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Innovation through local interaction, imitation and investment waves

Massimo Ricottilli

Department of Economics, and CIG, Centro Interdipartimentale 'Luigi Galvani', University of Bologna, Italy

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ABSTRACT

This paper inquires about the structural breaks that investment generated by innovation waves imparts to an economic system. Its analysis is confined to investigate only the kind of investment which follows from innovations by leading firms as well as from a catching up process by imitating laggards. The innovation process is modeled as a self-organising process of information search set off by Poisson arrivals. Resulting investment waves determine structural changes in effective demand patterns causing macroeconomic disequilibria that prompt adjustments in capacity, demand and employment. Finally, it is argued that the wave-like nature of innovations and innovation driven investment is a structural cause of economic activity oscillations.

1. Introduction

Historical investigation has shown (see Rosenberg, 1976; Mokyr, 1990) that since the Industrial Revolution technical progress has become an endogenous source of economic growth especially in manufacturing sectors. It has been remarked, however, that such progress has not appeared as a steady stream of innovations but in bouts of intense advancement followed by lapses of slackened pace. This fact indicates that there is a systematic tendency for technologically-relevant events to come in waves of innovations and imitations. This paper investigates this issue by relating them to the waves of investment generated by the profit opportunities provided by technology-driven increases in productivity. Innovation is the key to this process stemming from the intense learning and searching activity that technological leaders carry out. This paper considers this activity as a two-fold process consisting of an independent research and development effort and of an attempt to gather relevant information by interacting with other leading firms. This second facet of firms' efforts relies on the observable informational spillovers that successful innovators generate, an issue that has been dealt with by Andergassen et al. (2006a,b, 2009). While this clearly holds for imitation, it more importantly applies when technological breakthroughs occur in sectors other than a firm's own domain of activity (Fai and von Tunzelman, 2001). It is therefore a matter of cognitive interaction between heterogeneous firms able of exploring each other's technological capabilities. It is worth noting that this interaction is clearly local owing to bounded rationality and limits to technological competence constraining firms to an informational space spanning a relatively small cognitively defined neighbourhood. It is not however a passive, effortless undertaking but requires specific investment in mainly human resources. Investment discussed forthwith crucially depends on this activity.

E-mail address: massimo.ricottilli@unibo.it

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This paper main purpose is to enquire on the connection between technical progress and effective demand in upgraded, novel means of production. The latter is an event that causes discontinuities by imparting structural changes the time horizon of which is defined over periods of gradual, evolutionary adjustment. Because of this analytical focus, only investment prompted by new methods of production is dealt with. Other very important forms, comprised in the usual macroeconomic definition but responding to different kinds of stimuli are not considered. Replacement investment and that accounted for by demand variations are neglected. The former since it is the consequence of normal wear and tear, although technological change quickens its pace owing to early obsolescence, the latter because it is not an autonomous, even if a major short-term, source of demand. In spite of their relevance, they are ignored in order to concentrate on that kind that is held to be the mainstay of long term growth. An analysis is accordingly presented that studies a very simple economy in which its population and workforce remain constant but that undergoes changes provoking unsettling disequilibria due to technological innovation and its diffusion.

Structural changes due to technical progress embodied in new means of production have been cogently investigated by Hicks (1973) in terms of a traverse from one technological state to a more advanced one. His analysis, however, is made under a full performance assumption and as such it is a sequence of equilibria. In this paper, on the contrary, structural transformation is seen as a process generated by the surging and relapsing of effective demand as technology-driven investment emerges and as it wanes when its stimulus is exhausted. A crucial assumption is made: innovations are searched for and the required investment made only by leading firms; in fact, exclusively by a single firm in each sector. This is clearly a simplification of a normally complex reality in which firms compete to introduce innovations but its purpose is to avoid computational difficulties of a microeconomic nature in a paper that is mainly concerned with system-wide adjustments and structural change. Recent literature, however, has pointed out that leaders do tend to emerge. Zeira (2011) has argued that risk-aversion leads to concentration of R&D in a few firms to reduce the risks that are inherent in patent races. It is argued that the latter, if they occur, crowd easy to obtain innovations leading to an overconcentration of R&D spending at the expense of hard to obtain ones bearing little impact on growth but causing much duplication. Waste of research resources is also reported in Scotchmer (2004) pointing to losses and winner-take-all outcomes. Etro (2008) argues that when incumbent monopolists are leaders they engage in large R&D and are, therefore, likely to persist in a leadership position that enhances growth. Monopolists invest if they actually enjoy a leading position in the patent race, their innovation value including the option of monopoly persistence. Thus, growth is driven by market leaders. That R&D leaders are likely to emerge is a fact highlighted by Cohen and Klepper (1996). The reason they provide lies with the fact that leaders are normally large firms that can spread the costly undertaking of innovation investment on large output and related revenue making its burden relatively lower. This is an advantage that holds particularly on account of the difficulty of marketing innovations in disembodied form. Empirical work done by Malerba and Orsenigo (1999) indicates that much R&D is carried out by firms that have established themselves as leaders applying cutting-edge technologies. Their evidence supports the view that only a fraction of entrants in a given industry is capable of surviving but those that do grow large and, more importantly, become persistent innovators. Incumbents are found to invest more than outsiders leading to endogenous persistence of technological leadership. Interestingly, they argue that established innovators come from sectors or are likely to penetrate sectors other than the one in which they are currently engaged. The persistence of leaders is also indicated by a review on patent races authored by Jensen (2009).

Phases of absence, increase and later decrease of effective demand imply time breaks that this paper deals with by resorting to partitions exhibiting specific characteristics. The *first one*, describes a stationary state in which there is no investment in capital goods and the economy features demand and capacity equilibrium both in the aggregate and at the sectorial level. Firms earn a normal profit rate to which corresponds a wage rate fixed in the labour market. Although in this state of normality all firms earn the same profit rate, some, one in each sector, can be considered as technological leaders. There is however some special investment in this economy: it owes to these firms' expenditure to support a technological searching process. Thus, in this period of apparent stasis something is in fact in the making: it is the dynamic process of information gathering, study and exploring of technological opportunities. When successfully achieved an innovation becomes feasible and a *second* period is ushered in: investment materializes in the form of demand for capital goods embodying a technological, productivity-increasing advancement. It is important to state that this peculiar kind of investment is not decided and this searching activity is not performed on the grounds of a complete forward-looking capability. Leading agents are constrained by bounded rationality and profit expectations, although rational, are not necessarily time consistent. They can be faulted and frustrated.

The new production equipment that leading firms demand generates increases in above-normal employment: workers have to be brought in to produce the capital goods that incorporate the innovation. Thus, the foregoing state of normality cannot be envisaged as a total full employment state; a *normal* reserve 'army' of labour has to be available. Major technological transformations have all been achieved by mobilizing labour available in excess of strict production requirements: from traditional agriculture, from structural unemployment or immigration.

Drastically simple consumption habits are postulated throughout. The analysis is conducted by keeping the nominal wage rate constant and aggregate demand for consumption goods changes as a consequence of sudden jumps in employment. Constant capacity, however, implies a generalised price increase that lowers the real wage rate: a Kaldorian effect. This *interim* period is short-lived: it lasts the period of time required for the innovation wave to generate demand for new investment goods. Once the latter is exhausted another structural change