# Studies on the Japanese Business Cycle

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BY

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# Topics in Economics of Intellectual Property and Innovation

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Topics in Economics of Intellectual Property and Innovation

To John, Michael and Lisa

# Preface

On February 12, 1992, Honeywell took out a full page ad in the New York Times proclaiming victory over Minolta regarding the automatic focus patent. I realized that intellectual property systems differ across countries, the differences could explain differences in R&D patterns and that they are integral part of national innovation and economic policies. The differences between US and Japan, both research intensive economies, continue to fascinate me.

Immediately after the Honeywell victory, Texas Instruments strengthened its IP department, there were the Hyatt and Kilby disputes, introduction of Court of Appeals of the Federal Circuit, and passage of Bayh-Dole Act in US. During that time in Japan, it became possible to insure against patent infringement suits, the Japanese Bayh-Dole act was passed, national universities became independent agencies, Professor Nakamura won the LED patent dispute, and the Intellectual Property High Court was established. In short, pro-patent policies were implemented in both countries. Both polices were far reaching so as to affect university research, the primary source of basic research. I think the pendulum is swinging back and it must now rest in a new location to accommodate the new frontiers of innovation.

This book includes my more recent work on intellectual property and innovation related to new frontier technologies, with Sadao Nagaoka and Aaron Schiff. They analyze systems in place and suggest how they could be improved. In order to provide some further clues as to where we should go from here, I have included my work with Lee Branstetter on university research in U. S. and historical review of Japanese innovation. The latter is derived from a chapter I wrote for the Japanese translation of Suzanne Scotchmer "Innovation and Incentives". I am very grateful to them all for the opportunity to work them and their generosity.

I would like to use this opportunity to thank my co-authors immediately after Honeywell ad, Jin-Li Hu, Tom Prusa, David Reitman, Yossi Spiegel and Yair Tauman. I was unable to include the work with them due to lack of time although those were the direct results of the ad.

I also would like to thank members and staff of Council for Science and Technology Policy. They have no direct relationship with this book but my conversations with them were crucial in putting my research into context.

Last but not least I am grateful to Shuichiro Kobayashi at Maruzen for his patience and guidance and John, Michael and Lisa Hillas for their patience and support.

December 2009

Reiko Aoki

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Chapter 1

# Introduction

The focus of this book is role of intellectual property and innovation of frontier technologies. Innovation can mean many things. One can find a very innovative way of using an old tool for instance. This is not the innovation that this book addresses. We are concerned with frontier technology, which in 2009 include regenerative cells, molecular biochemistry, and nano-electronics. Society relies on basic research to provide earth breaking knowledge that constitute frontier technologies. By definition basic research output requires applied research before practical uses and products are developed.

Basic research is research "without any particular application or use in view" different from applied research which is "directed primarily towards a specific practical aim or objective" (OECD 2002, *Frascati Manual*). While ex-post it is possible to identify which basic research has contributed to society, it is impossible to predict ex-ante which basic research will have valuable applications. Not surprisingly, only a limited number of countries are able to sustain a portfolio of basic research large enough so that steady stream of frontier technologies will be produced. For those economies that are able to invest in basic research, disseminating of and guaranteeing access to basic research are very important public policy goals. We will be examining aspects of intellectual property for this purpose.

We first look at innovation in Japan before Meiji Restoration in Chapter 2. Needless to say, there was innovation before the modern patent law was introduced in 1889. There were institutions very similar to that of guilds in the West that monopolized information by paying a fee to the ruler. However it is probably not correct to say that innovation can be achieved without intellectual property. Transportation, information storage, and communication technologies was very limited at the time. Secrecy or difficulty of moving people, goods and information were sufficient for appropriation. What we seek in intellectual property, the balance between appropriation and information dissemination was balanced by physical constraints. On the other hand, because there was no way to strengthen appropriation, the only professional researchers were independently wealthy or supported by the state. Public minded independently wealthy existed due to allocation of property according to a rigid class system. Agricultural innovation during the Edo period was undertaken by local land lords. Local governments (han) sponsored research and innovation as part of export promotion. It is also interesting that Hiraga Gendai initiated the first intellectual property litigation in Japan on record. It is questionable if he was really an inventor but he obviously understood the concept.

Need for intellectual property arises when appropriation becomes difficult, ironically as result of technological innovation. Although the system was imported into Japan during the Meiji Restoration, the society benefited as is evident from performance of Riken as a private institution. Once intellectual property system was in place, it became possible to separate producers of ideas from consumers of ideas, giving rise to professional researchers and innovators. It is not surprising that intellectual property system and perhaps the innovation system needs to be adjusted again now that the technology has changed.

We start Chapter 3 Basic Research and Patents by examining the relationship between academic science and innovation. Our analysis was motivated by Figure 2 (in Chapter 2) which suggest that by far the greatest contribution of University of California to innovation is reflected in publications in scientific papers. We first construct a model where academic science changes the marginal productivity of research and innovation. Marginal productivity of innovation eventually declines and success in academic science is necessary for the innovation frontier to be "shifted" so that marginal product increases. We then verify this relationship measuring academic science by patent citation to academic publications and innovation output by US patents. We control patents for quality by various measures. We verify the empirically the positive relationship between access to academic science and research productivity. We note this relationship is very prominent in pharmaceutical products, medical devices, and biotechnology, i.e., the bio-nexus. Bio-nexus is a typical example of frontier technology based on basic research.

In the remaining two sections of Chapter 3, we examine two aspects of patents related to basic research : utility requirement and research exemption. Utility requirement is one of the three requirements that a technology must satisfy in order to be patentable. It is possible to use patented technology without risk of infringement, i. e., research exemption, if it is for research and not commercial purpose. When research was motivated by need, requirement that technology have actual utility was not a problem. Utility requirement became problematic when patents were sought for results of basic research. Bayh-Dole Act prompted universities to patent but universities specialize in very basic research. Firms as well as universities began to test the bounds of patentability and research exemption.

The economic question regarding strength of utility requirement and use of research exemption is that of division of profit between first and second generation of technologies, where first generation is basic research. Weaker utility requirement makes first generation more patentable, increasing its share of profit from the final product which is achieved only when the second generation is completed. On the other hand, strong utility requirement will leave the first generation not patentable and anyone is free to use the basic research. Research exemption would make it possible for anyone to use the basic technology for free as long as it is for non-commercial purpose and equivalent to weaker protection of first generation. Intuition is that first generation should be protected, either with weaker utility requirement or with no research exemption when cost of R&D is high relative to the second generation. Our analysis demonstrates cases where stronger protection first generation is necessary when the second generation is relatively more costly, suggesting closer patent protection is sensitive to nature of the particular technology. We also highlight the fact that although research exemption promotes innovation by reducing transaction cost, it can prevent implementation of efficient contracts.

In Chapter 4 Multiple Patents, we focus on patent pools which are useful for promoting multiple patents that are complementary. Complementary patens are necessary for implementing standards, such as DVD or MPEG. Standardization at early stage of technology development is an important strategy to obtain dominant position in a market. This has been proven with electronics and information technologies and is about to be implemented in the new frontier technologies such as brain machine interface and smart grids. Catalogue of patented genetic sequences for genetic testing is an example of multiple complementary patents necessarily not to implement standards.

We examine how formation and stability of patent pools is effected by heterogeneity of membership. In particular when there are members that only do research and contribute patents to the pool but they do not manufacturer anything. They have different incentives from vertically integrated firms that are both licensor and licensee of patents. There are many examples of the latter, such as Phillips and Toshiba. We show that research only entities which can be firms but also universities, have greater incentive to be independent licensor.

Primary focus of economic analysis of patent pools has been how they promote or impede research or production using the pool technology. In the long run, economic performance of a patent pools should also include how existence or prospect of forming a pool effects further innovation of the pool technology. We already know DVD patent pools were socially desirable for current generation of digital recording and reproduction technology. We ask the question is the prospect of forming such a pool good for the development of the technology in the first place? In other words, what is the effect of a patent pools designed for ex-post efficiency on ex-ante innovation? We show that ex-ante and ex-post efficiency are not achieved by the same patent profit distribution or anti-trust rule. Ex-ante consideration is the R&D investment incentive while ex-post the relevant factor is pool stability. We also show that the patent pools design needs to take into nature of technologies, specifically substitutes or complements, and number of firms engaged in ex-ante R&D.

In the last section, we examine an institution that is less structured than patent pools : clearinghouses. Benefit of clearinghouses comes from reduction of transaction costs such as searching and licensing. This benefit can be large enough even when patents are substitutes, which is a case in which patent pools are never socially desirable. On the other hand, reduction of this cost may result in patent owners raising royalties instead which can be welfare reducing.

Chapter 2

# Innovation before Intellectual Property

We start with historical look at innovation before patents in Japan. The current patent system was established only in the Meiji period, end of 19th century. But of course there was innovation before that. Promotion of innovation has been an important part of public policy from ancient times, as was in the west. We can observe institutions very similar to guilds in Japan that played an important role in appropriating innovation though it lacked the information dissemination function of a patent. We also find that the "senbai" system, which has been understood to be forerunner of modern patents, were not monopolies but monopsonies. The modern incarnation of "senbai" is not a patent, but export boards that are often effectively the sole buyer of exported products because all exports must be exported by the boards[1]. Export boards invest or subsidize R & D of exported product.

There are other examples of "history repeats itself" (Scotchmer (2004)). Notably, very much like the emergence of TRIPS (trade related intellectual property) bundling trade and intellectual property, Japan negotiated ability to set tariffs in return for extending patent protection to foreign residents in early days of Meiji. We also discuss Takamine Jokichi, a more modern inventor-entrepreneur and Riken Research Institute. The institute was a prime example of university-private partnership, funding research all from commercialization of its research and patents.

## 2.1 Weapon production in ancient and middle ages

Sword making was concentrated in areas close to source of raw materials, such as Yahata or close to consumers such as Awataguchi. Blacksmiths and weapon makers were given special treatment such as exemption from chou-yo (type of tax). Carpenters and craftsman were also protected. Dye makers were organized into groups and the central government called them (much like military service) to help with construction of temples and Buddha statues. The country depended on technology from abroad. For instance, there is a record of craftsman from China assisting with casting of bells for Goda-ji (temple) and Todai-ji (temple) in 1183.

Particularly after the feudal system deteriorated, local lords began to build and support individual armouries. As fighting between the local lords become more serious and wide spread, demand for weapons increased and the status of craftsmen improved. Production changed from methods that required highly skilled workers to methods that made mass production with low skilled labor possible. Manufacturers soon organized themselves into "za" (guilds). The sword-za obtained the exclusive right to produce and market swords from the Muromatchi Shogunate in return for dedicating him swords. These were very similar to the European guilds (Scotchmer 2004). As with guilds, za got monopoly in return for a payment to the Shogun. It was not a reward for innovation and was not designed as an incentive scheme. In order to sustain monopoly, it would have been necessary to have some advantage (cost, access to raw materials, knowledge). Secrecy was used to maintain this advantage. For instance, outsiders were not allowed to be present when iron was heated to make swords.

The first firearms arrived in Japan as part of a shipwreck on Tanegashima Island in 1543. When the sailors returned two years later, they were surprised that the Japanese were already producing firearms. The validity of this statement aside, the fact that Takeda army used 3000 riflemen in the Batlle of Nagashino in 1574 suggests that some level of mass production of firearms had been achieved.

Firearms, the weapon of mass destruction at the time was in high demand among the feuding daimyos (domain lords). What was the environment that allowed such quick development of firearm produc-