Codified-tacit and general-specific knowledge in the division of labour among firms A study of the software industry

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Abstract

This paper explores the organisation and codification of knowledge in software firms. It analyses various economic incentives to codification, including the need to improve the productivity and quality of software production and the networks of inter-firm alliances.

The paper examines the experience of five Italian software firms specialising in software packages and services. It compares their capabilities, main sources of tacit knowledge, specific incentives to invest in knowledge codification and the formal development methodologies and quality control systems adopted. Finally, the paper analyses two distinct technological collaborations that two of these firms have recently established. © 2001 Elsevier Science B.V. All rights reserved.

Keywords: Knowledge; Inter-firm networks; Innovation; Software

1. Objectives

This study analyses the process of knowledge codification and the division of labour between software firms. Our empirical analysis aims to provide insights into the following dimensions of the production and distribution of knowledge.

First, software production is often referred to as a 'craft' or as a 'creative' activity similar to industrial design. However, rising labour costs due to competition between firms for access to a relatively small skills pool and the internationalisation of the software market spur firms operating in this industry to adopt more efficient production techniques and to restructure their organisation. This in turn stimulates the codification of knowledge underlying software development activities. This paper investigates the extent to which the industrialisation of software activities leads to more codified knowledge, which types of knowledge are codified and which remain tacit.

Second, the empirical section focuses on the nature of (tacit versus codified) knowledge that firms share and exchange with other partners by means of collaborative agreements. In particular, it analyses the interdependence between knowledge codification and collaborative agreements. Collaborative agreements require a certain amount of knowledge codification in order to exchange and share knowledge among different organisations. Codified knowledge allows firms that enter a collaborative agreement to develop a common 'language' or to adapt their respective 'corporate languages' to one another so that communication between partners can occur. This suggests that in order to enter a collaborative relationship,

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firms must invest in knowledge codification. On the other hand, experience acquired through collaborative agreements induces a higher level of knowledge codification, or at least stimulates the development of organisational 'interfaces', which render some pieces of corporate knowledge transparent and hence transferable between firms. We wonder about the significance of these interactions and feedbacks in the software industry.

The type of knowledge exchanged and shared obviously depends on the objectives of the collaboration. There are different types of division of labour between firms in the software industry. Many software producers are involved in a variety of commercial agreements with distributors, resellers and retailers. Some of these agreements require close interaction with downstream firms (e.g. VAR, value-added retailers). Knowledge of specific user and market needs, which tends to be tacit and 'localised' (codified but poorly articulated in written documents), is exchanged on these occasions. But more often, the knowledge exchanged is very simple and codified, as in the case of contractual agreements with IT product distributors. Large software producers often set up contractual relationships with smaller firms. Often, these relationships are centred on the outsourcing of activities, which are not considered critical by the contractor (e.g. programming, detailed design, and maintenance). In other circumstances, outsourcing may also involve critical activities, such as systems design and systems integration. These forms of division of labour in the production of software often require a great deal of technical knowledge exchange between the partners. This knowledge is in part codified and embodied in products (software programs). Finally, joint R&D projects require a more intense exchange of codified knowledge embodied in designs, standards, user requirement specifications, development tools, documentation, and object code. However, a large amount of tacit knowledge is probably produced and exchanged in R&D agreements. Our case studies focus on technological and commercial agreements with the aim of analysing the economic incentives to investment in knowledge codification in different activities.

The empirical analysis of this paper draws on five case studies. With few case histories we cannot measure the importance of codified knowledge in software development, neither can we properly test 'theories'

or research hypotheses. But we can illustrate some characteristics of the codification process when a certain degree of knowledge codification is observed. We can also describe the incentives and obstacles to knowledge codification in firms that operate in markets where a significant amount of knowledge exchange between firms takes place. Finally, our analysis shows how differences in product and organisational complexity across firms affect the economics and management of knowledge codification. The analysis then provides suggestions and hypotheses that can help future empirical research which should be conducted on a larger scale.

The paper is organised as follows. Section 2 illustrates concepts that have emerged in the relevant literature. Section 3 analyses the organisation of knowledge and inter-firms networks in the software industry. Section 4 analyses the characteristics of knowledge codification and exchange in five Italian software producers. Section 5 concludes the paper.

2. Knowledge production and transmission between firms: survey of the literature

Knowledge is a complex and variegated good which can be tacit or codified, localised (context-specific) or abstract (generic). These characteristics of knowledge have important consequences for the economics and management of innovation. At one end of the spectrum, knowledge is assimilated with information and articulated (e.g. a blueprint). It is recordable, storable and transferable at negligible costs, and hence gives rise to market failures, which call for public support for innovation (Arrow, 1962). At the other end of the spectrum, knowledge is tacit, embodied in skills, and can be in part transferred through personal, informal contacts and training (Winter, 1987). Even skills and capabilities based on a formal, scientific background (for example mathematics or physics) are, in part, tacit. As Nelson (1962) and other scholars have illustrated, the knowledge created during scientific activities is usually difficult to articulate and evaluate from the outside. The implications for firm strategy and public policy are self-evident. Unlike information, tacit knowledge cannot easily be transmitted or imitated. For this reason, follower firms and countries have to accumulate 'absorptive' capabilities in order to take