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Optimal dispersion of R&D activities in multinational corporations with a genetic algorithm

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Abstract

This paper presents a new communication-economic network model to predict the allocation of R&D activities in MNCs. While traditional models examine the influencing factors of R&D internationalization separately for each country and come to a one-dimensional result, this multi-dimensional approach integrates the influencing factors in a way that allows to identify an efficient configuration of the entire R&D subsystem in many countries at a time. It captures the information flows and employs a genetic algorithm to find a dispersion of R&D activities in which the problems of international communication have the least negative impact. The model is tested with data from seven MNCs covering a range of 48 countries as potential R&D locations.

Keywords: Research and development; International management; Organization theory; Communication; Genetic algorithms

1. Introduction

Multinational corporations (MNCs) conduct research and development (R&D) not only in their home country but also in numerous foreign countries (Kuemmerle, 1999; Gerybadze and Reger, 1999; Meyer-Krahmer, 1999). The influencing factors of R&D internationalization are well-known and widely agreed on in literature (Cheng and Bolon, 1993; Granstrand et al., 1993; Brockhoff, 1998): employing highly qualified foreign personnel, reducing costs, tapping into foreign sources of knowledge, better recognizing and faster reacting to foreign customer demands, supporting local production units, and implementing incentives or regulations of host governments. Furthermore, advances in information and communication technologies, modular product concepts, and improved conditions in former developing countries foster the internationalization of R&D. A considerable share of R&D, however, happens to become international by acquisition of foreign companies (Dörrenbacher and Wortmann, 1991).

Empirical knowledge about the internationalization of R&D may seem complete, but in fact literature has been caught in an intermediate state for a long time, where methodological limitations interfere with further progress (Cantwell, 1994). Preceding studies mainly investigated single or a very limited number of countries as locations for foreign R&D or treated all foreign countries as one by considering the share of R&D activities abroad. Though the question of the international distribution of R&D in MNCs, which considers the allocation of R&D activities in a simultaneous view of multiple countries, has not been

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studied with quantitative methods yet. This shall be the research question of the paper at hand.

As stated by Pearce (1989), traditional research into R&D internationalization can be attributed to two sorts of models, which we call physical forces models and decision path models. Physical forces models interpret influencing factors as "attracting" and "repulsive forces" to international R&D. The attracting forces are listed above. The repulsive forces represent negative influencing factors, such as unwanted dissemination of knowledge from poorly controlled foreign parts of the company, diminished economies of scale in the home R&D laboratory, and higher communication costs within the R&D subsystem (Mansfield et al., 1979; Behrman and Fischer, 1980). Hirschey and Caves (1981) calculated an "equilibrium" degree of R&D internationalization in their model of centrifugal and centripetal forces. Chiesa (1995) talked about "centers of gravity" that attract international R&D activities. His perspective allows us to study the interrelationships between different R&D sites while the rotation forces approach strictly focuses on the home base. The drawback of all versions of physical forces models is that physical forces do not exist within international R&D. Metaphors are useful tools for description but can hardly serve as theories (Bacharach, 1989).

The second traditional stream of research focuses on R&D location decisions in foreign countries. Ronstadt (1978) argued that different conditions internal and external to an MNC suggest establishing local R&D units of a certain kind. Hewitt (1980), Håkanson (1992), and Beckmann (1997) presented models which suggest such efficient location choices. In this view, the international distribution of R&D activities is the consequence of separate location decisions. The decision path models will be able to explain the evolution of R&D organizations as soon as they include human decision-making (Simon, 1976). They are able to incorporate all variables that are relevant to the process of R&D internationalization because they focus on the individual case, respectively, and follow the chronological sequence of decisions. However, R&D managers are unable to measure the overall efficiency of the resulting distribution of R&D activities. Neither are academics who adopt this sequential approach in their research, since a set of sub-optimal location decisions do not necessarily lead to the global optimum. If one seeks to optimize the distribution of R&D it is necessary to consider all potential R&D locations at a time.

In recent years, new economic models of international R&D appeared. They use cost as an efficiency critierion of the international distribution of R&D activities. Cost is not able to incorporate all of the variables that may affect R&D internationalization, but it allows to combine most of them in a holistic approach. Casson (1991); Pearson et al. (1993), and Kuemmerle (1997) argued in their conceptual models that performing R&D activities abroad saved communication costs in the interaction with local corporate functions at the sacrifice of communication costs within the R&D organization itself. The ways to quantify the optimum, however, are still unknown. Problems of complexity have prevented all empirical tests of economic models so far.

It is obvious that economic models cannot guarantee an optimal configuration in terms of a maximized innovative capability. Because the present state of knowledge in literature does not allow for a maximization of the organizational advantages, economic models focus on minimizing the disadvantages instead, which are easier to quantify. This procedure does not deliver the desired outcome in a direct way, nor does is give evidence for a profit-maximizing configuration. But at least, economic models find a useful approximation of what other methods fail to find: a globally efficient solution. Thus, since economic models, unlike physical forces models, consider economically relevant variables and, unlike decision models, they are able to capture and evaluate entire R&D organizations, they are the most promising approach to study the international distribution of R&D activities in MNCs.

This paper aims for a causal prognosis of the international distribution of R&D activities in MNCs. It tries to predict what shares of R&D activities MNCs carry out in which countries. The following section checks organization and information theory for their contributions to such a new model. I develop a communication-economic network model that incorporates a multiplicity of influencing factors of R&D internationalization by their impact on the international communication in an R&D organization. A genetic algorithm, which I present in the method section, calculates the optimal international distribution of