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Preface

Professor Cesar Hidalgo's 2015 book, *Why Information Grows*, "describe(s) the economy as the system by which people accumulate knowledge and knowhow to create packages of physical order, or products, that augment our capacity to accumulate more knowledge and knowhow and, in turn, accumulate more information" (p. 8). According to his views on the growth of information, each product embodies the "crystallized imagination" of people as a fundamental embodiment of knowledge, so that quantization of knowhow or knowledge is restricted by "personbytes" and "firmbytes" of information capacities. In order to overcome these limits, there should be a network structure for information sharing, both spatially and organizationally.

This eBook reconsiders the idea proposed by Hidalgo (2015) as a new concept of "information agglomeration"; our neologism represented by industrial agglomeration within cities or innovation clusters embodying external increasing returns to scale. According to the conventional economics of transaction costs pioneered by Ronald Coase and Oliver Williamson, however, dispersed organizational networks for information sharing would be expensive to form and sustain.

Our book raises an important research question: what lowers transaction costs associated with organizational links for information agglomeration? To find an answer to this fundamental question, an industrial organization (IO) foundation for the concept of information agglomeration is constructed based on the transaction-cost approach to organizational networks, instead of the principal-agent approach to private information revelation. The transaction-cost models are also empirically tested by some structural estimations using establishment-based microdata of Japanese auto parts suppliers, which exemplify a general-purpose technology along with automobile electronics.

Our empirical analyses suggest that technology cooperation among suppliers improves their productivity through knowledge/information sharing; for example, auto parts suppliers' initiative to acquire relation-specific skills by joining technological cooperation associations. Moreover, a nation-wide competition policy, even in countries with a comparatively lower degree of law and order, is effective under legal enforcement that publicly regulates coalitions for incumbents and promotes entrants' incentive to innovate.

The empirical evidence on the IO models of information agglomeration from Japanese auto parts suppliers indicates the need for institutional arrangements for information agglomeration to create a global value chain. These may include a role of technological cooperation associations in sharing relation-specific skills, preferably organized on the initiative of suppliers. The other arrangement for region- or nation-wide competition policy is a legal enforcement scheme that publicly regulates coalitions for incumbents and mitigates entrants' incentive to innovate. Both factors would be relevant to policymakers seeking to enhance firms' technological innovation capabilities to raise productivity.

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This book consists of five chapters, including an ushering prefatory one; the four main chapters are based on our research work for a RIETI Discussion Paper Series independently written during 2009 and 2015. We want to thank the Research Institute of Economy, Trade and Industry (RIETI) for providing us with a platform to hold unfettered discussions about our research.

We also owe it to Prof. Cesar Hidalgo's inputs on a core concept of this publication. Author Takeda met him at the MIT Media Lab on July 17, 2017, and explained how Japanese auto parts suppliers had drawn our interest, and how Prof. Cesar's book had been an inspiration for this work. While compiling our *tetrabiblos* papers into a volume in 2019, we had a clear image of the concept and title of this eBook. We wish Prof. Cesar all the best for his new mission of learning collective intelligence at Toulouse, France.

The original papers of the volume have been presented at numerous conferences, including the 9th Comparative Analysis Enterprise Data (CAED) Conference 2009 in Tokyo, Japan; the Far Eastern and South Asia Meeting of the Econometric Society in Tokyo, Japan; and the 10th CAED and COST Conference 2010 in London, UK, for Chap. 2; the 62nd Annual Meeting of AFSE at Aix-en-Provence, France and Annual Meeting, AEA 2020, San Diego, US, for Chap. 3; the 11th CAED and COST Conference 2012 at Nuremberg, Germany, for Chap. 4; and the 64th Annual Meeting of AFSE at Rennes, France and the 7th European Conference on Corporate R&D and Innovation (CONCORDi 2019) in Seville, Spain, for Chap. 5. We are grateful to all the participants for their encouraging comments on each paper. We also want to acknowledge the research assistance and financial aids extended to us for participating in these events. We owe the completion of Chap. 4 entirely to the collaboration with Prof. Shirai Daichi of Tohoku Gakuin University; his computation skills were indispensable for the publication of this book.

Finally, we owe our intellectual stimulus to late Emeritus Professor Takeshi Ozeki of Sophia University, who always encouraged Takeda not to confine his interests only to economics but also physics, especially the network theory. I am also grateful to late Prof. Masayuki Otaki, University of Tokyo who has spurred me to keep up as a good economist since my graduation at University of Tokyo.

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Chapter 1
The Economics of Information Agglomeration

Contents

Abstract This chapter reviews some strands of economics literature concerning our research question, "what lowers transaction costs associated with organizational networks?" We give a brief summary of the following chapters.

Keywords Auto-parts supplier(s) · Information agglomeration · Hidalgo · cesar · Transaction cost(s) · Flexible specialization · Organizational network

1.1 Introduction

1.1.1 Information Agglomeration

Information as an invisible physical matter grows towards *physical order* against uncertainties. An ability to create physical order takes some form of idea or knowledge. The physics view on information seems to be different from the standard economics' one, as represented by the so-called "market for lemons" (Akerlof, 1970), which shows how informational asymmetries between buyers and sellers of products can make the market missing, or the use of knowledge in society (Hayek, 1945), where market mechanisms can play the role of an aggregator of knowledge into market prices. In economics, as complements to market prices, informational signals

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for quality of traded goods and services transform a prior distribution of the signals into a posterior distribution conditional on the observation.

In contrast to the qualitative definition of information in economics, physics especially in information theory, defines information as a physical order quantitatively measured with entropy in a unit of bit. As Arrow (1974) pointed out, "The quantitative definition which appears in information theory is probably of only limited value for economic analysis, for reasons pointed out by Marschak: different bits of information, equal from the viewpoint of information theory, will usually have very different benefits or costs." (p. 38).

In the face of such an inconsistency between quantitative and qualitative definitions of information, Hidalgo (2015) fills in the gap so that he "describe(s) the economy as the system by which people accumulate knowledge and knowhow to create packages of physical order, or products, that augment our capacity to accumulate more knowledge and knowhow and, in turn, accumulate more information." (p. 8) According to Hidalgo's view on the growth of information, each product embodies the "crystallized imagination" of people as a fundamental embodiment of knowledge, so that quantization of knowhow or knowledge is restricted by "personbytes" and "firmbytes" of limits to information capacities. In order to overcome these limits, there should be a network structure for information sharing, both spatially and organizationally.

The chapter follows the idea of Hidalgo (2015) as our new concept of "*information agglomeration*" represented by industrial agglomeration within cities or innovation clusters as external increasing returns to scale, similar to the concept of "domain" as technological clustering in engineering (Arthur, 2009). Based on the conventional economics of transaction costs pioneered by Coase (1937) and Williamson (1985), however, dispersed organizational networks for information sharing would be costly for organizations to form and sustain. In the following chapters, a recurring research question is "what lowers transaction costs associated with organizational links for information agglomeration?" To find an answer, we build an industrial organization (IO) foundation for the concept and apply the transaction-cost models to Japanese auto-parts suppliers as an eligible case of empirical tests.

1.1.2 Japanese Auto-Parts Suppliers

The so-called Moore's Law states that the number of transistors per integrated circuit would double every 18 months. Similarly, the number of micro-controller units (MCUs) installed per vehicle has doubled every decade: for example, in so-called middle-class cars, it increased from 8 on an average in 1980 to 17 in 1990, 32 in 2000, and so on (YANO Research, 2009). "Automobile electronics" has dramatically changed the concept of automobiles, evolving from mechanical alignment to human anatomy, as depicted by Fig. 4.2 in Chap. 4. Consisting of a variety of auto-parts products,[1] automobile electronics makes full use of general purpose technologies (David, 1990; Jovanovic & Rousseau, 2005).

In 1970, automobile constructors responded to first-time emission controls imposed by the Muskie Act (the U.S. Clean Air Act), which aimed to reduce HC, CO, and NOx emissions by 90% each. The overly strict standards required Japanese constructors to make fuel efficiency and engine performance compatible with each other. Some Japanese automobile constructors developed "hybrid cars" with built-in devices for electronically controlled fuel injection: Toyota Motor Corporation launched the Prius in 1997, followed by Honda's Insight in 1999, and Nissan's Tino Hybrid in 2000.

Regarding an outcome of research and development held by constructors and suppliers of newly-required parts, we witness a change in a trend of market prices for both automobiles and auto parts (Fig. 4.1 in Chap. 4). The fluctuation in prices happened parallelly for both, with the relative prices holding relatively steady till 1995. During the second half of the nineties, however, motor vehicles encountered a spike in prices, which remained on a gradual upward trend thereafter. By contrast, prices of auto parts and accessories constantly decreased from the mid-eighties. The structural change in the relative prices of auto parts coincides with the prominent rise of automobile electronics.

We can address some microeconomic mechanisms in the development of general purpose technology, exemplified by the technological innovations by the Japanese auto-parts suppliers along with the rise of automobile electronics.

First, Piore and Sable (1984) pointed out that technological changes from mass-production mode, called Fordism, to a mode of limited manufacturing of diversified products are enabled by "flexible specialization." Flexible specialization can be described as the sharing of organizational capital within limited participants, and the coexistence of external competition and internal cooperation. Technological clusters are distributed across the US' Silicon Valley, where firms located close to one another learn innovations (Saxenian, 1996). Similarly, in 1997, Toyota Motor Corporation stepped in to help Aisin Seiki, a critical supplier of p-valves to Toyota, when a fire broke out at its Kariya plant in Japan and forced the supplier to stop production. Corporations affilated to Toyota, including member companies of its association for technology cooperation, came together to reproduce the parts manufactured by Aisin (Nishiguchi & Beaudet, 1998).

Second, Mokyr (2002) also hypothesizes functionally that technological progress maps from a Ω-type of propositional knowledge, invented by scientific inquiries and discoveries and retained in terms of personbytes or firmbytes, selectively to feasible sets of a λ-type of prescriptive knowledge accessed society-wide. Even

[1] We can list the products here: engine control; electro AT (automatic transmission)/CVT (continuously variable transmission); electronically-controlled suspension; ABS (antilock brake system); train control system; electronically-controlled 4WS (4-wheel steering); EPS (electronically-controlled power steering); airbags; corner- and back-SONAR (sound navigation and ranging); driver positional memory; ACC (fully-automatic climate control system); cruise control; RKE (remote keyless entry); navigation; digital meters; multiplex transmission; on-board ETC (electronic toll collection); in-car camera; NVD (night vision device); or tire-pressure monitoring system.

technology choices based on rational decisions are subject to political processes, which often signify technophobic resistance to new technological changes from labor unions, lobbyists, and bureaucratic organizations, including governments. The political economy aspect of technology also matters between incumbents and entrants in global value chains, where different countries have different legal enforcement schemes. Japanese auto-parts suppliers have entered countries that maintain a high degree of law and order and have legal origin historically transplanted, and frequently face antitrust lawsuits with enormous reparations. Among the top 10 host countries where Japanese auto-parts suppliers deployed between 2003 and 2005, the US, UK, Thailand, India, and Malaysia have common law traditions, while China, Taiwan, and the Republic of Korea are under the German legal origin of civil law, and Indonesia and Philippines come under the French civil law, as indicated in Table 5.1 in Chap. 5.

1.1.3 Our Maintained Hypotheses

According to the conventional economics of transaction costs, as suggested by Ronald Coase and Oliver Williamson, it is costly for corporate managers to form and sustain dispersed organizational networks where information agglomerates. Therefore, the questions that arise are: (1) what lowers the transaction costs associated with organizational links? (2) how are the lowered transaction costs related to flexible specialization as pointed out by Piore and Sable (1984) and the political economy aspects of technology choice suggested by Mokyr (2002)?

Based on the motivation, the following chapters of this volume aim to create an industrial organization (IO) foundation for information agglomeration, and empirically test the theoretical models in case of Japanese auto-parts suppliers. We use establishment-based microdata compiled by the Ministry of Economy, Trade and Industry, Japan: *Census of Manufactures*; *Basic Survey of Japanese Business Structure and Activities*; and *Basic Survey of Overseas Business Activities*. We also supplement these establishment-based microdata with the databases of industrial associations and public organizations: the Japan Auto Parts Industries Association's annual magazine *Japanese Auto Parts Industries*, the Japan Patent Office's *IP Gazettes*; the World Bank's *Worldwide Governance Indicators*; and the Transparency International's *Corruption Perceptions Index*.

We consider four hypotheses on what lowers transaction costs associated with organizational links for information agglomeration. We mention a brief summary of the results in the following chapters:

1. (Chapter 2) Technology cooperation among suppliers improves their productivity through knowledge/information sharing.
2. (Chapter 3) Auto-parts suppliers have probably designed initiatives to acquire relation-specific skills by joining technological cooperation associations.
3. (Chapter 4) Capital adjustment costs are higher in automobile electronics.