

Nelson and Winter Conference
Theme E: Growth, Development and Structural Change

**Technological diffusion, welfare and growth: modelling technological
substitution in the presence of network externalities**

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Abstract

In an earlier paper (Windrum and Birchenhall, 1998), the authors examined the dynamics of co-evolving product designs and user preferences leading to the horizontal segmentation of new technology markets into distinct ‘niches’. In this paper the generic framework is applied to the issue of how new technologies are able to overwhelm the network externalities enjoyed by established technologies (Arthur *et al.*, 1987; Arthur, 1989; David, 1985; Katz and Shapiro, 1986; Farrell and Saloner, 1985).

The analysis builds on earlier discussions of technological successions and explores a number of issues not normally considered but which are likely to have a bearing on the probability of technological substitutions occurring. First, we consider differentiation in the characteristic sets offered by the old and new technologies (Lancaster, 1971; Archibald and Eaton, 1989). This contrasts with the possibility of a new technology offering higher specification over the same characteristic set (Hotelling, 1929). Second, we consider differential costs due to scale economies. Differential falling unit costs of alternative technologies affect demand when these are transmitted to prices, altering the price-quality combinations offered by old and new technology products (Choi, DeSarbo, and Harker, 1990). Third, we consider time as a possible explanatory variable. Altering the time in which new technology providers are able to exploit their superior applications is likely to affect the probability of a technological substitution occurring.

Given the large number of parameters involved in the analysis, and the desire to examine these in a meaningful manner, the paper employs simulation techniques on an agent-based model containing heterogeneous populations of adaptive users and providers that co-evolve over time. In the spirit of Nelson and Winter (1982), producers employ various adjustment rules to their production routines, while simultaneously innovating through a combination of imitation and internal R&D. Whereas Nelson and Winter modelled these using a replicator dynamic algorithm, the current paper employs a modified GA in which imitation is conducted via a process of

selective transfer (one-way crossover) and internal R&D is conducted via selective mutation.

The evolution of consumer preferences was not explicitly considered by Nelson and Winter, and remains an underdeveloped area (see recent special issue on demand in the Journal of Evolutionary Economics). This model builds on the work of Simmel and Bourdieu on social distinction and imitation in consumption. Different social consumption groups are structured with regards to income and social status. Social groups with higher status (and disposable income) are attracted to distinction goods. Groups with lower social status seek to imitate, given income constraints, these groups. Imitation reduces the value of a distinction good. Herein lies a key driver for the diffusion of particular technological goods and, simultaneously, the periodic search for new technology goods by higher status consumer groups. The dynamic expresses itself through the rise and decline of consumption preferences over time and the periodic exploration of new dimensions of characteristic space.

The paper identifies a number of necessary conditions for technological substitutions, leading to higher welfare and growth. These compliment earlier suggestions while also highlight new issues;

i) *functional equivalence*

A technological succession involves the substitution of an established product or process by a new alternative that fulfils the same basic function. (Grübler *et al*, 1988; Grübler, 1990)

ii) *quality of alternative designs*

Choice is tied to the relative fitness (quality) and welfare associated with alternative technology products (Frenken, Saviotti, and Trommetter, 1999).

iii) *trade-off between quality and price*

A trade-off is likely to exist between the quality of the rival technologies and their price, tied to costs of producing these alternative bundles of characteristics. Given that user welfare depends on both the relative performance of each technology product and its price, this will affect demand and hence the outcome of a technological competition (Shy, 1996)

iv) *new user preferences*

In addition to firms offering new technology products, substitution requires the emergences of new user preferences.

v) *time*