Product architecture and the organisation of industry
The role of firm competitive behaviour

Tommaso Ciarli\(^1\) - Riccardo Leoncini\(^2\) - Sandro Montresor\(^3\) - Marco Valente\(^4\)

Abstract submitted for the
EAEPE 2007 Conference on
“Economic growth, development, and institutions –
lessons for policy and the need for an evolutionary framework of analysis”

Faculdade de Economia, Porto, Portugal

1-3 November 2007

Extended abstract

The main aim of this paper is to study, from a theoretical point of view, the relation between (i) firms’ capabilities to react to market and technological changes, (ii) product architecture and modularity, and (iii) the organisation of industries. In particular, we investigate two related aspects: a) on the one hand, the way in which given technological interdependencies between products’ components (production modules) affect the division of labour of firms’ production processes\(^5\); b) on the other hand, the extent to which firms’ capabilities allow them to tune, accordingly, changes in the governance structure, the product architecture, and the production process. Different firms (with different information and ‘capabilities’ sets) may face the changes occurring in (a) focusing on one strategy (or a combination of strategies) categorised in (b). Indeed, the firms’ ability to modify products’ architecture allows for an endogenous contribution in the change of technological interdependencies. It is a dynamic adjustment of those strategies, we argue, that allow firms to increase their relative fitness.

The research questions entailed above draw on a theoretical background which considers the relationship between technology and organisation as a complex link of mutual interactions, rather than a unique ‘straightforward’ causal link, in whatever direction. Therefore, we shed some interpretative light on research issues such as: “How does firms’ governance and organisation affects their innovative behaviour?” “How does product innovation routines affect firms’ organisational choice?” “How do firms tune research and organisational routines in order to increase their competitiveness on the market” “How do different industrial systems evolve”?

\(^1\) University of L’Aquila and University of Bologna, Italy. E-mail: tommaso.ciarli@unibo.it
\(^2\) Department of Economics, University of Bologna, Italy. E-mail: riccardo.leoncini@unibo.it
\(^3\) Department of Economics, University of Bologna, Italy. E-mail: montreso@spbo.unibo.it
\(^4\) Department of Economics, University of L’Aquila, Italy. E-mail: valente@ec.univaq.it
\(^5\) Some aspects of this relation have been modelled in Ciarli et al. (2006b).
This way of looking at the dynamics of the technology–organisation relationship combines at least three strands of the literature. First, in very broad terms, the evolutionary perspective acknowledges that firms deal with innovation activities, as well as with production, as bounded rational agents: they resort to given research heuristics, rather than to optimal procedures (e.g. Dosi, Nelson and Winter 2000). Second, the “Simonian” perspective to the solution of complex problems, (such as innovation in ‘complex products and systems’ as “tailored capital goods, systems constructs and services” (Dosi, Hobday, and Marengo 2000, p. 5). In other words, the way in which a new problem (e.g. innovation) is posed — decomposed — and the structure of the related (collective) problem–solving activity, define the second basic ingredient of the firm’s innovative dynamics (e.g. Marengo, Dosi, Legrenzi, and Pasquali 2000). Third, we refer to the growing literature on the issue of ‘modularity’ (e.g. Brusoni and Prencipe 2001). In fact, the interrelations among the elements of a complex problem may be translated into different economic dimensions: (i) a product with a modular (rather than an integrated) architecture; (ii) an innovation in the core design concepts (rather than in the architectural knowledge) of a certain product. The third basic ingredient of the firm’s innovative dynamics is thus represented by both the opportunities and the limits of modularity (Ernst 2005).

As far as the paper’s methodology is concerned, the intertwining of problem decomposability, product and organisational modularity, and technological search, is studied via a computational model that represents one industrial sector, in which an heterogeneous good for the consumers’ market is produced (Ciarli et al. 2006a, 2006b). Heterogeneous firms compete for a final demand that has preferences on a number of characteristics of the consumers good. In order to produce the good, each assembling firm uses a certain number of input components. Each input component contributes to each assembled good characteristic, according to the technological architecture of the good, and to the degree of modularity among components.

Improvements in the technological performance is achieved by exploiting a ‘corrugated’ technological landscape. The characteristics contribution of a single module is increased by looking for a maximum (either global or local) value of its fitness. However, the global fitness of the integrated good is determined by the correlation structure between the whole set of modules. Therefore, firms may opt for a change in the correlation structure, i.e. product architecture. The landscape exploration is modelled through a continuous version of the NK model elaborated, for instance, by Kaufmann et al. (2000).

Thus firms seek to increase their competitiveness on the market through a number of strategies that impact on the cost of production and the quality of the final good. At one extreme, (short-term) strategies address adaptive changes in process routines, acquisition of fitter components, or product innovation on components manufactured in-house. At the other extreme, firms seek to introduce changes in the overall architecture of the product to define standard for components’ characteristics, and eventually re-frame the most competitive organisational structure. When successful, this second (mid-term) strategy, reshapes transaction costs and core competencies.

The main contribution of our model is that it allows to study the relationships between the technological interdependence of input components (modularity and architecture), the innovation strategy (product and organisation), firms capabilities attached to it, and the emerging industrial organisation. The paper mainly concentrates
on the study of firms capabilities, in a setup where only a ratio of firms in the population is endowed with dynamic capabilities that allow them to refine their strategic behaviour.

References


