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Endogenous R&D symmetry in linear duopoly with one-way spillovers

Antonio Tesoriere*

SEAF, Università Degli Studi di Palermo, 90128 Palermo, Italy

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Abstract

A duopoly model of cost reducing R&D-Cournot market competition is extended to encompass endogenous timing of R&D investments. Under the assumption that R&D spillovers are zero under simultaneous choices of R&D and only flow from the R&D leader to the follower under sequential choices, sequential and simultaneous play at the R&D stage are compared in order to assess the role of technological externalities in stimulating or attenuating endogenous firm asymmetry. The only timing structure of the R&D stage sustainable as subgame–perfect Nash equilibrium involves simultaneous play and thus zero spillovers.

JEL classification: C72; D43; L11; L13

Keywords: Endogenous symmetry; Endogenous timing; Stackelberg equilibrium

1. Introduction

Many studies of strategic R&D adopt multi-stage games in which firms' prior investments lower the cost of production in the product market. The model by d'Aspremont and Jacquemin (1988) is a leading example for the two-stage, two-firm case. In the first stage firms reduce their initial unit costs by investing simultaneously in R&D. R&D generates an external effect (spillover), a fraction of each firm's autonomous cost reduction flowing without payment to the rival. In the second stage, firms engage in Cournot competition in the product market, given their

* Corresponding author. Tel.: +39 091 612 4085.
E-mail address: tesoriere@core.ucl.ac.be. (A. Tesoriere).

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effective unit cost reductions. Many other studies on this field of research build on this standard framework.[1]

Issues in these studies are usually restricted to symmetric equilibria. Following Henriques (1990), Amir and Wooders (1998) show that the symmetric non-cooperative equilibrium of the d'Aspremont and Jacquemin model is, however, sometimes unstable. In this case two other asymmetric and stable equilibria must also exist. These latter might represent the appropriate benchmark of analysis.

The main concern in this paper is endogenous asymmetry of firms competing in the research activity. The study here claims that differences in firms' R&D levels, besides resulting from the instability of the model, might also reflect the endogenous emergence of strategic roles for firms. For instance, firm asymmetry might reflect R&D leadership and represent the outcome of a sequential game where, say, the larger firm moves first in the R&D stage and acts as a Stackelberg leader. The issue of *ex post* asymmetry is hence addressed in terms of endogenous assignment of both a timing structure (simultaneous or sequential) and a players' role configuration (leader, follower) to a given R&D game.

Studying the strategic positions of firms as an equilibrium phenomenon is motivated by the inadequacy of the Stackelberg equilibrium as a solution concept. As is shown by Gal-Or (1985), first or second mover advantages in a Stackelberg game occur when actions are strategic substitutes or complements, as in quantity competition with substitute goods and in price competition with differentiated goods, respectively, so providing a sequential game with an exogenous timing structure may not be justified when competitors are assumed to be *ex ante* identical.

Many studies have tried to overcome this flaw.[2] Hamilton and Slutsky (1990) propose a foundation of the Stackelberg equilibrium concept in terms of endogenous timing of firms' actions. Given a *basic* duopolistic game, they construct an extended framework by adding a precompetitive stage in which leadership is assigned. Namely, at the precompetitive stage, firms simultaneously commit to move early or late in the subsequent basic game. The equilibrium of the resultant game induces a pair of actions in the basic game as well as the order of moves according to which the basic game itself is played.

The present study compares sequential and simultaneous R&D by introducing two different games of strategic R&D investments, each involving Cournot competition in the product market. The former is a two stage game with simultaneous play at the R&D stage and zero R&D spillovers. The second one is a three stage game with sequential play and perfect information in the R&D phase with spillovers flowing from the first mover to the second mover. The equilibrium concept introduced by Hamilton and Slutsky is used to address the issue of endogenous timing of R&D decisions.

Endogenous timing of R&D decisions has been already studied by Amir et al. (2000). For a version of the d'Aspremont and Jacquemin model that allows for differentiated products and firm specific (bidirectional) spillovers, they identify a partition of the parameter space in terms of the equilibrium timing structure that obtains. When the ratios of own spillover rate over demand cross-slope is high (low) for both firms, then only sequential (simultaneous) R&D is observed,

[1] The literature on strategic R&D has been pioneered by Ruff (1969). Other seminal contributions are Dasgupta and Stiglitz (1980) and Spence (1984). Among more recent studies, see Kamien et al. (1992), Suzumura (1992), and Hinloopen (2003).

[2] Many contributions reinterpret the Stackelberg solution as a special case among a large family of equilibria of a certain class of simultaneous games. See, for example, Saloner (1987) and Maggi (1996).