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Government roles in evaluation and arrangement of R&D consortia

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ABSTRACT

The role of government in forming and coordinating R&D consortia has often been cited in studies of the economic success of latecomer countries such as Korea and Japan. Most previous studies documented the government's efforts to provide funding. In our research about the government's role in determining the quality of innovation, we develop a computational model based on genetic algorithms. The two main aspects of government involvement explored in this study are 1) the timing of evaluation of participating firms in a consortium, and 2) the form that these consortia take. In terms of the timing of evaluation, we find that continuous evaluation is consistently superior to early evaluation. In addition, the effect of the form of the consortium depends on the timing of evaluation. An inverse pyramid arrangement, which emphasizes variation at the beginning of the innovation process, outperforms a pyramid-form arrangement only when evaluation is continuous. We identify the tension and reconciliation between diversity and selection as the force underlying the results of this study. We discuss these findings and their implications for how governments should balance diversity and selection when designing innovation systems.

1. Introduction: the role of government in government-coordinated R&D consortia

The purpose of this article is to examine the role of government in formation and coordination of R&D consortia by modeling the process from an evolutionary perspective (Nelson and Winter, 1982; Devezas, 2005). In particular, we modify genetic algorithms to model different possible forms of government-coordinated R&D consortia (Holland, 1975; Goldberg, 2000; Devezas, 2005). According to Aldrich and Sasaki (1995), the government's involvement with R&D consortia may be minimal, they may contribute funding, or they may coordinate projects. We focus on the third role, in which government officials or agencies choose to participate in the life of the consortium by allocating tasks to firms and orchestrating the within-consortium innovation process. We use the term "government-coordinated R&D consortia" in order to differentiate from "government-sponsored R&D consortia". Unlike the current study, in most studies of government-sponsored R&D consortia (e.g., Sakakibara, 1997; Branstetter and Sakakibara, 2002), samples were limited to projects in which the cooperation of private firms was vital to the consortium's success (e.g., the VLSI, or Very Large Scale Integrated circuit project in Japan). Thus, previous studies focused on R&D consortia in which, although government financial support was present, voluntary cooperation among participating firms was essential. In our study, government decision-making determines whom to include in the consortium and how tasks are allocated; thus, the government is more directly involved, which affects the extent of the consortium's success.

Government-coordinated R&D consortia are highly relevant to economies, particularly in "latecomer countries" such as Korea and Japan (Cho et al., 1998; Choi, 1986; Lee, 1988). In these countries, the collaboration within government-coordinated

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R&D consortia is important in aggregating and consolidating potentially fragmented R&D efforts at the national level. For example, the government initiated and coordinated the development of High Definition TV (HDTV) technology in Japan and the commercialization of CDMA (Code Division Multi-Access) technology in Korea. Although the role of government in sponsoring and coordinating R&D consortia is reported to have declined in the mid-1990s (Sakakibara, 1997), it retained importance in newly emerging sectors such as large-scale renewable energy in both developed and developing countries (Mah et al., 2013). For example, the Japanese government established NEDO (the New Energy and Industrial Technology Development Organization), a quasi-governmental organization, to promote the development of new energy technologies with an annual budget of 121.1 billion yen[1](Kajikawa et al., 2008). The South Korean government, noting the importance of nano-technology for scientific competiveness and economic prosperity, has been aggressively promoting nano-science technology since the late 1990s by establishing and executing the National Comprehensive Development Plan of Nanotechnology (NCDPN). As a result of the nationally coordinated effort, Korea came to rank the highest in the amount of R&D expenditure as a share of Gross Domestic Product (GDP) only three years after its inception. In terms of the output, the level of nanotechnology in Korea reached 75% of that in the United States as of 2008 from 25% in 2001 (Kim, 2010). Other performance measures such as number of SCI papers published, number of patent registrations recently show that Korea has become one of the leading nations in this area (Bae et al., 2013). This example testifies to the potentially important roles of a government in forming and orchestrating R&D consortia.

Despite its importance, most previous studies of R&D consortia excluded cases with heavy government involvement (Sakakibara, 1997). Thus, the role of government in government-coordinated R&D consortia, in which government involvement is much more direct than in other types of consortia, is understudied.[2]

From an evolutionary perspective, the characteristics of government-coordinated R&D consortia are intriguing. Often innovation is viewed as a social evolutionary process involving a sequence of variation, selection, and retention (VSR, hereafter) (Nelson and Winter, 1982; Van de Ven and Garud, 1994). Other innovation models such as the A–U model (Abernathy and Utterback, 1978) and Tushman and Anderson's (1986) model assume the existence of the VSR process to a certain degree in their models as well. Especially for emerging technologies, a certain degree of variation at the early stage seems to be inevitable due to the uncertain nature of technical change. In government-coordinated R&D consortia, however, the innovation process differs from a natural evolution in an important way: the government manages the VSR process, creating and orchestrating innovation *artificially* rather than relying on natural social forces.

Because of this difference, participants in government-coordinated R&D consortia potentially enjoy several benefits that participants in natural evolutionary processes do not. First, depending on the needs of the agents involved and the level of urgency, the VSR process may be expedited in government-coordinated consortia. Through the planning and engineering of government agents, a government-coordinated innovation can bypass many procedures that would normally require more time. Secondly, a government-coordinated consortium can avoid many of the normal processes involved in VSR, where variation is emphasized and created in the early stages. Governments in latecomer countries successfully develop new industries by investing heavily in a small number of firms and R&D institutions at the beginning of an innovation cycle rather than increasing product variation or the number of consortia participants. In fact, by implementing a reversed VSR model (in other words, by starting with a few firms and R&D institutions and focusing on variation at the later stage of commercialization), firms in government-coordinated consortia can focus on development of certain technologies, though this involves a high level of risk. By reducing the level of competition in the early stages, consortia participants can avoid redundant investment and concentrate their resources. For example, the South Korean government intervened in the process of developing the CDMA technology by allowing one institution (ETRI: the Electronics and Telecommunications Research Institute) to develop the commercialization technology and limiting licensing to a small number of firms (Wang and Kim, 2007). Recently, a similar pattern was evident in the process of developing the LTE-A (Long Term Evolution-Advanced) technology. Thirdly, government-coordinated consortia can avoid the early selection myopia that results in overlooking of potentially promising innovations. When the performance of a technology is expected to be unstable over time, population-level, market-driven selection forces may favor technologies with potentially superior long-run performance (Levinthal and Posen, 2007). Government intervention may protect technologies from these selection forces, allowing the consortium to realize long-term benefits.

To maximize these potential benefits in government-coordinated R&D consortia, the government must be capable of making sound decisions in evaluation and selection of consortium participants, configuration of the consortium, and management of knowledge flow within the consortium (i.e., selecting "upstream technologies" for transfer or dissemination). In this study, we focus on the first two aspects. In particular, we ask the following three questions: 1) should governments evaluate and select consortium participants at the time of consortium formation, or should participants be added as the evolution of the technology unfolds? (i.e., the *timing of evaluation*); 2) should variation be encouraged early or late in the evolutionary process? (i.e., the *form of the consortium*); and 3) what is the effect of these two decision-making dimensions in combination? (i.e., the *interaction between timing of evaluation and form of the consortium*).

In order to provide a context to the questions we are proposing, consider NCDPN of South Korea. As a part of the nation-level effort, in 2008, the Ministry of Education and Science Technology of Korea announced "The National Nano-Technology Roadmap" in which the future trends of

[1] http://www.nedo.go.jp/english/introducing_pja.html.

[2] One of the few exceptions is Tripsas et al. (1995) in which the role of government in preventing opportunistic behaviors among participating firms within consortia is discussed. Another rare exception is Bard et al. (1999) in which the idea of "bubble planning" is used for designing consortia.