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# Global technological races

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## Abstract

A prime consideration of technological competition is the observation that firms are engaged in a race toward a larger market share. A major focus is the strategic orientation of corporations in participating in such a race, revealing empirically observable phenomena such as ‘catch-up’ and ‘leapfrogging’, as supported by statistical measurements. A statistical profiling of technological evolution and innovation is analyzed as it relates to competitive racing and rivalry among leading firms. Among the performance criteria to be assessed are frequency of frontier pushing, technological domination period, innovations versus imitations in the race, innovation frequency when behind or ahead, nature of jumps, leapfrogging or frontier-sticking, inter-jump times and jump sizes, race closeness measures, and interfrontier distance. A tentative policy conclusion of the paper is that technological racing patterns on a micro scale reinforce globalization and limit control of national and industry policy.

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## 1. Introduction

The striking pattern that emerges in firms’ innovative activities is that the firms’ rival for a technological leadership position in situations best described as ‘races’. A ‘race’ is an interactive pattern characterized by firms constantly trying to get ahead of their rivals, or trying not to fall too far behind. In high technology industries, where customers are willing

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to pay a premium for advanced technology, leadership translates into increased returns in the market. Each race involves only a subset of the firms in the industry, and the activity within each race appears to strongly influence the behaviour of the firms within that race. Surprisingly, the races share broad similarities. In particular, firms which fall behind, in their race, display a robust tendency to accelerate innovative effort in order to catch-up.

In contrast to any existing way of looking at the evolution of technology, racing behaviour recognizes the fundamental importance of strategic interactions between competing firms. Thus, firms take their rivals' actions into account when formulating their own decisions.

The prescription and description of industrial racing patterns can be viewed as identifying objectives for performance evaluation of firms, industries, regions and national economies:

- (a) A key objective is to explore and explain which type of 'racing behaviour' is prevalent in global high technology industries, as exemplified by information technology (semiconductors, computers, telecommunications) industries. The pattern evolving from such racing behaviour would be benchmarked against the frontier racing type of the global technological leaders.
- (b) Another objective is to draw policy inferences on market structure, entrepreneurship, innovation activity, industrial policy and regulatory frameworks in promoting and hindering industry frontier races in a global industrial context.
- (c) Given the statistical profile of technological evolution and innovation for respective global industries, how does it relate to competitive racing and rivalry among the leading firms? Among the performance criteria to be assessed are frequency of frontier pushing, technological domination period, innovations versus imitations in the race, innovation frequency when behind or ahead, nature of jumps, leapfrogging or frontier sticking, inter-jump times and jump sizes and race closeness measures.
- (d) An empirical proliferation of racing in these global industries can be explored, comprising of datasets identifying 'relationship between technological positions (ranks) of firms in successive years' (10–25-year period).

## **2. Review of previous research**

Economic models and observations on 'technology races' are the most direct intellectual precursor to this paper (Reinganum, 1989; Scherer, 1991; Tirole, 1988). This follows from the tradition of investigating the varied implications of the notion, first advanced by Schumpeter, that it is the expectation of supernormal profits from the temporary monopoly position following an innovation, which is the chief driver of R&D investment. The simplest technology race model would be as follows. A number of firms invest in R&D. Their investment results in an innovation with the time spent in R&D subject to some uncertainty (Gottinger, 1989). However, a greater investment reduces the expected time to completion of R&D. The models investigate how many firms will choose to enter such a contest, and how much they will invest.

Despite some extensive theoretical examination of technological races, there have been very few empirical studies on the subject (Lerner, 1997) and virtually none in the context of

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