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Innovation and growth through local and global interaction

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ABSTRACT

This paper investigates the research and development activity of heterogeneous and rationally bounded firms. The latter conduct this activity through in-house research and by collecting information originating in other firms' spillovers. Thus, research and development activity owes both to independent searching and to interaction diffusing information. We study the conditions under which this idiosyncratic effort yields effects that have either local, system-wise negligible impacts or cumulate to generate significant aggregate ones. In the latter case, global effects feed back upon the incentive to innovate and therefore on the strength of local interaction as well as on autonomous research efforts. It is these dynamic forces that we model. We compare cases in which significant aggregate effects do emerge with cases in which they do not and study their outcome on innovation-directed investment and on long-term growth.

1. Introduction

It is a well established fact that technical progress is an engine of growth. Economic history and theory concur to indicate that the reason lies with profit opportunities pried open by innovation-generated productivity growth and the spurt in economic activity that thereby follows.[1] They also point out that innovations are themselves the result of a complex effort involving one sided investment in autonomous research as well as interaction between firms as they attempt to capture informative spillovers that they, in turn, willingly or unwillingly, broadcast. It is, indeed, this two-pronged, complex activity that renders technical progress largely endogenous to firms' endeavours. Although an innovation may involve any part of a firm's activity or process, economic historians (David, 1990; Rosenberg, 1976; Mokyr, 1992) have highlighted the crucial role played by machine-producing industries in raising productivity and fostering a radical transformation of production systems. This occurrence much owes to the fact that embodying technical advances in these firms' output is a powerful, if not the main, tool of competition and finally market dominance. Thus, capital goods producing firms appear as the fundamental protagonists of the innovation process. New devices, machines, tools, whole new manufacturing systems, in fact the introduction of entirely novel technological paradigms are in great part due to the innovative efforts of firms which then supply those lying forward in the production chain: the final goods producers. Their technological and, ultimately, economic success depends on the breadth and depth of their learning and searching process, a process that normally requires costly investment in human capabilities. It is important to note that firms so engaged are

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[1] See, for example, Aghion and Howitt (1992, 1998) and Romer (1990).

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necessarily specialised and thus each one attempting to innovate is cognitively bound within a fairly well defined and possibly narrow knowledge domain. They are not, however, islands barred from all communication. On the contrary, they benefit from the structural externalities afforded by the system as a whole; namely, the educational system providing general competence and skills, institutions able of crafting an innovation-friendly environment, a thriving scientific context capable of fostering the development of viable technologies and, crucially, the all-important entrepreneurship without which innovative activity is left wanting. None of these favourable structural elements can be exploited without resourceful striving. In very broad terms, innovation requires information that can be contrived both by an independent search and by interacting with other firms. Both are crucial features of the race to innovate. While the former consists in a self generated attempt such as it occurs in research and development departments, the latter is an effort at gleaning useful information from other firms. This information collection activity is clearly made possible by the fact that spillovers are available although through a costly search that largely depends on information interaction (Arthur, 1994). As literature on technological convergence has shown (Dosi, 1988; Fai and von Tunzelmann, 2001; Rosenberg, 1976) this kind of information on cutting-edge technologies comes from firms that belong to other industries and that have been able to innovate in their own sector of activity.[2] They are, in this sense, leaders that to some extent broadcast technologically novel features to cognitively nearby industries. What may, in fact, appear as a wholly new technology in a given industry may feature principles pioneered elsewhere in the economy, its information leading to implementation in different industries through spillovers. Yet, this externality can be captured only by means of industrious and clearly costly observation requiring effort and resources. Recent literature has stressed the role of firms' interaction in spreading technological paradigms (Andergassen et al., 2005, 2006). In this context, two relevant aspects of firms' innovative activity must be stressed. The first concerns the limits they encounter as a consequence of their specialisation, the latter being a factor bounding the cognitive distance that can effectively be covered when searching for information. It is quite clear that the specificity of their acquired skills and, more generally, of their cumulated knowledge sets a hurdle to the type and amount of information they can actually glean by scanning their technological environment. In this sense, firms are better assumed as rationality bounded agents availing themselves of limited capabilities as to the amount of information they can process and the number of sources they can observe. These matter-of-fact conjectures suggest that learning and searching carried out by firms, their interaction and networking are activities that take place in a neighbourhood the cardinality of which is rather small in terms of their overall number. Thus, while an economy can be viewed as a complex network of cognitive relations, the latter are better construed within neighbourhoods of limited size. The second aspect concerns what may be termed the contiguity principle. Whilst information is easily broadcast and easily captured within neighbourhoods of fairly homogeneous knowledge, it can nevertheless travel abroad since links between them are likely to exist. What matters in this respect is the density of knowledge-wise contiguous industries and thus of neighbourhoods that they make up. Economies endowed with a dense grid of industries perform better in spreading information than economies whose industries are cognitively sparse and far apart. This paper attempts to provide a model in which these aspects are taken in due consideration by positing that information interaction be a process that leads to a time constrained, gradual collection of elements of information contributed by different sources. It also intends to show that the joint impact of self generation of new, technology-relevant, knowledge and localised firms' interaction leads to a critical process that eventually gives rise to an innovation activity that is highly correlated at the aggregate level. In this context, a large number of firms becomes empowered by sufficient information to introduce an innovation as a consequence of other firm's innovative activity, producing a system-wide impact. By so doing they devise a new capital good that embodies a productivity-augmenting technological novelty. As mentioned, this occurrence is not the consequence of a purely random event and is not scot-free but, although randomness is part of the process, it clearly requires substantial investment in, mainly, human resources. Thus, capital goods producing firms intending to innovate have to sustain relevant expenditure in the hope of cashing in future rewards. It is, indeed, the expectation of future profits that drives investment: profits that accrue thanks to the higher productivity that innovations afford and to the monopolist strength the would-be innovator will eventually enjoy.

Search-for-innovation results may have either local or aggregate outcomes: we specifically distinguish these two cases. On the one hand, a productivity rise, a sector-specific occurrence, if interaction is weak may have system-wise negligible effects. On the other hand, if interaction is strong, it becomes a momentous event that determines far-flung effects at a global level. Observers and policy-makers hold as a rather well documented fact that productivity increases are shared out as to keep income shares roughly constant, a fact that bears relevant consequences on the equilibrium prices of those industries that are involved in the innovation wave. If the process of information gathering and searching is one of local interaction, it may nevertheless have an important impact on the system and determine a global interaction effect that then feeds back locally. To show how this happens, the paper models the impact of sectorial changes on the economy as a whole. It is important to note in this respect that expected profits depend on the likelihood of an innovation and on the probability that the consequently gained market power be maintained. In a dynamic context, in which the innovation race goes on, this is possible provided that the next innovations occur in sectors other than in the would-be monopolist's own. Yet, profits depend on prices whose magnitude is fixed by the innovation-induced productivity rise and, in turn, determine aggregate expenditure in final goods. For any given labour force, while expected profits set current investment consisting of highly specialised employment, the grey matter behind innovations, and then its size in the sector engaged in producing

[2] See also Helpman and Trajtenberg (1998) and Jaffe and Trajtenberg (2002).