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論文審査の要旨（2000字程度）

This thesis, entitled 'data instrumentation for management of science based on collaboration and knowledge-structural features', aims at the instrumentation to enable data-driven decision making for the management of scientific research, which consists of five Chapters.

Scientific research, particularly publicly-funded scientific research and development (R&D) for innovation and solving multifaceted societal issues, is significantly increasing in scale and complexity. However, the literature on strategic and organizational management of scientific research (so-called 'the management of science') at universities and public research institutes is still underdeveloped compared to the literature of management of technology that mainly includes industrial R&D. Furthermore, methodologies that enable the acquisition of prescriptive knowledge in the management of science need to be developed alongside the descriptive knowledge that has been nurtured based on conventional scientometrics. To address these outstanding issues, it is essential to develop a methodology for the instrumentation of structural features in scientific research by focusing on collaboration and knowledge structures in large-scale R&D programs and their descendant projects. Based on the understanding, a methodology for capturing the real-time status of a scientific research project was developed to support data-driven decision making by defining activity indicators for scientific research based on network science and conventional scientometrics.

Chapter 1 provides a background of the research including the concept of the management of science, its relation to scientometrics and the significance of instrumentation. The research objective is disseminated in this chapter as to develop a methodology for instrumentation of structural features of research activities by focusing on the collaboration and knowledge structures in large-scale R&D projects centred on science research. Further, a general framework is provided as the micro-meso-macro architecture that corresponds to phenomena at the individual (or team), project and program levels, respectively.

Chapter 2 focuses on the system structure of an interdisciplinary R&D program and its descendant projects based on empirical observation of the FIRST Program and its descendant NanoBio First project. In the program-level analysis, the linkage of research funds and human resources to the outcomes is examined using a structural equation model, which suggests that different mechanisms work in the creation of academic outcomes and intellectual properties. In the project-level analysis, factors that promote or impede the creation of intellectual properties are explored. It was found that a collaboration between a central university and a startup firm (which has a complementary role) established a knowledge logistics system to realize not only the social implementation of research results through joint patent applications but also cultivated a reciprocal mindset and flexible resource management according to the R&D stage.

Chapter 3 explores the interactive dynamics of collaboration and knowledge structures in an interdisciplinary R&D project by visualizing the co-author and the co-word networks, respectively, based on bibliographic analyses of publications. By introducing the graph entropy as a measure of the complexity of these weighted network structures, the instrumentation of individual and institutional R&D activities can be visualized. Co-author and co-word network analyses constructed upon bibliographic information from publications in the case of the COINS project confirmed that these networks have distinctive structural features and different modes of time-course evolution.

Chapter 4 examines a qualitative case study on how changes in the collaboration and knowledge structures at the team and individual levels can influence those at the project level in achieving R&D project goals based on the COINS project. Based on the information from the key participants in the COINS project and the qualitative and time-course observation of the co-author and co-word networks at the individual level, an R&D strategy taken by each observed individual was assigned to one of four quadrants comprised with two independent axes: the production/consumption of core/peripheral knowledge, which was in line with the result of the graph entropy-based collaboration and knowledge structures in Chapter 3. Furthermore, based on the observations and analysis of the COINS project, these results were verified to be consistent with

the R&D strategy and organization management in the real world.
Chapter 5 summarizes results, limitations and perspectives, and the insights obtained from the previous chapters and discusses how to apply these insights for the management of science.
The present research proposes an instrument analyzing knowledge and collaboration structures and their dynamics in R&D by the graph entropy measures, and demonstrates its relevance to the R&D strategy and organization management of a case study. The proposed methods and obtained results are expected to contribute to the theoretical advancement of the management of science as the author has argued. Based on the above, the present research is worthy of awarding Doctor of Philosophy (Technology Management).