for UK firms

Gracias por su atención
Thanks for your attention

Muy bien venidos a Dijon!

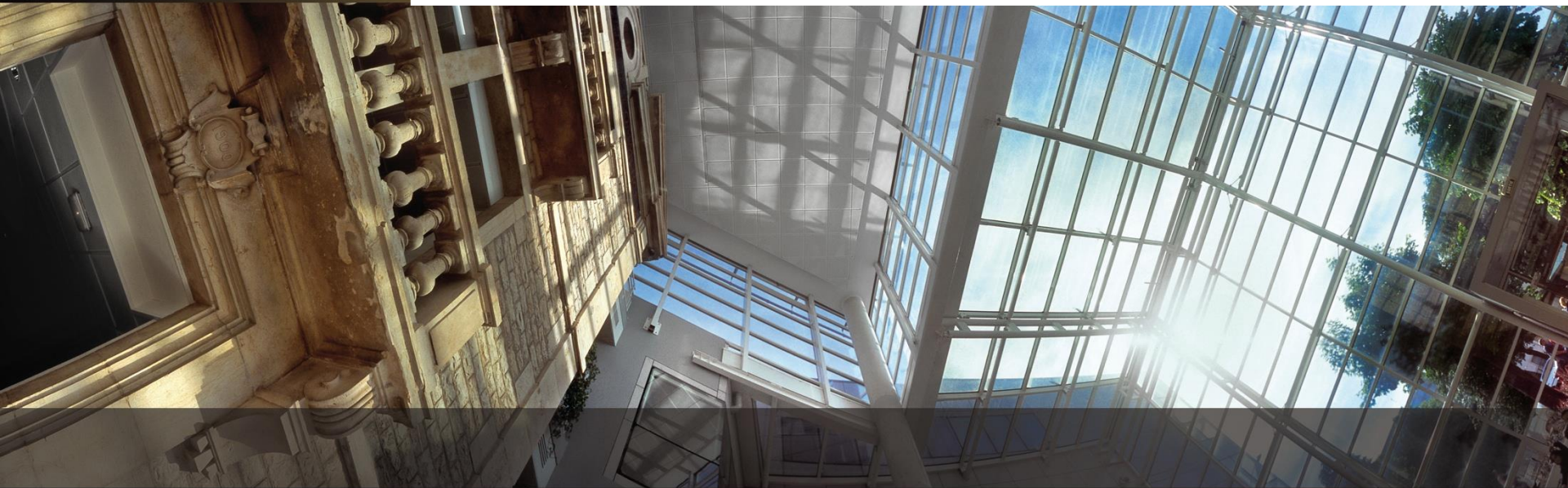
Your are more than welcome to come to Dijon!

Preguntas? Comentarios?

Questions? Comments?

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The Process of Innovation: Obstacles and Complementarities



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