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Path dependence in technologies and organizations: a concise guide

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Abstract

The note on which an entry for the *Palgrave Encyclopedia of Strategic Management* will draw offers a beginner's guide to path dependency in technologies and organizations. We address the very meaning of the concept and its centrality in various aspects of economic analysis. We outline the various levels of the ecomic system in which it is observable, its sources, concequences and different formal representations of path dependent processes.

Keywords:

Path dependence, lock-in, dynamic increasing returns, organizational inertia

1. Introduction

The concept of path dependence captures the idea that *history matters.* Analytical approaches entailing path-dependence stand against the mainstream development of economics as an 'ahistorical system of thought' (David, 2001). The notion is a key one within evolutionary economics (Nelson and Winter, 1982) and has found powerful applications to the understanding of irreversibilities in technological and organizational change. Path dependence may be defined over a spectrum of phenomena ranging from mere dependence upon initial conditions all the way to strong dependence upon a specific unfolding of events (see also the degrees of 'historicity' defined in David, 2001, Bassanini and Dosi,2001 and Castaldi and Dosi, 2006).

2. Levels of observation and sources

Path dependence is observable at various layers of the economic system, ranging from the individual up to the aggregate system levels.

Individual decision making and learning tend to be path dependent as soon as decisions are taken sequentially over time, reflect uncertainty or imperfect information, depend on local interactions, and even more so if one accepts that preferences are endogenous in the first place (Aversi et al, 1999).

At *technology* level, path dependence shows up with the persistence and lock in onto particular technological choices reinforced by the increasing returns in the production or adoption of technologies and products, and the positive feedbacks and network externalities. Technological innovation and diffusion in fact often display *dynamic* increasing returns unravelling over time (Castaldi and Dosi, 2006; Dosi and Nelson,2010, and more specifically on industrial dynamics, Antonelli,1999). A famous example of lock in, out of many, into a suboptimal technology is the QWERTY keyboard supported by the path-dependent reproduction of users' skills (David, 1985). Another quite general source of path-dependence entailing positive feedbacks is grounded in agglomeration economies, plausibly an important driver of the emergence of industrial districts such as Silicon Valley (Krugman, 1991; Kenney and Von Burg, 1999).

Path dependence is ubiquitous also in the evolution and patterns of decision making of *organizations*. Organizational path dependence has been linked to various factors that explain persistence of organizational choices and that emphasize the importance that past events bear for the future orientation of organizations (see Sydow, Schreyong and Koch, 2009 for an extensive discussion). Imprinting, idiosyncratic learning and structural inertia (Stinchcobe, 1965; Beckman and Burton, 2008; Hannan and Freeman, 1984; Argote, 1999), to mention the most obvious ones, are the usual suspect mechanisms leading to path dependent reproduction of organizational knowledge and behaviours. This is linked to the ways organizations elicit stored information i.e. their ability to remember. The structure and rigidity of organizational memory, as well as the processes of interpretation, information retrieval and action formation of organizations are fundamental sources of path dependence (Dosi et al., 2011).

The features of selection processes are an important source of path dependence whenever evolutionary fitness (i.e. competitiveness of firms, technologies, etc) depends in non-trivial ways upon multiple traits. In such cases selection happens on a fitness landscape with multiple local maxima that are determined by (possibly random) initial conditions (Levinthal, 1997; Castaldi and Dosi, 2006). Organizations typically compete on such complex landscapes and interrelated technological and behavioural traits are responsible for path dependent reproduction of organizational arrangements (Marengo, 1996, Levinthal,1997 and 2000). Moreover, the link between what firms do and the way they are selectively rewarded in the market, is utterly opaque for at least three reasons: (i) the complexity of the environments where they operate; (ii) the mentioned multiple 'epistatic correlations' amongst behavioural and technological traits; and (iii) significant lags between organizational actions and performance-revealing feedbacks. In such circumstances, path dependence is also likely to be fuelled by behavioural/procedural and 'cognitive' forms of inertia (Tripsas and Gavetti, 2000). At organizational level, failure to account for the changes of the environment where an entity operates and persistent reproduction of interpretative frameworks and actions lead essentially to cognitive and operational lock-ins (that is , *competence traps*).

In fact these latter properties apply to many other formal organizations (in addition to business firms, also public agencies, trade unions, etc.) and to many institutional arrangements, e.g. ethical codes, habits of thought, etc. (Dosi, 1995). As argued by David (1994), institutions are a fundamental carrier of history. The attractiveness of "doing things

the way we know" can often act as an obstacle to change and lock individuals, organizations and whole economic systems in suboptimal behaviours and problem-solving heuristics. A famous example on the consequences of path dependent individual decision making relates to segregation phenomena (Schelling, 1971).

As countries can be characterized by combinations of complementary institutions, path dependence also strongly affects national dynamics (see for example the discussion on national systems of innovation: Lundvall, 1992 and Nelson, 1993, Kogut, 1993 and the evidence of persistence of national specializations).

Note in any case that evolution does not need to equate to progress, as one can identify many examples of path dependent dynamics going *from better to worse* (see the story of Easter Island in Diamond, 2005).

3. Escape routes

Tackling with "bad path-dependencies" involves different sorts of remedies with different degrees of intentionality. First, de-locking may rely on environmental shocks, on the arrival of new knowledge bases and, consequently, new paradigms. Relatedly, deviant behaviours may "autocatalyze" and aggregately account for shifts in the system orientation (Castaldi and Dosi, 2006). Within organizations path breaking routes include the purposeful loss of memory, changes in the organizational structure, increasing "cognitive dissonance" between organizational cognitive frames and action repertoire and management and labour turnover (Garud and Karnøe, 2001; Dosi et al, 2011).

4. Formal representations

Path-dependent phenomena have been modelled using mathematical tools such as nonlinear dynamics and chaos (Brock and Malliaris, 1989), stochastic processes such as generalized polya urns (Arthur, 1994; Dosi and Kaniovski, 1994), and borrowing models and concepts from (evolutionary) biology (e.g. on the dynamics of evolution on fitness landscapes of Kauffman, 1989). Moreover, the broad field of complexity has been the fertile ground for multi-disciplinary research on path dependence (see Frenken, 2006).

5. Open questions

Understanding path dependence is seriously hampered from an empirical point of view by the fact that in social sciences one generally observes only one of the many possible histories. Still, Gould (1977) already suggested the power of trying to imagine what would remain unchanged if “the tape of evolution would be run twice”. The risk is the one of ex-post evolutionary rationalizations, but plenty of opportunities are offered by available mathematical and conceptual models. A major challenge is the one of conceptualizing hierarchically nested evolutionary processes allowing for slowly changing macro institutions which in turn structuring faster micro-dynamics of adaptation.

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