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# Does complexity affect the speed of innovation?

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**Abstract**

This paper examines whether there is a relation between innovation complexity and the speed of innovation (the time taken from development to commercialisation). A complexity measure along three stages of innovation: a means to develop, a means to deliver and a means to market is developed to give insights into the difficulties of innovation. The study draws on detailed case studies of 6 technology based innovations in the financial and non-financial sector: ATM/Cash cards, Credit cards, EFTPOS/Debit cards, Videocassette Recorder (VCR), Windows operating system for PC, and Plain paper copier. The results indicate that there is no relation between innovation complexity and the speed of innovation. Also, the study gives implications for R&D managers on how to manage the complexity of innovation towards commercialisation.


*Keywords:* Innovation; Complexity; Speed; Commercialisation; Timing

## 1. Introduction

The purpose of this paper is to gain insights about complexity along the innovation process and examine whether complexity might be expected to affect the time taken to bring innovation to commercialisation. Section 2 reviews the theoretical framework concerning the concept of innovation, innovation process and complexity of innovation. Section 3 introduces the new methodology: a metric for analysing complexity of innovation. Section 4 presents the analysis of findings for 6 case study innovations. Section 5 concludes the findings and suggests further use of larger sample to provide a firmer foundation for generalisation.

## 2. Theoretical framework

### 2.1. Concept of innovation and innovation process

The concept of 'innovation' is viewed in different ways in the literature (Table 1).

These concepts offer perspectives on the meaning of 'innovation' in describing technological change. Rosenberg (1976, 1982), Nelson and Winter (1977; 1982) and Dosi (1982) view innovation as a process of improvement which may reside in the form of a problem solving activity (a new method) whereas Pavitt (1984) and Tidd et al. (1997) regard it as a process involving commercial use (a new business). A concept of innovation combining these in an integrated process of incremental improvement and turning into commercial use is developed by scholars like Schott (1981), Daft (1982) and Rothwell and Gardiner (1985). The last concept of innovation, used by Rogers and Shoemaker (1971), Porter (1990) and Voss (1994) is somewhat broader. This is because the concept is concerned with implementation of new technologies and new processes although not necessary both together in all cases.

The term 'innovation' used in this study will follow the third concept, that is an integrated process of enhancing the technology frontier (a means to develop), transforming this into the best commercial opportunities (a means to deliver) and delivering the commercialised product/process innovation in a competitive market (a means to market) with widespread use.

Technological process innovation can occur in the forms of both radical and incremental changes. The level of technological change can be described at a conceptual level in two frameworks—Schumpeterian and neo-Schumpeterian.

#### 2.1.1. Schumpeterian theory of long waves (Mark I)

Schumpeter (1939)'s 'long-wave theory' is based on the technological revolutions underlying the 'Kondratieff'

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Table 1
Alternative concepts of 'innovation'

| Concepts of innovation | Scholars |
|---|---|
| (1) Innovation: a process of enhancing existing technology | Rosenberg (1976, 1982), Nelson and Winter (1977, 1982) and Dosi (1982) |
| (2) Innovation: a process of turning opportunities into practical use | Pavitt (1984) and Tidd et al. (1997) |
| (3) Innovation: an integrated process involving (1) and (2) | Schott (1981), Daft (1982) and Rothwell and Gardiner (1985) |
| (4) Innovation: any new technologies and new processes | Rogers and Shoemaker (1971), Porter (1990) and Voss (1994) |

Source: the author's design

cycles or long waves of economic development. His theory stresses the importance of clusters of innovations in the development of business cycles. The Schumpeterian stance on this development provides a view that the abandonment of one cycle with the replacement by another occurs because the existing cycle cannot offer adequate solutions to firms in new or changing circumstance. In other words, structural change explains the impermanence of advantage that is gained for firm advancing innovation. While the early cycles of revolution are punctuated by material activities, the fifth cycle—the innovations based on information and communication technologies (ICTs) (Barras, 1986; Freeman and Soete, 1997) has now shifted to information revolution in which the form of organisations ranges from competitive to collaborative structure.

Schumpeter (1967) argues that the development cycle of technology-based industries involves 'creative destruction' whereby the new technology is able to operate at full costs below the marginal cost of the old technology and the replacement of the old technology is not accidental but the result of organisational as well as technical reforms. In this manner, the *radical* implications are straightforward under the Schumpeterian's view of creative destruction in the sense that cluster of radical innovations are closely linked to the organisational reforms, albeit in the real world the new product/process innovations may never completely replace the old ones.

#### 2.1.2. Neo-Schumpeterian theory (Mark II)

The Schumpeterian's creative destruction is argued by neo-Schumpeterian economists as unhelpful, given that technology is rather cumulative in nature—accumulation of technological capabilities based on the existing capabilities rather than clearcut destruction and displacement (Rickards, 1985; Rosenberg, 1976; Rosenberg, 1982; Nelson and Winter, 1977; Nelson and Winter, 1982; Dosi, 1982; Pavitt, 1986a; 1986b; 1989). In other words, they argue that *incremental* innovations occur as a result of firms competing with new product/process innovations (Nelson and Winter, 1982). In financial service industry, most of the technologies on which financial innovations are based are widely available well in advance of the emergence of applications that use it. Major innovations therefore tend to occur at the means to deliver and means to market stage. Financial applications are quite modest in their numerical intensity and information storage/retrieval requirements compared with scientific and military applications. The main challenge of financial applications is volume of applications and the interlinking of numerous card holders, ATMs, etc. rather than complexity of any particular case.

### 2.2. Complexities along the process of innovation

Rickards (1999) noted that innovation is very complicated because there are uncertainties with product and process innovation whereby the outcome is contingent or state dependent. Although significant prior research exists in the study of determinants of success and failure of innovation (factors indicating complexities or uncertainties), the literature reviewed does not provide direct empirical evidence on any relationship between complexity of an innovation and the time taken to complete the innovation. To study complexity profile of innovation, an operationalisation of the term 'complexity' is needed. The definition of 'complexity' in the Oxford Advanced Learner's Dictionary (1995) describes it as the combination of effects from different factors. Although many literature refers to complexity in different ways (Hobday, 1998; Rycroft and Kash, 1999) such as product complexity, technological complexity, organisational complexity; the point is the same: components integrated together cause difficulties in transformation into successful products/processes. The study by Drazin and Schoonhoven (1996) concentrates on the influence of the integrated variables/elements to the innovation diffusion process. These variables/elements range from the firm's strategy to the creativity focus. They argue that the firm's strategies, for example, mergers, acquisitions, and divestitures can influence innovation in the sense of enabling or inhibiting innovation (the influence on the firm's ability to produce innovations).

The following table summarises previous studies investigating the common characteristics of successful innovation (Table 2).

In this research, the term 'complexity' is used to describe the factors that will affect the progression of innovations along the 3 stages of commercialisation—a means to develop, deliver and market (Section 3).

From the table, it can be seen that a number of recurring factors are identified across sectors. However, the importance of each factor can vary by sector of industry (Rothwell et al., 1974). For example, the classic project SAPPHO concludes that in the chemical industry, technical factors are the most important whereas in the scientific instruments