



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



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ABSTRACT

This paper explores the relationships among product, process and organizational innovation, examining the *complementarities-in-performance* between these forms of innovation, within a supermodularity framework. Drawing upon two large samples of French and UK manufacturing firms using CIS4 (2002–2004), we explore whether firms can find a beneficial interplay between different forms of innovation. Since unconditional tests are often inconclusive about these complementarities, we implement a new procedure testing pairwise relations conditional on the presence/absence of a third form. Using this approach, we find conditional complementarities between product and process innovations in French and UK firms and between organizational and product innovations in French firms, but no complementarities between all three forms of innovation. Using different sub-samples, we show that the presence of complementarities depends on the national context as well as on firm size and firm capabilities, which gives support to the contingency perspective.

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1. Introduction

This paper explores the relationship between product, process and organizational innovations in order to better understand the complementarities between different forms of innovation. Milgrom and Roberts's (1990, 1995) seminal contributions provoked increased research interest in the complementarities in economics and management. This body of work explores conditions when the sum is more than its parts, and examines the beneficial interplay between different parts in a system (Athey and Stern, 1998). The complementarities perspective does not

constitute a theory of organizational design or performance, but rather is an approach that provides a better understanding of relational phenomena and how relationships between parts of a system create more value than the system's individual elements (Ennen and Richter, 2010; Brynjolfsson and Milgrom, 2013). The complementarities perspective helps to enrich our understanding of how different practices and strategies are combined and recombined, and how such combinations shape subsequent performance.

Complementarities research uses two broad approaches to measure and understand complementarities: we term them *complementarities-in-use* and *complementarities-in-performance*.¹ *Complementarities-in-use* arise from the linking between two sets

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¹ Examples of work on *complementarities-in-use* are Galia and Legros (2004), Reichstein and Salter (2006) and Mart nez-Ros and Labeaga (2009), and examples on *complementarities-in-performance* are Mohnen and R ller (2005) and Cassiman and Veugelers (2006). See below for a survey related to our topic.

of activities such that employment of one practice often requires the addition of some other practice. In this case, there is a good fit between these practices, suggesting a mutual and beneficial interaction. Researchers investigating *complementarities-in-use* have sought to identify relatedness in the use of different practices and to show that certain practices tend often to be linked. *Complementarities-in-performance* explores the effects on performance of the use of different practices in combination. This group of studies directly tests the economic value to the firm of combining different activities or practices, and shows that their joint application can produce economic benefits that are greater than the individual parts. However, the presence of *complementarities-in-use* does not necessarily imply the existence of *complementarities-in-performance*. Firms may not know which complementarities are really beneficial or they simply may copy the behaviour of other firms. For instance, in the management and organizational innovation field, fashions may trigger a wave of adoption of innovations (Damanpour, 2013). If this is the case, complementarities among different types of innovation may not always lead to higher performance.

Using French and UK Community Innovation Survey (CIS) 2005 data, we explore the effects on performance of the presence of different combinations of three forms of innovation. We test for complementarity by adapting a supermodularity framework and proxying performance by sales per employee. Our approach builds on techniques developed in Mohnen and Röller (2005) and implemented by Leiponen (2005), Cassiman and Veugelers (2006), Cozzarin and Percival (2006) and Miravete and Pernias (2006). We first test for unconditional complementarities that we find often inconclusive. We then implement a new procedure testing pairwise relations conditional on the presence/absence of the third form. We investigate the complementarities between the different forms of innovation: product, process and organization and then explore differences across sub-samples from two countries, from different size groups, and among high-R&D and low-R&D intensive firms.

The results show that complementarities between innovation forms are highly contingent. We find that firms derive benefits from the combination of product and process innovations, and from the combination of organizational and product innovations, but gain no advantage from a combination of all three forms of innovation. Thus, the fateful triangle is not the key to paradise. We show also that the national context and firm characteristics matter. UK firms appear less able than French firms to exploit the complementarities between different forms of innovation, and smaller firms and less R&D intensive firms are less able to profit from the complementarities between different forms of innovation than large firms and R&D intensive firms. Since our paper is among the firsts to investigate simultaneously the complementarities between technological and organizational innovations within the supermodularity framework, it helps to enrich the understanding of the relations between different forms of innovation obtained by previous research methodologies (Schmidt and Rammer, 2007; Mol and Birkinshaw, 2009; Battisti and Stoneman, 2010; Evangelista and Vezzani, 2010).

2. Complementarities in the innovation literature

2.1. The literature on complementarities among innovations

The recent focus in the innovation literature on complementarities is not new. Since Schumpeter (1934), it has been widely acknowledged that there are strong complementarities between forms of innovation. For example, innovation scholars have highlighted that radical innovations often involve changes in products

and in production processes (Freeman and Soete, 1997; Utterback, 1994) as well as changes to the marketing, delivery and geographic scope of production or service activities. This characteristic of innovation suggests that studies that focus on one form of innovation, for example product, process or organization innovation may overlook important relationships between these forms. In order for the firm to benefit from an innovation, it may be necessary to make changes to other parts of its innovation efforts, including the system of production or delivery and the organizational structure that supports the innovation (Pisano, 1990). The importance of different forms of innovation is reflected in Teece (1986) profiting from innovation framework, which emphasizes that the returns from innovation usually accrue to organizations that hold valuable and rare complementary assets. Organizational coherence is critical to ensure the benefits of complementarity, but the complexity of a complementarity strategy has also the advantage of protecting against imitation and may provide a lasting competitive advantage (see Rivkin, 2000). Damanpour (2013) surveys the (small) managerial literature on the synchronous versus sequential occurrence within a firm of technological and non-technological innovations. He concludes that the arguments are strong for simultaneity, but that rigorous empirical work is needed to know how firms really behave.

Empirical research on the complementarities between different forms of innovation is being enabled by data provided by the Community Innovation Surveys (CIS). Several studies focus on the *complementarities-in-use* between product and process innovation (Martínez-Ros and Labeaga, 2009) and show that new products may require changes to production processes or vice versa. For a sample of UK manufacturing firms, Reichstein and Salter (2006) found that the overlap between the two forms of innovation was greatest when the level of novelty of the innovations was high. However, their methodology has some limitations since it is based on correlation among residuals. These limitations include omitted variables and endogeneity problems, and the lack of evidence of the impact of these combinations of innovations on performance (Athey and Stern, 1998).

Starting 2001, the CIS collected information on a wider range of innovative efforts, renewing research interest in the relationship between product/process innovation and 'non-technological' innovation. The UK CIS questionnaire (2004:12) refers to non-technological innovation as wider innovation and the latter covers "new or significantly amended forms of organization, business structures or practices, aimed at step changes in internal efficiency or effectiveness or in approaching markets and customers". The concept of 'non-technological innovation' remains associated with 'organizational' or 'managerial' innovation, and has spawned a wide range of research on its causes and consequences and its relation to other forms of innovations (see Schmidt and Rammer, 2007; Ballot et al., 2011).

Recently, researchers have focused on *complementarities-in-performance* using interaction terms and cluster methodologies. Some studies investigate interaction terms in a performance equation.² Schmidt and Rammer (2007) use German CIS4 data to investigate the link between non-technological innovation and profit margins. They find that the propensity to introduce technological and non-technological innovations is similar and that these forms are closely related. They find also that the effects of non-technological innovation on the firm's profit margins are much

² For purposes of brevity, we do not include work on the effects of different forms of innovation (including non-technological innovation) on performance that does not consider formal interactions between these forms of innovation (Mol and Birkinshaw, 2009) or when it excludes technological innovation (Shaparov and Kattuman, 2010).

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