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Innovation determinants over industry life cycle

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ABSTRACT

This paper analyzes how the influence of firm-level innovation determinants varies over the industry life cycle. Two sets of determinants are distinguished: (1) determinants of a firm's innovation propensity, i.e. the likelihood of being innovative and (2) determinants of its innovation intensity, i.e. innovation sales. By combining the literature emphasizing firms' internal resources (micro-level) with the research strand on the role of the industry context (meso-level), the paper develops hypotheses about the relative importance of firm-level innovation determinants over the industry life cycle. Estimation of a firm-level model of innovation in Sweden, while acknowledging the stage of the life cycle of the industry a firm belongs to, shows that the importance of the determinants of innovation propensity and intensity is not equal over the stages of an industry's life cycle.

1. Introduction

Firms' innovation efforts and outcomes take place in contexts. One of the contexts in which innovation happens is provided by the industry in which firms operate in. A large literature on industry life cycles (ILC) emphasizes that the stage of the life cycle of the industry in which a firm operates provides an important context for innovation [1–4].[1] The stage of the ILC is often claimed to be an important factor influencing the dynamics and behavior of firms, particularly innovative behavior [5]. This has been a recurrent argument in the evolutionary school of economics [6], and in particular the literature on technological regimes [7]. However, one aspect that is seldom dealt with is if and to what extent the stage of an ILC influences the relative importance of firm-level innovation determinants.[2] The aim of this paper is to fill this gap in the literature.

This paper provides an empirical analysis on how the relative importance of firm-level innovation determinants varies over the stages of ILC in which firms operate and innovate. This is done by *bringing together* micro- (firm-level innovation studies) and meso-level arguments (ILC literature) in which innovation happens, and testing them in a common empirical setting. While this is rarely done in the literature, it is frequently called for [8, p. 206]. Apart from such contribution, the paper has a number of novelties. In particular, it employs firm-level Community Innovation Survey (CIS) data, allowing for a direct measure of innovation and a distinction between determinants of innovation propensity (probability of being innovative) and intensity (innovation sales), respectively. Such distinction is beneficial (at least) from a theoretical point of view (this will be discussed in Section 4). The paper also adapts various established methods to empirically identify stages of industry life cycles.

Using firm-level CIS4 data for Sweden, it is shown that firm's innovation investment has the highest explanatory power for innovation intensity of firms in growing industries. Size is more pronounced to explain likelihood of being innovative for firms in mature industries. Finally, engagement in international trade appears to be the most influential determinant for innovation propensity of firms in declining

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[1] The (product) life cycle concept can be can be traced back at least to the work by [63].

[2] Several studies address various 'aspects' of innovation through the stages of ILC: *who* innovate [3,5,60], *how much* innovation [3,44,61], *what mode* of innovation [42], and *where* innovation takes place [45]. The aspect that this paper is dealing with is *what makes* innovation, i.e. determinants of innovation, which seems rare in literature.

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industries. The analyses provide a better understanding of the significance of innovation determinants over the ILC, which may lead to a better contingency approach for firms as well as policy makers with regard to innovation strategy and policy.

The rest of the paper is organized as follows. Section 2 builds hypotheses concerning the relative importance of each innovation determinants based on ILC stages. This is done by describing important innovation determinants briefly and weaving it with the specific characteristics of each stages of ILC. Section 3 develops empirical methods for identification of the stages of the ILC. Section 4 describes the dataset, presents the firm-level model of innovation, tests the hypotheses by empirical estimation, and discusses the main results. Section 5 summarizes, concludes and discusses further research.

2. Determinants of innovation and industry life cycle

The main argument of this paper is that the role of different firm-level innovation determinants depends on the stage of the industry in which firms operate. The overall reason for such claim is that the meso-level context (here referring to stage of ILC) does matter for firm-level innovation, which is motivated by evolutionary economics [6] and particularly by technological regime literature [7]. Malerba [9, p. 387] noted "heterogeneous firms [within a same industry] facing similar technologies, searching around similar knowledge bases, undertaking similar production activities, and embedded in the same institutional setting, share some common behavioral traits and develop a similar range of learning patterns, behavior, and organizational form".[3] Sections 2.1 and 2.2 develop the hypothesis concerning the relative importance of the innovation determinants over stages of ILC, by distinguishing them into two groups: determinants of innovation propensity and innovation intensity.

2.1. Determinants of innovation propensity

In line with neo-Schumpeterian literature and the resource based view (RBV), one of the determinants of innovation propensity of firms is shown to be human capital (or skilled labor). Human capital is considered as reflecting a firm's capacity to absorb, assimilate and develop 'new knowledge and technology' [10,11]. The more such new knowledge and technology, the more innovation propensity of the firms is expected [12,13].

The crucial point is that such new knowledge (leading to higher innovation propensity) is needed and also generated mostly in the 'early stage' of ILC, in comparison with later stages. This is because in the early stage of the ILC, product and market situation is uncertain and in order to overcome such uncertainty and reaching to the dominant design, there is a need for the generation of new knowledge and innovation [14,1]. As noted before, it is usually assumed that such knowledge generation and development is accomplished mostly by human capital (skilled labor). This can be interpreted as the relative importance of human capital in the early stage of ILC (i.e. growing industries) in comparison with later stages. Such statement is clearly concluded in [5, p. 571]: "an industry tends to rely on the highest component of skilled labor during the early stages of the life-cycle, and the least amount of skilled labor after the product has become standardized in the mature and declining phases".

More specifically, the reason for such statement could be the fact that growing stage of ILC is usually characterized by labor-intensity rather than capital-intensity [15,5]. Accordingly, [16] provide empirical evidence showing that firms entering/exiting in early stages of the product life cycle are more knowledge-intensive than their counterparts in later stages. Hirsch [15] already argued that 'human capital' can be more influential for production (of innovation) in the growing industries, while capital and unskilled labor are the most important production factors in the mature (and declining) stage(s). Recent empirical evidences also emphasized the importance of skilled labor in the growing stage of industries [17], while noting even the negative effect of it in later stages [18]. This is again because of a lack of dominant design in the growing industries and the more pronounced need for the generation of new knowledge, which is assumed to be accomplished by skilled labor (human capital).

Moreover, comparing the role of human capital in earlier versus later stages of ILC could be analogical to compare Schumpeter Mark I/entrepreneurial regime versus Schumpeter Mark II/routine regime, respectively, where the role of human capital is argued to be more pronounced for the sake of higher innovation propensity in the former rather than the later regime.[4] The relative importance of human capital has been also studies over the stages (age) of the plants, and similar evidence has been found in line with the studies over the stages of ILC: the importance of human capital is declining as the age of the plant is increasing [10].

To sum up, human capital is mostly responsible for generation of new knowledge within the firms and the more new knowledge the more innovation propensity for firms. Importantly, the need for generation of new knowledge is expected to be more pronounced in the growing stage of ILC compared with later stages, and hence the need for human capital (as the generator of such new knowledge). Therefore, the first hypothesis is formulated as follows:

Hp1. Human capital is more important for innovation propensity of the firms in growing industries than the firms in other stages of ILC.

Another determinant of innovation propensity of firms is considered to be the 'size' of the firms. The size reflects access to finance and scale economies [19]. Such access to finance and scale economies play a crucial role for firms to increase (i) advertisement power (leading to product differentiation) [20] and (ii) scope economies for R&D (provided by scale economy in production) [21].

[3] There is indeed a recent and alternative approach arguing that industries do not account for the considerable fraction of variance observed in a firm's innovation strategy [67,68]. Therefore, the result of the analysis of this paper is only valid assuming to accept the standard industry classification and the systematic difference between industries in their innovative behavior. While it is not a perfect assumption, nevertheless the debate between two approaches seems to be still open, so no strict preference seems to be established in favor of the alternative approach.

[4] The terminology 'entrepreneurial regime' versus 'routine regime' is associated with [65].