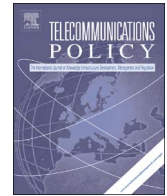


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Digital knowledge generation and the appropriability trade-off[☆]

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ABSTRACT

The introduction of information and communication technologies (ICT) has changed in depth the organization of the generation of knowledge reducing significantly knowledge absorption cost and improving knowledge interactions. The digital generation of knowledge relies on the systematic access and use of the stock of quasi-public knowledge. ICT enable to reconsider the knowledge appropriability trade-off as it helps to better appreciate the positive role of knowledge spillovers in the recombinant generation of new knowledge, next to the well-known negative effects of the limited appropriability of knowledge on revenues and hence incentives to innovate. This new analytical framework calls for an augmented role of telecommunications policy that should take into account the positive effects of knowledge connectivity on the generation of knowledge.

1. Introduction

New information and communication technologies (ICT) have been a radical innovation. As a general purpose technology their introduction has enabled an array of technological and organizational changes in a wide variety of activities (Bauer & Latzer, 2016; Bresnahan & Trajtenberg, 1995; Brynjolfsson & Saunders, 2010; David & Wright, 2003).

Their impact on the generation of knowledge is one of the most important. ICT have induced significant innovations in the knowledge generation process increasing its efficiency and changing in depth its organization and structure. These changes have in turn major effects on the role of knowledge spillovers and the cost of new knowledge. The new understanding of the actual role of knowledge appropriability on knowledge cost and revenue, brought about by the organizational innovations associated to the introduction of ICT, enables to reconsider the Arrowian market failure hypothesis, to reframe the appropriability trade-off and to suggest an augmented role of telecommunications policy.

The rest of the paper is structured as it follows. Section 2 recalls the analytical context of the knowledge appropriability trade-off. Section 3 reviews the main results of the different and yet complementary literatures ranging from knowledge management to economics of innovation and economics of knowledge that have explored the effects of the introduction of ICT on the organization of the knowledge generation process. Section 4 elaborates an integrated framework to assess their effects on the knowledge appropriability trade-off. Section 5 explores the implications of the results stressing the need for a new agenda for telecommunications policy. The conclusions summarize the analysis.

2. The knowledge appropriability trade-off

The understanding of the knowledge appropriability trade-off is the result of a long standing process started with the

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identification of the peculiar characteristics of knowledge as an economic good.

2.1. Knowledge appropriability as a problem

Nelson (1959) opens the process with the identification and exploration of the consequences of the limited appropriability of knowledge and articulates the distinction between the social and private profit of knowledge: “The quantity of resources that a society should allocate to basic research is that quantity which maximizes social profit. Under which conditions will private-profit opportunities draw into basic research a quantity of resources that is socially desirable? If all sectors of the economy are perfectly competitive, if every business firm can collect from society through the market mechanism the full value of benefits it produces, and if social costs of each business are exclusively attached to the inputs it purchases, then the allocation of resources among alternatives uses generated by profit maximizing will be a socially optimal allocation of resources. But when the marginal value of a ‘good’ to society exceeds the marginal value of the good to the individual who pays for it, the allocation of resources that maximizes private profits will not be optimal” (Nelson, 1959: 298).

The comparative analysis of knowledge and standard economic good enabled Kenneth Arrow (1962) to generalize the intuition of Richard Nelson and to identify the peculiar and idiosyncratic characteristics of knowledge, such as limited appropriability, poor excludability and negligible reproduction costs. Because of the limited appropriability of knowledge ‘inventors’ can retain only a fraction of the economic benefits of the knowledge they generated.

The limited appropriability of knowledge exerts negative effects on the price of goods that include knowledge as an input in the production process. As a consequence, its derived demand is lower than the derived demand of a standard production input. In the Arrovian framework –because of the lower levels of the price of output - the equilibrium price of knowledge is below the competitive level. Because of the limited appropriability of knowledge and the divergence between its generation and reproduction costs, the market price of the product that embodies can actually be so low that it does not allow recovering the costs incurred to purchase - and use - knowledge.

In extreme Arrovian conditions, the use of knowledge with very low levels of appropriability, high generation costs and very low reproduction cost, in other words, can be at the origin not only of *lucrum cessans* (missing profitability) but also of *damnum emergens* (emerging losses). In competitive markets, where both incumbents and entrants can imitate and use the knowledge generated by inventors, the market price would rapidly fall to levels below the marginal cost incurred by the inventor. These levels, in fact, would take into account all the other costs, incurred by every other firm, but the costs of knowledge that have been paid to inventors. Knowing his inability to appropriate knowledge, the inventor lacks incentive to innovate and the classical Arrovian market failure occurs.

The Arrovian analysis focused on the consequences of the properties of knowledge on the levels of knowledge produced and used by firms. Because of the reduction of the private rates of returns measured by the marginal productivity and profitability of knowledge -caused by its limited appropriability- firms generate and use –at the same time- a lower amount of knowledge than it would have happened had knowledge been a standard good (Arrow, 1962, 1969). This effect results in a negative incentive that lead to generate less knowledge than socially desirable.

This represents the Arrovian hypothesis of the “failure of the market” as the appropriate institutional setting for the allocation of resources to the generation of knowledge. The markets are unable to allocate and produce the correct amount of knowledge. Because of the idiosyncratic characteristics of knowledge as an economic good the market place is doomed to undersupply knowledge. The Arrovian framework has so far provided the foundations of an economic policy aimed at remedying the knowledge market failure (Antonelli & David, 2016).

The analysis of Arrow (1962) is a founding stone not only for its normative implications, but also as it makes an important methodological contribution as it relies the comparative analysis of ‘knowledge as a standard good’ with respect to ‘knowledge as a special good’. The comparative approach remains at the core of the economics of knowledge and enables to identify the full range of implications and consequences of the properties of knowledge both for economics and economic policy.

Recent contributions have further elaborated and developed the Arrovian analysis qualifying the context: the limited appropriability of knowledge exerts strong negative effects on the price of innovated goods mainly if not especially for the dynamics of imitation by competent rivals in the very same product markets. Rivals active in the very same product markets can easily take advantage of the novelties contained in each innovation and reproduce the knowledge on which they rely, at low cost (Aghion, Akcigit, & Howitt, 2015). The price of innovated goods falls and affects directly the position of the derived demand of knowledge. The negative effects of the limited appropriability of knowledge are much lower when the spillover of knowledge concerns unrelated agents active in other product markets for two reasons: i) the risks of imitative entry are much lower and hence the risks of missing revenue stemming from the spillover; ii) their capability to actual use it again as an input into their own knowledge generation processes is hindered by absorption costs that are larger the larger the distance in cognitive and product spaces.

2.2. Knowledge appropriability as an opportunity

The Arrovian framework was questioned by the intuition of Griliches (1979) that the limited appropriability of knowledge may have some beneficial consequences due to the occurrence of positive externality that favor the recipients of spillovers, rather than just negative ones due to the missing incentives and the consequent underproduction of knowledge. The knowledge that inventors cannot appropriate *spills* in the atmosphere and because of its non-exhaustibility contributes the stock of quasi-public knowledge that can be used by third parties at low costs.

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