Université de Montréal

Productivity Growth, Government Intervention, and Institutional Environment

par

YunXiang Shen

Département de sciences économiques

Faculté des arts et des sciences

Thèse présentée a la Faculté des études supérieures
en vue de l'obtention du grade de
Philosophiae Doctor (Ph.D.)
en sciences économiques

Janvier, 1995

Université de Montréal
Faculté des études supérieures

Cette thèse intitulée:

Productivity Growth, Government Intervention, and Institutional Environment

présentée par

YunXiang Shen

a été évaluée par un jury composé des personnes suivantes:

Mme Lise Salvas	: présidente rapporteur
Mr. Pierre Lasserre	: directeur de recherche
Mr. Georges Dionne	: codirecteur de recherche
Mr. Marcel Boyer	: Membre du jury
Mr. Pierre Mohnen	: Examinateur externe Université du Québec à Montréal
Mr. Louis Lessard	: Représentant du doyen Vice-doyen Faculté des études supérieures

Thèse accéptée le: 12 mai 1995

ACKNOWLEDGEMENTS

I wish to acknowledge the assistance of my research supervisor, Prof. Pierre Lasserre, in the preparation of this thesis. In addition to his valuable advice and guidance in connection with the research work itself, I am very grateful for the wider range of assistance which was always forthcoming whenever required.

I would like to express my appreciation to Prof. G. Dionne my co-director, Prof. J. Robert, Prof. M. Dagenais, and Prof. A. Martens for providing many helpful assistances, as well as to my friends Mr. Paul Cruciat, Ms. Colette Trudel and Mr. Chris Tritten for their help in correcting preliminary manuscripts. I wish to thank the staff and colleagues of the Department of Economics at Université de Montréal, for their encouragement and help.

Finally, I am grateful to the opportunity to work on Government and Competitiveness Project in Economic Council of Canada, and in the School of Policy Studies of Queen's University, where I had chances to look deeply at what and how governments do to help the private sectors to compete in the increasingly globalized world. I would also like to thank my parents and my wife, MingZhao Tang, for their encouragement and patient throughout my studies.

ABSTRACT

With increasing globalization and competition, to have a competitive product a firm needs not only highly sophisticated technologies and skillful labour, but also efficient ways to organize the whole system of production: research and development, product design, manufacturing, marketing, after-sale services, relevant information collection and its utilization.

In the real world, many factors influence a firm's optimal reactions and decisions. In this study, we focus on some traditionally overlooked factors. In particular, we study firms' internal optimization decisions as they are affected by external competitive pressure, relationship with other firms, and financial institutions. In other words, we examine the effect of a firm's economic and institutional environment on its investment behaviour and, in turn, on its cost performance and competitiveness.

To pursue this study, we first review relevant topics that examine the factors which affect a firm's investment decisions and performance. Then, with reference to the real world observations and experience, in an informal way, we specifically examine the role of financial institutions and the legal framework, and the relationship between firms in affecting a firm's investment behaviour.

In the theoretic chapter, we discuss the two aspects of a firm's technology (the hardware versus software technologies) and its implications in complementary technology exchanges between firms. With a general model, we show that the effect of the economic and institutional environment varies with specific conditions and circumstances. To further deepen our understanding of the effect, two simplified models are used to illustrate the mechanisms that determine technology investments of firms.

The theoretic predictions are then confronted with an empirical study and a specific case study. A cost function is estimated for Canadian manufacturing industries and a specific case study is performed on the transportation equipment industry. Both results confirm the importance of the factors discussed earlier and conform with the prediction by the theoretical analysis. These results also indicate that the mechanisms identified with the simplified models are helpful in interpreting real world observations.

Policy implications of this study is that a more effective government interventions may be achieved through providing an appropriate economic and institutional environment.

Key Words: Economic environment, institutional environment, hardware technology, software technology, externality, technology complementarity, exports, financial interpenetration between firms, financial interpenetration between firms and banks, mergers and acquisitions

RÉSUMÉ

Avec la globalisation et la compétition croissantes, l'obtention d'un produit compétitif nécéssite de la part des firmes non seulement une technologie hautement sophistiquée et du travail qualifié, mais aussi une organisation efficace de son système entier de production: recherche et développement, design de produits, fabrication, marketing, service après vente, collecte et utilisation d'information utile.

Dans le monde réel, plusieurs facteurs influencent les réactions et les décisions optimales des firmes. Dans cette étude, nous nous concentrons sur certains facteurs traditionnellement négligés. En particulier, nous étudions les décisions d'optimisations internes des firmes affectées par les pressions compétitives externes, par leurs relations avec les autres firmes, et par les institutions financières. En d'autres mots, nous examinons l'effet de l'environnement économique et institutionnel sur le comportement d'investissement d'une firme, sur sa performance au niveau des coûts et sur sa compétitivité.

Dans cette étude, nous revoyons premièrement dans la littérature les facteurs pertinents qui affectent les décisions d'investissements et la performance d'une firme. Ensuite, en se référant aux observations et aux expériences tirées du monde réel, nous examinons spécifiquement, de façon

informelle, le rôle des institutions financières et du cadre légal; nous examinons aussi l'effet des relations entre les firmes sur le comportement d'investissement d'une firme.

Dans le chapitre théorique, nous discutons les deux aspects de la technologie d'une firme (technologie hardware versus software) ainsi que ses implications dans les échanges de technologies complémentaires entre firmes. Avec un modèle général, nous montrons que l'effet de l'environnement économique et institutionnel varie avec les conditions et les circonstances spécifiques. De façon à approfondir notre compréhension de cet effet, deux modèles simplifiés sont utilisés pour illustrer les mécanismes qui déterminent les investissements technologiques des firmes.

Les prédictions théoriques sont ensuite confrontées à une étude empirique et à une étude de cas spécifique. Une fonction de coût est estimée pour les industries manufacturières canadiennes et l'étude de cas porte sur l'industrie des équipements de transport. Les deux résultats confirment l'importance des facteurs considérés auparavant et sont conformes avec les prédictions de l'analyse théorique. Ces résultats indiquent aussi que les mécanismes identifiés avec les modèles sont utiles pour l'interprétation des observations du monde réel.

Les résultats de cette étude impliquent que les gouvernements peuvent intervenir plus efficacement en créant un environnement économique et institutionnel approprié.

MOTS CLÉS: environnement économique, environnement institutionnel, technologie hardware, technologie software, extérnalité, exportations, interpénétration financière entre firmes, interpénétration financière entre firmes et banques, fusions et acquisitions.

TABLE OF CONTENTS

List of Figures

List of Tables

Chapter 1 Introduction

With increasing globalization and competition, to have a competitive product requires not only highly sophisticated technologies and skillful labour, but also efficient ways to organize the whole system: research and development, product design, manufacturing, marketing, after-sale services, relevant information collection and its utilization.

Many factors influence a firm's optimal reactions and decisions in such a world. In this study, we focus on some traditionally overlooked factors. In particular, we study the internal optimization decisions of firms as they are affected by external competitive pressure, relationships with other firms, and financial institutions. In other words, we examine the effect of a firm's economic and institutional environment on its investment behaviour and, in turn, on its cost of production and competitiveness.

After the introduction, we present a literature review. We review some relevant topics such as information and transaction costs, the role of institutions, the role of cooperation and its impact on performance, the effect of exports[1], and finally, the effect of advanced organization versus advanced equipment.

In the third chapter, in a non formalized fashion, we

[1]In this study, the term exports refers to export orientation. For an industry, it is defined as the export of the industry divided by the total shipment of the industry.

specifically examine the role of financial institutions and the legal framework, and the role of the relationship between firms in affecting investment behaviour. This, in turn, changes a firm's technological progress and its competitive position. Institutions and relationships between firms are especially important with the increasing globalization of business activities and the increasing sophistication of consumers and products.

In chapter 4, we first discuss the increasing complexity of technology (its hardware versus software aspects), and its implications in cooperation between firms through complementary technology exchanges. Complementarity between technologies may result in investment externalities between firms. Depending on the level of these externalities, firms will choose higher, or lower, investment levels. Furthermore, these externalities, together with various other factors, will affect the extent to which firms cooperate with each other and change their technology investments. However, as illustrated by the general model presented in the first part of the chapter, the effect of the economic and institutional environment varies with specific conditions and circumstances. As a complement to the general model, simplified models are used to go further in deepening our understanding of the effect. The analysis is performed in the framework of a two-stage game and in a two-period continuous setup. We examine the effect on a firm's investment behaviour of the legal system, the financial system , the degree of exposure to external pressure and the current technology level. The simplified models illustrate the mechanisms that determine technology investment, and are useful simplifications of reality.

In chapter 5, some of the theoretical predictions are confronted with empirical data on Canadian manufacturing industries. More specifically, we track out the impact of the various factors discussed earlier, on the productivity growth and cost performance of Canadian manufacturing industries between 1967 and 1986. The empirical results confirm the importance of the factors discussed earlier. However, as implied by our theoretical analysis, the effects may differ qualitatively according to the circumstances of individual sectors. It is found that the mechanisms identified with the simplified models help interpret the empirical results. However, due to lack of more disaggregate, detailed information, the empirical study in this chapter is not able to answer all questions put forward by the theoretic models. Another way to answer some of these questions is by performing case studies. Without being able to have information for all sectors, we carry out a case study for the transportation equipment industry in next chapter.

In chapter 6, as a specific case study, the transportation equipment industry is analyzed to verify whether or not the result of chapter 5 may be interpreted in terms of what is known about the industry, and whether they conform to any of the stylized cases examined in chapter 4. The case study confirms the empirical results of chapter 5 for the transportation equipment industry. That is, exports, financial interpenetration between firms and financial interpenetration between firms and banks all exert favourable impacts on the firm's cost or productivity.

With the real world observations, the case study also illustrates some concepts discussed in previous chapters, and answers some questions put forward in the theoretical chapter. For example, with real world observations, this study illustrates the concept of technology complexity, software and hardware technologies, and answers the question of the relationship between differences in exposure to competitive pressure and different technology investment behaviours. It further indicates the usefulness of the simplified models in helping interpret what is going on in the real world.

In the final chapter, we conclude this study and discuss policy implications. With increasing complexity of technology and changing economic and institutional environments, it implies that government interventions should be indirect and conditional. To be effective, the intervention should be conducted, as much as possible, through private institutions or organizations, such as banks and industrial associations. The legal system and the financial system will play a key role in providing a framework for such interventions.

Further research is also recommended in this final chapter. In particular, it would be useful to perform a similar study at a more disaggregated level (at 4-digit level or plant level). An international comparison study would also be helpful in providing policy implications with respect to different institutional setups and state interventions.

Chapter 2 Literature Survey

Many factors influence a firm's optimal reactions and decisions in such an increasingly globalized world. In this study, we focus on some traditionally overlooked factors. In particular, we study the internal optimization decisions of firms as they are affected by the economic and institutional environment.

In this chapter, we will survey both theoretical and empirical studies which deal with subjects pertinent to our interest. In particular, we will review the following relevant topics: information and transaction costs, the role of institutions, the role of cooperation and its impact on performance, the effect of export, and finally, the effect of advanced organization versus advanced equipment. The literature review indicates that there is a lack of rigorous studies which systematically analyze the effect of the economic and institutional environment on firms' investment decisions in general, especially in Canada.

2.1 Information and Transaction Costs

The problem of asymmetric information causes many market imperfections and, in turn, costs to business. Agency costs and transaction costs result from information problems. These two kinds of costs influence a firm's organizational structure. While principal-agent problems limit the growth of the size of a firm, transaction costs provide the rationale for the size expansion of a firm.

In "The Nature of Firm", **Coase** shows that firms exist in order to reduce transaction costs. He describes transaction costs as follows: "In order to carry out a market transaction it is necessary to discover who it is that one wishes to deal with, to inform people that one wishes to deal and on what terms, to conduct negotiations leading up to a bargain, to draw up the contract, to undertake the inspection needed to make sure that the terms of the contract are being observed and so on." Markets are institutions designed to facilitate exchange and to reduce the cost of carrying out exchange transactions. Efficient markets require the provision of physical facilities, in which buying and selling can take place, as well as a legal system, which sets up constraints for transactions.

In "The Problem of Social Cost", **Coase** shows that the initial allocation of legal entitlement of property does not matter from an efficiency perspective as long as the transaction costs of exchange are nil. That is, without transaction costs, the social and private costs are the same.

Defining transaction costs as information and enforcement costs, **Wallis and North** (1986) find that transaction costs that go through markets in U.S. account for more than 45% of National Income, compared to 25% one century ago. They demonstrate that both technology and institutions influence the economic behaviour of a producer and his decision-making processes. Applying this theory in case studies comparing Britain and Spain, and comparing U.S. and Mexico, they find that the main differences in development originate in institutional differences.

2.2 The Role of Institutions

Coase (1988) points out that "The interrelationship between the economic system and the legal system is extremely complex, and many of the effects of changes in law on the working of the economic system (the very stuff of economic policy) are still hidden from us." Government economic policies involve choices among alternative social institutions, such as an appropriate financial system.

North (1990) outlines a theory of institution and economic performance. Institutions are defined as the rules of the game in a society. These rules are the humanly devised constraints that shape human interactions and structure incentives in human exchange. Informal rules underlie and supplement the formal ones. Institutions define and limit the set of choices of an individual or a firm. He analyses the interrelationship between institutions and organizations, and the influence of institutions on transaction costs. Different institutions are created or evolve because of uncertainty and imperfect information. They provide hospitable environment for cooperative solutions to complex exchange for economic growth. Because evolutions of institutions in different countries are different, there are various economic development processes - some faster, some slower, some stagnated. Transaction costs are the main obstacle for the evolution of institutions in an economy. This is why some non productive institutions still exist in some developing countries. When making a production decision, a producer is constrained by both technology and institutions. Furthermore, because of imperfect information and uncertainty, individuals can only build imperfect subjective models to understand and explain the complexities of problems confronted in the real world. Rationality is not assumed as in the standard neoclassical theory, but as adaptive rationality, constrained by institutions.

Samuels (1988), in "Interrelationships between legal and economic processes", uses a 40 year-old court case to analyse the interrelationship between legal and economic processes. Market forces emerge and take on shape only within the pattern of legal choices as relative rights, relative exposure to injury, and relative coercive advantage or disadvantage. The legal system or process affects the economic decisions of individuals in a society. Individuals in a society may also influence the making of the legal system by using their economic powers.

Tetrault et al (1992), in "Securitization in Canada: the Legal Issues", describe briefly the legal issues raised and the framework employed in the so-called securitization program. Securitization has evolved as a viable alternative to the common forms of debt financing. Under proper legal structure and government regulation, this process can provide companies with funds at a lower cost than debt financing process, while at the same time provide investors with an attractive yield to maturity on their investment relative to traditional debt financing and a bankruptcy-remote borrower. As a result, it may increase a firm's investment and the efficiency of an economy as a whole. In Canada, the securitization experience is dominated by mortgage securitization, while securitization in other areas has been hindered due to various government regulations.

Williamson (1983), in "The Economic Institutions of Capitalism", integrates the work on law, economics and organization based on "transaction costs economics" point of view. He analyses the institutions of capitalism and traces its evolution. With the assumption of "economizing as being central to economic organization", he points out that the main purpose and effect of institutions are to economize transaction costs. The behaviour assumptions for individuals are opportunism and bounded rationality or "intended rationality". Institutions are dynamically evolving and their changes are affected by all social organizations, although the organizations are affected by the institutions.

2.3 Cooperation and Firm's Performance

Balakrishnan and Koza (1993) find that joint ventures are superior to mergers and hierarchies when costs of valuing complementary assets are high. The finding is based on a cross-sectional analysis of abnormal returns to the parent firms in 64 joint venture announcements and 165 merger announcements. By reviewing earlier studies of joint ventures, mergers and acquisitions, they conclude that under certain conditions, one may be superior to the other. Therefore, the results have implications not only for management's choice between acquisition and joint-venture, but also for policy makers in areas of anti-trust and inter-firm cooperation.

Bolton and Farrell (1990), in "Decentralization, Duplication, and Delay", examine the coordination problem when a firm wants to find a low-cost solution for production. It is found that although the market can find low-cost solutions, there are coordination problems which lead to delay or duplication. Market is better off only when there is little urgency or a great deal of private information. Otherwise, it is more efficient with a central coordinator.

Goodman (1992) finds that Japanese trading companies play an important role as information gatherers, processors and providers. A typical trading company has 10,000 employees stationed in 180 overseas offices. These offices send in, on a daily average, a total of 100,000 pieces of information they have gathered. After being processed, this flood of information forms a valuable database and is often provided free-charge to clients. For example, manufacturers are provided with detailed information about markets, so that they can control their inventories, plan production and invest wisely; Exporters are given information about overseas markets and the activities of competitors; Investors are provided with information on business climate, currency exchange rates and current regulations. Therefore, the trading company is, in effect, an information industry, which turns raw information into the real software of trade. It plays a critical role because information is the linchpin for today's complex economy.

By using plant-level Census Bureau data, **Lichtenberg** (1992) shows that total factor productivity is inversely related to the degree of diversification. That is, the greater the number of industries in which a parent firm operates, the lower the productivity of its plants if the number of parent-firm plants is held constant. It is also found that the extent of the industrial diversification of American firms declined significantly during the second half of the 1980s. Firms that were created during this period were much less diversified than those that ceased to operate. Surviving or continuing firms reduced the number of industries in which they operated.

In the journal **Research•Technology Management** (July-

August, 1992), Germany's excellence in producing world-class, high-quality goods is attributed to its emphasis on innovation, coordination and cooperation between firms as well as between firms and government. More specifically, these factors are as follows:

- German government's emphasis and support on a dense network of coordinated yet adaptable research institutions and industrial organizations that complement and assist the private sector;
- Research cooperations in most sectors to help firms resolve everyday technical problems and to share information;
- Technology diffusion among firms as top priority, with active involvement of industry and trade associations, chambers of industry and commerce, and regional technology transfer and innovation centres;
- Industrially relevant training and apprenticeship programs with participation from chambers of industry and commerce, vocational schools and labour representatives;
- Government's frequent consultations with industry associations and trade unions when drafting legislation.

Teece (1992) examines the organizational arrangement for regimes of rapid technological progress. With economic development, the boundaries of a firm have become fuzzy. Both competition and cooperation are essential to the innovation process. Interfirm alliance/cooperation can facilitate complex coordination that the price system can not accomplish, while avoiding dysfunctional properties sometimes associated with hierarchy. He shows that complex forms of cooperation are usually necessary to promote competition because very few firms can successfully 'go it alone' any more. He advocates the Japanese form of industrial organization which has complex interfirm relationships, and the long tradition of cooperation among German companies in innovation since the beginning of the 20th century.

Wolf and Globerman (1992) examines strategic alliances in the automotive industry. It is found that strategic alliances are an increasingly prevalent governance structure in this increasingly globalized world. The key motive for strategic alliances is the learning or knowledge transfers, such as the organizational learning of lean production by American automakers. It is found that strategic alliances have thus far increased competition in U.S. Therefore, strategic alliance should not be discouraged by policy makers. Anti-trust laws should be modified to allow joint commercialization of innovation. The relative stability of strategic alliances in automobile industry is attributed to the following factors. First of all, the alliances are among relative large firms within the same industry in which partners may be better able to gauge and agree upon mutual obligations and expectations than when their backgrounds are more varied; secondly, partners are already competitors with different specializations; there is little danger from a common cause of failure, and; thirdly, there is less dramatic change in technology in auto industry such as compared with computer and electronics industries.

2.4 The Effect of Exports

Chen (1992) studies technical adaptation of multinational firms in the electronics industry in Taiwan. It is found that export-oriented multinational firms modify their production techniques more rapidly than those that are local market oriented. For those export-oriented firms, there is an effort toward correcting the overuse of skilled labour relative to unskilled labour and the overuse of capital relative to labour in the early stage of operations.

Liang (1992) defines trade strategies in a three-sector model and identifies five mutually-exclusive strategies: inward-oriented, outward-oriented, free trade, potential export protection, and de facto import promotion. He also defines the concepts of sectoral and market orientation, and discusses the orientation patterns of each alternative strategy. It is found that South Korea has pursued an infant industry-based, export-oriented "protected export promotion" strategy. This strategy is not the commonly perceived neutral outward-oriented strategy. The difference between the South Korean and the Argentinean strategies is not the absence of inward-oriented bias, but the presence of outward-oriented incentives. It is concluded that extreme protection harms more than helps the economy of a country, but there are indeed strategic sectors worthy of protection and promotion.

Sheehey (1992) analyses the relationship between exports and growth. His empirical study for the period of 1960-1981 indicates that the positive effects of shifting more resources into exports were confirmed to a limited number of more industrialised developing countries in the 1960's, a period of strong growth for world trade. A stronger trade orientation than in other countries can result in a lower rate of output growth during a period of weak world demand.

2.5 Advanced Organization VS Advanced Equipment

In "Ex-Ante and Ex-Post Criticisms of X-efficiency Theory and Literature", **Frantz** (1990) indicates that the development of X-efficiency concept was primarily driven by various types of data, and observations. These data and observations indicate differences between the prediction of formal models of economic development and various experiences in less developed countries. For example, it is found that firms are able to increase their output by making relatively simple changes in the internal organization. This implies that something other than physical labor and physical capital plays an important role in the growth rates of several industrial nations. One of the reviewed studies, by using a sample of 116 new factories among 46 Australian industries, shows that the growth in labour productivity between 1956 and 1958 among new factories was not different from the industry average growth rate. The productivity difference is in the range of 10 to 15 percent, which is very different from the prediction of neoclassical models as in the range of 50 to 100 percent.

Shen (1984) examines if X-inefficiency is the main reason for low labour productivity in the less developed countries by comparing X-inefficiency in manufacturing industries in eighteen countries which are at different stages of development. It is found that differences in the labour and capital inputs productivities exist between pairs of countries at successive stages of development. The dominant source of such differences is either a decline in X-inefficiency or factor substitution. In less developed countries, differences in input productivity result primarily from a decline in X-inefficiency; in more developed countries, the differences result primarily from factor substitution. It is also found that the variance of factor combination is greater among the poorer countries, despite generally comparable prices.

2.6 Summary

We reviewed various studies which examine the effect on a firm's investment behaviour of factors which will be studied in this study. It is shown that these factors influence a firm's investment decisions and performance. However, the literature review indicated that there is a lack of rigorous studies which systematically analyze the effect of the economic and institutional environment on firms' investment decisions theoretically and empirically. This is particularly true in Canada.

A systematical analysis of these factors will be helpful in understanding the mechanisms by which their effects on a firm's investment behaviour can be determined. This will, in turn, be useful for government policy making. In the following chapters, we will pursue in this direction: to incorporate important economic and institutional environment variables in our analysis and examine their impact on a firm's behaviour and performance.

In next chapter, before getting into a formal theoretic analysis, we will first discuss the economic and institutional environment of a firm. Then, with reference to the real world experience, we will examine in a non formalized fashion the impact of the economic and institutional environment on the firm's behaviour and performance, such as changes of its organizational form and competitiveness.

Chapter 3 Economic and Institutional Environment of a Firm

The recently unprecedented variation in economic growth across countries has surprised many people, including economists. It is believed and agreed that both governments and private sectors, state intervention and market mechanism play important roles. In this chapter, with reference to the real world observation and experience we will, in a non formalized fashion, show that both economic and institutional environments influence a firm's investment behaviour and, in turn, its competitiveness and economic development of a country.

In the following sections, we will examine the increasingly globalized economic environment (section 3.1), the two important institutions (the financial system and the legal system) and their effects (section 3.2). In section 3.3, we will examine the effect of the economic and institutional environment on a firm's investment behaviour, its organizational form including the interrelationship between firms, and its competitiveness. Summary is given in section 3.4.

3.1 Economic Environment of the Firm

Various behaviour of a firm are affected by its economic environment. Economic environment in the context means the economic development level of a country and globalization of the world economy. The increasing globalization results from the advancement in transportation and telecommunication technologies, due to low cost of communication and information exchange. For example, the communications superhighway could permit far-flung units of different companies to quickly locate suppliers, designers and manufacturers through an information clearinghouse at a relatively low cost. This enhances the efficiency of small autonomous firms.

World economy has been developed and integrated at very high speed since the end of World War II. With increasing globalization, separate areas of the world economy are becoming integrated and interdependent. Furthermore, this changed economic environment has greatly increased the complexity of the traditionally defined technology.

In such a new environment, if a country or an industry is exposed to the increasingly globalized world economy, the competitive pressure on firms will become higher. To be competitive, a firm must increase its investment in research and development, and continuously update its multi-dimensional technology. A new technology can be achieved by either in-house research or acquisition from outside. This new technology (or innovation) includes not only advanced equipment and machinery, but also new ways or organizational forms to adapt to the firm's changing environments. This new technology must be able to make efficient use of all internal resources as well as resources available from outside. An innovating firm that has developed the core technology needed for a new product or process with good commercialization prospects must also secure access to complementary technologies and assets. Furthermore, these complementary technologies and assets must be obtained on favourable terms so that the firm can successfully commercialize the product or process (Teece, 1992). These complementary technologies and assets may include marketing, manufacturing, after-sales support.

Therefore, with changing economic environments, a successful firm has to realize both static (allocative) and dynamic (adaptive) efficiencies. This, in turn, requires change in a firm's investment behaviour, and its relationship with other firms or organizations.

3.2 Firms' Institutional Environment

North (1990) defines institutions as the humanly devised constraints that shape human interactions and structure incentives in human exchange, and as the rules of the game in a society. In this study, we define an institution as a system of rules which regulate activities of firms and humans in a field, such as the financial and legal systems. Therefore, our concept is more aggregated than the one defined by North. In the following subsections, we examine two important institutions: the financial system and the legal system. These two institutions form an important institutional environment for firms, which affects various behaviours of a firm.

3.2.1 Financial System and Its Role

The financial system is a system which channels funds from surplus-spending savers to deficit-spending investors. It consists of financial intermediaries and rules regulating the functions or activities of these intermediaries. Depending on the economic development of a society, financial intermediaries include banks, credit unions, trust companies, insurance companies, pension funds and investment dealers or brokers. In sophisticated financial markets, many transactions may occur between different financial intermediaries.

Financial services are to match saving and investing when savers are different from investors. The efficient matching between savers and investors is critical to reduce capital costs to a firm and economic development.

Difference exists between investment brokers (dealers), banks and other financial intermediaries. In a matching process, a broker takes little or no risk, while banks and other financial intermediaries assume risk. The difference between banks and other intermediaries is that banks can create funds to be channelled to capital users. Securities markets perform matching by providing a convenient means whereby savers and investors can meet directly (or through brokers) and trade financial claims among themselves. Banks and other financial intermediaries operate by issuing claims on themselves to sources of funds and lend the proceeds to capital users. Due to its ability to collect large pools of funds, banks or financial intermediaries can diversify the risks of its investments. In this way, they can take advantage of economies of scale in collecting and assessing financial information in extending loans and purchasing financial instruments. They can transfer short-term available funds to medium- and long-term investable capital so that funds can be allocated more efficiently.

A bank's ability to create funds enables it to dominate financial intermediaries during the initial stage of economic development. The deposit liability of banks, along with currency, constitute the means of payment in an economy. In a market economy, with the help of Central Bank by settling accounts between banks, the banking system processes payment for the rest of the economy. The Central Bank influences economic activities principally by working through banks. The unique characteristics of banks have motivated various government regulations on their activities. The main purposes are to ensure the safety and soundness of the banking and money system; to ensure that credit is fairly and honestly allocated, and; to ensure that banking organizations do not grow too large, thus too economically or politically powerful

(Litan, 1987). Different regulations in different countries lead to varied financial systems (Zysman, 1983): a capital-market-based system with resources allocated by prices established in competitive markets such as in Britain, Canada and U.S.; a credit-based system with critical prices administrated by government such as in France and Japan, and; a credit-based system dominated by financial institutions such as in Germany.

The activities of banks are greatly affected by perceived risks and profitability, and advancement in transportation and communication technologies. Banks may either transfer funds into **financial investments** such as existing stock and shares, or into **productive investments** such as machinery and equipment (Carrington, 1979). Uncertainty and imperfect information make banks' lendings more transactional or short-term speculation-oriented.

With globalization, a bank's role as a coordinator for cooperation between firms has become increasingly important. This role is often overlooked. In Japan and Germany, banks help fostering the healthy financial interpenetration and cooperation among different firms in an industrial group. They not only provide firms with long-term investment funds at the right time, but also gather, process and provide information in domestic and international markets to the group. Many studies attribute the high competitiveness of Japanese and German firms to the positive role played by their banks. This is in contrast to the banks' activities in North America. Real world experience has showed that the transaction-oriented activities of banks may not serve the public interest. For example, in the late 1960's and early 1970's, for their own profit, many banks encouraged and provided financing for the over-diversification activities of firms, instead of restructuring the firms' core or closed-related business operations. The over-diversified merger and acquisition activity affected the investment behaviour of American firms and their competitiveness negatively.

A healthy, socially beneficial role of the financial system may be achieved through active roles from the government, industrial corporations and the financial sector itself. To a great extent, the success of the Japanese industrial group played an encouraging role in the emergence of the co-operative movement in Canada, especially in Quebec. Quebec government has been in the position to encourage the involvement of financial institutions in industrial activities so that a Quebec Inc. can be established. However, there has been no systematical analysis on the effect of this co-operative movement. In the following paragraphs, we will briefly review the relationship between banks and corporations in Germany.

In Germany, relations between banks and companies are traditionally closer than in North America. The German government has a supportive stand on the long-term relationship between banks and private firms. Banks have always subscribed to the principle of relationship banking as opposed to transaction-oriented approach (Scheider-Lenné, 1992). They see individual transactions within the context of a comprehensive business relationship with the customer. They tend to seek a stable relationship with the customer and vice versa. This is seen to be very much to the long-term benefit of both the company and the bank. Many companies regard a long-standing relationship with a bank as a kind of insurance which bears appropriate premium in good times and offers corresponding protection when operations are less lubricative. For example, Deutsche Bank AG was found by banks and industrial companies as a consortium bank in order to finance foreign trade. This has remained a distinctive feature of Deutsche Bank ever since. The situation is similar for other big universal banks, be they state-owned or private (Scheider-Lenné, 1992). The influence exerted by banks via supervisory board mandates into management of a company is quite substantial, because of their expertise in financial matters and specialty in information gathering and processing. The role of the supervisory board is not only to detect past mistakes, but, more important, to prevent these mistakes from being made in the first place.

Banks influence companies by helping financing or restructuring. For example, converting loans into equity is sometimes part of restructurings. Banks retain their stakes only as long as necessary and sell them to interested investors as soon as possible. Companies often invite representatives of competing banks to join their supervisory board. For example, at Dailmer-Benz AG, where Deutsche Bank AG is the largest shareholder with 28.5% of shares, Germany's other two commercial banks are both represented on the supervisory board, although they have no stake in Dailmer.

The importance of financial system cannot be over emphasized. Although the matching function is critical to economic development, the coordination function becomes overwhelmingly important for a firm's efficient investment and restructuring. Governments can guide the financial system to a certain extent. The communication and cooperation between financial and industrial sectors are important. Whether a financial system will help enhancing the competitiveness of an industrial sector depends on the characteristics of the financial system as well as other conditions.

3.2.2 The Legal System and Its Role

The legal system is defined as the formal rules to regulate an agent's behaviour in a society. Various legal tools are adopted by governments as fundamental means to implement state policies, such as statutes, regulations, courts, and contracts. With economic development, the system becomes more and more complex. For example, in North America it includes the legislative, executive, judicial, and administrative agencies, whose dealings range from social to business problems. We will restrict ourselves on the economic roles of the legal system, i.e. its influence on a firm's investment behaviour.

In a market economy, laws define private property rights and convey entitlements. They also spell out individual and corporate responsibility for the production, use, transfer, and consumption of goods and services. For most things that are brought and sold, the right to exclusive transferable ownership is guaranteed by the legal system and enforced by the state. Exclusive ownership rights are deemed to be an essential condition for ensuring efficiency in production and in the use of labour, capital, and other resources. However, in the case of public goods or common-property resources, such rights do not exist or only exist in a highly attenuated form. As a result, the usual property regulations do not apply.

The economic behaviours of firms and their performance are strongly affected by the legal system. The system affects markets organization, disputes resolution, and the conduct of business. Rational, profit-seeking firms choose whether to invest in a new technology or litigate, depending on the associated costs and returns. The conventional economic theory assumes an executive be a passive combiner of labour and capital, and maximize profit according to specific optimizing rules, under an exogenous legal structure of markets. In reality, firms are active players in a society. The legal system may either impose costs or reduce social transaction costs.

In certain circumstances, even a very stringent legal system may not be as effective or efficient as expected. Common-property resources raise the problem of enforceability. Imperfect information makes a well-thought legal system function imperfectly, because it is too costly to write all contingent contracts. Excessingly relying on legal actions may impose high costs to a society because of increased litigation and confrontation when facing disputes. In certain cases, informal rules are also important, and sometimes more effective as a complement, such as arbitration used in some civil disputes. Therefore, the legal system influences a firm's investment behaviour as well as its relations with other firms or sectors, in turn, the firm's competitiveness.

For example, in financial markets, the legal system affects firms in their costs of financial services, such as dealings with lenders on the debt side and with shareholders on the equity side. Where the prospect of litigation is higher, the amount of cost and paperwork to avoid such action is higher. There is an insistence that agreements between a firm and lenders be in writing, supervised by lawyers, to cover possibilities such as breach of contract. Low court filing fees and contingency fees to lawyers for plaintiffs increase litigation, as opposed to arbitration, in resolving disputes. A handshake or gentlemen's agreement where one's word is honoured may arise because the cost of alternative dispute resolution is high. As a result, a firm's investment behaviour is affected accordingly.

In response to a more complicated judicial structure, firms increase the size of their legal department, both in-house and in the retention of outside counsel. Corporations recruit more accountants, lawyers and other professional workers in addition to support staffs, with relatively fewer in research and engineering. By doing this, firms can be better off in terms of maximizing their profits. A survey of senior executives in U.S. (Chinloy, 1989) suggests that litigation has reduced innovation. 65 percent of the executives indicated that lawyers have a greater role within their firms.

Different legal systems create differences in the rate of litigation and cost of doing business. In 1985, of each 1000 disputes, 44 went to trial in U.S., but only 12 and 23 in Japan and West Germany respectively. In U.S., the legal system encourages litigation, because of the lack of penalty on litigants. In Japan and Germany, the emphasis of the legal system is on society as a whole, rather than on the individual. Freedom to an individual does not mean that the individual does not have responsibility to a society. Germany and Japan do not have contingency fee payments to attorneys for plaintiffs. Lawyers are paid direct fees. On the contrary, in the United States, the filing of suits has little downside risk of loss to a firm.

Different legal systems have different impacts on a firm's investment behaviour and its relations with other firms. The German and Japanese systems tend to enhance communication and cooperation between firms, while the American system tends to encourage confrontation between firms. As a result, firms behave differently in different legal environments or countries.

The following example will illustrate how a firm uses legal action to react to competition from outside instead of improving the technology in U.S.(Chinloy, 1989). Sony's attempt to enter the U.S. market for television sets was affected by legal harassment. The problem with the legal and regulatory system commenced in 1968 and lasted through 1975. Sony was known to be the sellers of the most expensive television sets in U.S. Emerson, the American producer, filed a dumping lawsuit against Sony. It cost Emerson almost nothing, because American Revenue Act of 1916 permits private lawsuits and treble damages in competition cases. However, the cost to Sony was legal fees, distraction of managers from control of business. At one point during the Emerson lawsuit, Sony attempted to settle and Emerson was willing to accept a settlement. However, Emerson could not accept, because its lawyers were gambling on receiving a portion of the punitive damages on contingency and had a contractual right to approve the settlement. Ultimately, Emerson lost the case, although it would have benefited from the early settlement.

The excessing reliance on formal legal actions as an instrument of economic and social development has caused concern in North America. People have realized the great costs to business and effects on the competitiveness compared to Japan and Germany. In 1983, in his annual report to the university's board of governors, the president of Harvard University, Derel C. Bok, proposed a new orientation of teaching in the law faculties as opposed to what were too geared toward adversarial approaches. He pointed out that

> "Over the next generation, I predict, society's greatest opportunities will lie in tapping human inclinations toward collaboration and compromise rather that stirring our proclivities for competition and rivalry."

In summary, a basic legal system can insure stable environment and foster economic development. Excessingly relying on laws may raise too high costs for business, in turn lower its competitiveness. Informal rules are useful in complementing the formal legal rules and in bridging healthy communications among firms.

The legal system in Canada resembles the American system, although Canadian society is less litigious. Lawyers' services have been divided about equally between household and business clients through the postwar period, but satisfactory data on the demand for lawyers' services are not readily available (Strager, 1990). The 1981 Census showed that government is the single largest employer of in-house lawyers (59%), with the second largest employer the financial and insurance industries (10%), followed by transportation (5%), manufacturing (4%), and mining industries (4%). In general, the basic rules for business in Canadian legal system has been relatively the same since the early 1960's.

3.3 Organization, Investment and Competitiveness

The economic and institutional environments together shape various behaviours of a firm. These include a firm's investment decision and its organizational forms such as the inter-relationships between firms. As a result the firm's competitiveness is affected.

When a firm is exposed to the increasingly globalized world, it faces a higher competitive pressure. The globalization also increases the complexity of technology and the cost of doing research and development. A firm needs not only advanced equipment and machinery, but also a new organizational form to compete successfully and efficiently. For example, successful product or process development often requires horizontal as well as vertical cooperation. Horizontal linkages assist in the definition of technical standards for systemic innovation, assist firms to overcome the appropriability (spillover) problems, reduce needless duplication of effort, and encourage a greater investment in new technology. Vertical cooperation increases the efficiency of the product or process development and the product's acceptance in the market. With advanced telecommunications facilities, small autonomous organizational units (communicating and interacting directly with each other) are likely to develop and implement an action plan faster and more efficiently than large organizational units.

The institutional environment is important in affecting a firm's investment behaviour and competitiveness. An appropriate institutional environment may enhance a firm's investment and competitiveness. For example, banks play positive roles in helping firms to improve their competitiveness in Japan and Germany. An inappropriate institutional environment may lead to wasteful activities. For instance, banks played a negative role in their active involvement in the over-diversification activities of firms in the U.S. in the late 1960s and the early 1970s.

Increasing complexity of technologies implies that many cooperative firms also compete at the same time. Technologies evolve progressively. Different firms have different technological evolution paths. Differences in technology specializations may result in variation in the exposure of firms to external competitive pressure in a new economic and institutional environment. This, in turn, leads to different reactions of firms. For example, some firms may invest in new equipment and machinery while others invest in improving its organizational efficiency. Some firms may achieve their technical innovations by getting breakthroughs beyond existing technology, while others by fusing different existing technologies. For example, in the electronics industry, many American semiconductor makers achieve new innovations and enhance their competitiveness by combining their specialties in design and development with the impressive manufacturing skills of Japanese firms.

Certain technologies may simultaneously affect several different activities, such as a common core technology to several businesses. These interdependencies require interaction, information and materials flows among firms so that efficiency can be enhanced. However, the competitive-enhanced relationship (cooperation) between firms needs a supportive economic and institutional environment.

An efficient organizational form enables a firm to incorporate efforts from various parts. For example, the firm can combine its internal resources with resources from its suppliers and even its competitors in various ways, so that its investment efficiency can be increased.

Firms can make good use of other firms' resources through strategic alliances[1], joint ventures and mergers. Through these interfirm alliance, firms are capable of achieving various forms of operational and strategic coordination and cooperation. It may include coordination and cooperation in investments in complementary technologies or assets, user know-how, and in lowering costs and risks of innovation. For example, the joint venture formation between American and international partners grew by 27% annually between 1985 and 1991 (Fortune, Sept.21, 1992). The joint venture saved cash, got a firm access to a new market or a special expertise, and enhanced each partner's investment efficiency.

Credible coordination and cooperation between firms can be achieved through mid- and long-term bilateral operation contracts and reciprocal financial relationship, such as equity holdings. Equity stakes provide a mechanism for distributing residuals when ex ante contractual agreements cannot be written to specify or enforce a division of returns. If equity membership also provides board membership, the higher level strategic coordination and cooperation is also possible, such as in the Japanese and German industrial groups. Banks may act as a coordinator through their involvement in the financing of firms; their position to

---

[1]A strategic alliance (Teece 1990) is defined as a constellation of agreements characterized by the commitment of two or more partner firms to reach a common goal, entailing the pooling of some of their resources and activities. It might include: an exclusive purchase agreement; exclusionary market or manufacturing rights; technology swaps; joint R&D or co-development agreements, and; co-marketing arrangements.

gather various valuable information on demand, supply and financial data in domestic as well as international markets; their ability to process the information; their capacity to provide most comprehensive information and needed financing for critical investments. Under certain conditions, a government may play the role which would have been played by a bank under regular conditions. For example, under high risks, a government's financial involvement may help bring cooperations from banks and various other firms. Its involvement can help turn a difficult situation around, for example, in the restructuring of Chrysler in late 1970's and early 1980s.

Economic and institutional constraints affect a firm's investment behaviour and, in turn, its competitiveness. For instance, an incomplete legal system, such as on patent protection, may discourage the productive investment of a firm. It may instead encourage rent-seeking activities. In the U.S., higher profits from mergers and acquisitions in late 1960's and early 1970's encouraged many firms and banks to get involved in the business of buying and selling corporations, instead of investing in advancing the technology of firms. The mergers and acquisitions established the buying and selling of corporations as a business - and a lucrative one. Many financial institutions (particularly investment banks) turned away from what had been their basic function: providing funds to supplement retained earnings to keep people and plants competitive. On the contrary, the Japanese and German financial institutions performed their lending functions effectively. Consequently, the short-term profit maximization behaviour hurt the long-term health of the involved American enterprises and industries, and affected their competitiveness negatively. In the following paragraphs, we will use the semiconductors industry as an example to illustrate the effect of an appropriate and an inappropriate institutional system.

The semiconductors industry was created in the U.S. In the mid-1970s, American companies held 60% of the world market, 95% of the American domestic market, half of the European market, and a quarter of the Japanese market. By 1987, its world market share had fallen to 40%, while the Japanese share had risen to 50%. The United States had become a net importer, with the Japanese supplying 25% of its market. Japanese enterprises controlled over 80% of the world's sales of DRAMs invented by the U.S. company Intel. The main reason was due to the over-diversification of American firms and their investments in unproductive speculation (Chandler,1990), as opposed to Japanese and German firms.

When facing the unprecedented competitive pressure from Europe and Japan, with current institutional environment most American firms diversified into unrelated businesses for short-term profits (Chandler, 1990). Many firms began to grow by moving into industries in which their enterprises had no particular competitive advantage. They acquired businesses in which they had few if any organizational capacities to give them a competitive edge. For example, from 1963 to 1972, close to three-fourths of the assets acquired were in unrelated product lines. From 1973 to 1977, one-half of all assets acquired through merger and acquisition came from unrelated industries. On the other hand, Japanese companies (such as NEC, Hitachi, Toshiba, Mitsubishi Electric) produced semiconductors for domestic and international markets. They diversified but only into closely related product lines, unlike American counterparts. As members of an allied and independent enterprises group, with their own bank and trading companies, firms coordinated activities in financial, marketing and research areas.

In the U.S., the over-diversification led to management problems, which, in turn, quickly led to the sale of operating units in unheard-of numbers. For example, there was only one divesture for every 11 mergers in 1965; by 1970, it was 1 to 2.4; and from 1974 to 1977, the ratio was close to or even under 1 to 2.

These over-diversification activities caused social costs and led to the deterioration of the competitiveness of American firms, as compared to firms in Japan and Germany. To a great extent, the American financial and legal systems contributed to this deterioration. However, this situation started to reverse in late 1970's, when many rules in the financial system and the legal system were adjusted by the government, such as the anti-trust law.

3.4 Summary

Both economic and institutional environments are important in affecting a firm's decision-making. This has been illustrated by reviewing the changed economic environment of firms, the two important institutions, and their roles with reference to the real world experience.

Increasing globalization has greatly increased competitive pressure on firms. In this new environment, many technologies become multidimensional and interdependent. The costs of doing research and development has been getting higher and higher as well. All these have affected a firm's organizational form, and raised the importance of appropriate relationships between firms.

The financial system plays an important role in transferring short-term available fund to medium- and long-term investable capital, as well as in helping foster appropriate relationships between firms. For example, banks may be able to act as an efficient coordinator for cooperation between firms. As illustrated in this chapter, different financial systems affect a firm's investment behaviour differently and, in turn, its competitiveness. Real world examples were given in the U.S., Japan and Germany.

These different effects depend on how the banks are involved in the activities of firms.

The legal system defines formal rules to regulate a firm's activities, and to provide conditions for markets to work properly. Informal rules are often needed to supplement the formal rules, so that an economy can perform more efficiently. An under-developed legal system may hinder progress; too much reliance on the legal system may have the same effect.

Economic environment and institutional constraints affect a firm's investment behaviour and its organizational forms such as its relationship with other firms. Indeed, this has been illustrated by the experience from the U.S., Japan and Germany in this chapter. In recent years, under the new economic and institutional environment, strategic alliances and other inter-firm cooperations have increased in frequency, particularly in the high-technology industries. Joint R&D, know-how, manufacturing, and marketing agreements are common. Firms cooperate in order to make good use of their complementary technologies and assets, and to enhance their investment efficiency and competitiveness.

In next chapter, we will, in a formalized fashion, examine the effect of the economic and institutional environment on a firm's investment behaviour. We will first use a general theoretical model (in section 4.1) to show formally that the economic and institutional environment does affect a firm's investment behaviour, but the direction of the effect depends on specific circumstances. Then, two simplified stylized models are used in section 4.2 and 4.3 to help go beyond the indetermining of the general model in section 4.1, and to illustrate the mechanisms by which the environment affects the firm's investment decision and in turn its competitiveness

Chapter 4 A Model of Firm's Investment Behaviour

To be competitive, a firm has to invest in improving its technology. However, as discussed in chapter 3, technologies have become more complex and multidimensional with increasing globalization. As a result, commercially successful innovations require linking scientific, engineering, entrepreneurial and management skills with an intimate understanding of user needs. It is important that firms appreciate the importance of the flow of activity from the research and development, through to the design, production and marketing stages. The constant feedback between and among these different stages must be incorporated in the firm's decision making process.

When a firm is having difficulty in introducing new products, it is crucial that the firm is able to redesign quickly and efficiently, and integrate new information from markets and consumers as well. Tight linkages and feedback mechanisms are particularly important in this increasingly globalized world. Therefore, a competitive firm must be able to quickly realize its environmental variety, and react to it efficiently and effectively. It has to have advanced equipment and machinery as well as an efficient organizational form. As a result, it can adapt to its changing environment and make good use of the needed complementary technologies and assets from other firms or agents.

In this chapter, following the discussion in chapter 3, we will narrow down our analysis to examine a firm's investment behaviour when its economic and institutional environment is taken into account. In section 4.1, we will discuss the two important aspects of a firm's technology, hardware and software, and analyze a firm's investment behaviour with respect to these two aspects. Although it illustrates formally how economic and institutional environment variables affect investment decisions, the model of section 4.1 also confirms an impression gathered from the discussion in chapter 3: that these factors have ambiguous effects in general.

In order to go further in deepening our understanding of the effect of the economic and institutional environment, we use simplified stylized models in sections 4.2 (which uses six cases in an easy understandable way) and 4.3 (as complement to section 4.2 to examine more other cases) to analyze the investment behaviour of a firm in specific circumstances. These simplified models illustrate the mechanisms that determine firms' technology investments. They may be useful simplifications of reality, and be used as a basis for empirical study.

4.1 Hardware and Software Technologies and Firm's Investment Behaviour

In this section, we will discuss the concept of hardware and software technologies. Then, a firm's investment in the two aspects is analyzed in the framework of n firms with investment and technology externality.

4.1.1 The Concept of Hardware and Software Technologies

A successful firm has to be able to match available human resources with its available equipment, and also to coordinate all inputs from various processes such as manufacturing, marketing and distribution. Furthermore, its products must be able to efficiently adapt to changing customer's needs such as user-friendly preferences. Therefore, a firm needs efficient equipment as well as a systemic approach to organize its production processes. That is, it needs efficient hardware and software technologies.

Hardware technology is defined as the advanced technology embodied in new machinery, an important ingredient for a firm to reduce its cost or increase its competitiveness. However, with the increasing complexity of production procedures and the increasing sophistication of equipment, there is an increasingly important counterpart of the hardware technology. That is the **Software technology**, which is defined as a firm's organizational form, its ability to organize production inputs and to coordinate with business partners or associates from outside. The evolution of software technology is influenced by both the economic and the institutional environments. It has both static (managing and using inputs efficiently and effectively) and dynamic aspects (motivating productive human resources, timely adapting to changing environments, and strategically integrating external inputs).

It is often observed that, with similar human resources, some firms have lower production efficiency than other firms, even though they may have more advanced equipment and machinery (hardware technology). Womack et al (1990) find many examples when comparing the productivity performance among automobile firms in U.S., Japan and South Korea. To be successfully innovative and adaptive in a market, it is important for a firm to realize both technologies. Sometimes, an increase in production efficiency can be realized with an improvement in software technology, which permits a better use of available hardware technology. This is particularly so when a society is more developed. In such a society, wealth accumulation, more sophisticated consumers and the associated saturation of markets with standardized products call for greater concerns regarding the quality and versatility of products offered. Differences in decisions by various firms under a similar situation often result from their different technology specializations.

4.1.2 Investment Behaviour of Firms When They Have Investment Externality

A competitive firm optimizes its investment in both hardware and software technologies according to its changing economic and institutional environments. Suppose both hardware and software knowledges (stocks) accumulate with time. Part of old technology is obsolete while new investment adds to the current stock. The firm makes decisions on the investment of both technologies and output, so that its profit is maximized. In what follows, we will assume that the two technologies affect production costs through the Cobb-Douglas form.

Suppose there are n firms in a market. There exist externalities between firms' technology investments (X_1 represents hardware technology investment and X_2 software technology investment), and between technology stocks (A represents hardware technology stock and S software technology stock). To simplify the analysis, we assume that the externality coefficient between software technology investments of firm i and firm m is η_{im}; the externality coefficient between hardware technology investments of firm i and firm m is also η_{im}; the externality coefficient between software technology stocks of firm i and firm m is θ_{im} and; the externality coefficient between hardware technology stocks of firm i and firm m is also θ_{im}.

At each time period, the profit of firm i is equal to revenue from sales of its products $(P(Y)Y^i)$, minus its production costs $(C(Y^i,w,r)/(A^i)^\sigma(S^i)^{1-\sigma})$, and minus its investment costs $(P_1X_1^i+P_1X_1^i)$. Under perfect information we have a differential game problem for firm i, with time subscripts suppressed, as follows.

$$\underset{\{Y^i,X_1^i,X_2^i\}}{MAX} \left\{\pi^i=\int_0^\infty e^{-\rho t}[P(Y)\,Y^i-\frac{C(Y^i,w,r)}{(A^i)^\sigma(S^i)^{1-\sigma}}-P_1X_1^i-P_2X_2^i]dt\right\} \qquad (4.1)$$

$$S.T. \quad \dot{A}^i=h(A^i,S^i,X_1^i,\theta^i A^{-i},\eta^i X_1^{-i})-\mu_1 A^i$$
$$\dot{S}^i=g(A^i,S^i,X_2^i,\theta^i S^{-i},\eta^i X_2^{-i})-\mu_2 S^i$$

Where

ρ - Discount rate
Y - total output of all n firms
P(Y) - price of output
w, r - prices of labour and capital input service
P_1, P_2 - Prices of inputs for hardware and software technologies investment
X_1^i, X_2^i - Inputs for hardware and software technology investment of firm i
X_1^{-i}, X_2^{-i} - Inputs vector of hardware and software technology investments for all firms except firm i, $X_1^{-i}=[X_1^1,..X_1^m,..,X_1^n]'$, $X_2^{-i}=[X_2^1,..,X_2^m,..,X_2^n]'$, $m\neq i$
A^i, S^i - Stocks of hardware and software technologies of firm i
A^{-i}, S^{-i} - stocks vector of hardware and software technologies of all firms except firm i, $A^{-i}=[A_1^1,..A_1^m,..,A_1^n]'$, $S^{-i}=[S_2^1,..,S_2^m,..,S_2^n]'$, $m\neq i$
μ_1, μ_2 - depreciation rates for hardware and software technologies
h(.) - Investment-production function of hardware technology, $h'(.) \geq 0$
g(.) - Investment-production function of software technology, $g'(.) \geq 0$
θ^i - externality coefficients vector of hardware & software technology stocks from all other firms except firm i, for firm i, $\theta^i=[\theta_{i1},..,\theta_{im},..,\theta_{in}]$, $m\neq i$
η^i - externality coefficients vector of hardware & software technology investments from all other firms except firm i, for firm i, $\eta^i=[\eta_{i1},..,\eta_{im},..,\eta_{in}]$, $m\neq i$

The Current Value Hamiltonian for firm i is

$$H^i = P(Y)\,Y^i - \frac{C(Y^i,w,r)}{(A^i)^{\sigma}(S^i)^{1-\sigma}} - P_1X_1^i - P_2X_2^i + \lambda_1^i[h(A^i,S^i,X_1^i,\theta^iA^{-i},\eta^iX_1^{-i}) - \mu_1A^i]$$
$$+\lambda_2^i[g(A^i,S^i,X_2^i,\theta^iS^{-i},\eta^iX_2^{-i}) - \mu_2S^i]$$

The current value Hamiltonian is equal to the revenue from selling product in output market, plus the revenue from investment in hardware technology, plus the revenue from investment in software technology. $\lambda_1{}^i$ and $\lambda_2{}^i$ are the implicit prices, or opportunity costs, of hardware and software technologies. The first-order conditions for maximizing the Hamiltonian, with respect to Y^i, $X_1{}^i$ and $X_2{}^i$, are as follows.

$$\begin{aligned}
\frac{\partial H^i}{\partial Y^i} &= P'(Y)\,Y^i + P(Y) - \frac{C'(Y^i,w,r)}{(A^i)^{\sigma}(S^i)^{1-\sigma}} = 0\\
\frac{\partial H^i}{\partial X_1^i} &= -P_1 + \lambda_1^i\frac{\partial h(A^i,S^i,X_1^i,\theta A^{-i},\eta X_1^{-i})}{\partial X_1^i} = 0\\
\frac{\partial H^i}{\partial X_2^i} &= -P_2 + \lambda_2^i\frac{\partial g(A^i,S^i,X_2^i,\theta S^{-i},\eta X_2^{-i})}{\partial X_2^i} = 0
\end{aligned} \tag{4.2}$$

The first order conditions are conditions at each point of time for given A^i, S^i, A^{-i}, S^{-i}, and $\lambda_1{}^i$, $\lambda_2{}^i$. The first equation is the familiar marginal revenue being equal to marginal costs condition. The second and third are the conditions that marginal revenues from increase in investment in hardware and software technologies must be equal to their respective costs.

For n firms, we will have n sets of the first order conditions, one for each firm. Theoretically, we solve them jointly to get the solution Y^{i*}, X_1^{i*}, X_2^{i*} (i=1,..,n) at each time t as a function of state variables A^i, S^i, A^{-i}, S^{-i}, and the implicit prices λ_1^i, λ_2^i. That is, at each time t, we have

$$
\begin{aligned}
Y_t^{i*} &= Y^{i*}(w_t, r_t, A_t^i, S_t^i, A_t^{-i}, S_t^{-i}) \\
X_{1t}^{i*} &= X_1^{i*}(P_{1t}, A_t^i, S_t^i, A_t^{-i}, S_t^{-i}, \lambda_{1t}^i, \lambda_{1t}^{-i}) \\
X_{2t}^{i*} &= X_2^{i*}(P_{2t}, A_t^i, S_t^i, A_t^{-i}, S_t^{-i}, \lambda_{2t}^i, \lambda_{2t}^{-i})
\end{aligned} \tag{4.3}
$$

Where

λ_{1t}^{-i}, λ_{2t}^{-i} - implicit prices vector of hardware and software technologies of all firms except firm i,
$\lambda_{1t}^{-i} = [\lambda_{1t}^1, \ldots, \lambda_{1t}^m, \ldots, \lambda_{1t}^n]$,
$\lambda_{2t}^{-i} = [\lambda_{2t}^1, \ldots, \lambda_{2t}^m, \ldots, \lambda_{2t}^n]$, $m \neq i$

It can be seen that the economic and institutional environment affects a firm's investment behaviour and in turn its competitiveness. Changes in the economic and institutional environment cause variations in various functions or parameters, which in turn affect technology investments of firms. For example, increasing globalization leads to changes in the functions h(.) and g(.), because, under high competitive pressure, technology investments of firms become more efficient. Increasing globalization may also change the relative importance of hardware and software technologies, i.e. cause a different σ. Changes in institutional environment influence inter-firm relationships and in turn their investment and stock externalities, i.e. cause different θ^i and η^i. As one of the important institutions, banks in the U.S., Japan and Germany play different roles, as reviewed in chapter 3.

It is very difficult to determine the direction of the effect of the economic and institutional environment, unless various conditions or circumstances are specified. Different firms have different technology specializations and in turn market positions. Firms may react differently when there are changes in the environment. For example, under increasing car imports and competition from the Japanese in late 1970's and 1980's, different American firms reacted differently. With the then current institutional environment, GM spent more money on updating automation technology to replace workers, while Ford tried very hard to learn the soft aspect of efficient production (the Japanese Lean Production Techniques). The results were also different. Productivity and profitability at Ford improved while it deteriorated at GM at the initial reaction stage (Womack et al, 1990).

The difficulty to determine the direction of the effect can be further illustrated with an extension of our model. Suppose imperfect information prevails and some firms may not be able to realize changes in the importance of the software technology. The firm may attach zero or very small value to the implicit price of software technology (λ_2), which in turn leads to a small investment in software technology (x_2) and an over-investment in hardware technology (x_1). As a result, these firms will become less competitive. This often happens during transition or restructuring periods.

In the above, we analyzed a firm's investment behaviour by examining the firm's first order conditions at each point of time for given A^i, S^i, A^{-i}, S^{-i}, and $\lambda_1{}^i$, $\lambda_2{}^i$. In what follows, we will examine the firm's investment and output decisions with time by examining a dynamic system. Both open-loop and closed-loop Nash strategies are discussed. We have the following conditions for firm i in partial differential equations, with time subscript suppressed:

Open-Loop Nash Strategy:

$$\dot{\lambda}_1^i=\rho\lambda_1^i-\frac{\partial H^i(.)}{\partial A^i}=[\rho-\frac{\partial h(.)}{\partial A^i}+\mu_1]\lambda_1^i-\frac{\partial g(.)}{\partial A^i}\lambda_2^i-\sigma\frac{C(Y^i,w,r)}{(A^i)^{\sigma+1}(S^i)^{1-\sigma}}$$

$$\dot{\lambda}_2^i=\rho\lambda_2^i-\frac{\partial H^i(.)}{\partial S^i}=[\rho-\frac{\partial g(.)}{\partial S^i}+\mu_2]\lambda_2^i-\frac{\partial h(.)}{\partial S^i}\lambda_1^i-(1-\sigma)\frac{C(Y^i,w,r)}{(A^i)^{\sigma}(S^i)^{2-\sigma}}$$

Closed-Loop Nash Strategy:

$$\begin{aligned}\dot{\lambda}_1^i&=\rho\lambda_1^i-\frac{\partial H^i(.)}{\partial A^i}-\frac{\partial H^i}{\partial Y^{-i}}\frac{\partial Y^{-i*}}{\partial A^i}-\frac{\partial H^i}{\partial X_1^{-i}}\frac{\partial X_1^{-i*}}{\partial A^i}-\frac{\partial H^i}{\partial X_2^{-i}}\frac{\partial X_2^{-i*}}{\partial A^i}\\&=[\rho-\frac{\partial h(.)}{\partial A^i}+\mu_1]\lambda_1^i-\frac{\partial g(.)}{\partial A^i}\lambda_2^i-\sigma\frac{C(Y^i,w,r)}{(A^i)^{\sigma+1}(S^i)^{1-\sigma}}-\frac{\partial H^i}{\partial Y^{-i}}\frac{\partial Y^{-i*}}{\partial A^i}-\frac{\partial H^i}{\partial X_1^{-i}}\frac{\partial X_1^{-i*}}{\partial A^i}-\frac{\partial H^i}{\partial X_2^{-i}}\frac{\partial X_2^{-i*}}{\partial A^i}\end{aligned}$$

$$\begin{aligned}\dot{\lambda}_2^i&=\rho\lambda_2^i-\frac{\partial H(.)}{\partial S^i}-\frac{\partial H^i}{\partial Y^{-i}}\frac{\partial Y^{-i*}}{\partial S^i}-\frac{\partial H^i}{\partial X_1^{-i}}\frac{\partial X_1^{-i*}}{\partial S^i}-\frac{\partial H^i}{\partial X_2^{-i}}\frac{\partial X_2^{-i*}}{\partial S^i}\\&=[\rho-\frac{\partial g(.)}{\partial S^i}+\mu_2]\lambda_2^i-\frac{\partial h(.)}{\partial S^i}\lambda_1^i-(1-\sigma)\frac{C(Y^i,w,r)}{(A^i)^{\sigma}(S^i)^{2-\sigma}}-\frac{\partial H^i}{\partial Y^{-i}}\frac{\partial Y^{-i*}}{\partial S^i}-\frac{\partial H^i}{\partial X_1^{-i}}\frac{\partial X_1^{-i*}}{\partial S^i}-\frac{\partial H^i}{\partial X_2^{-i}}\frac{\partial X_2^{-i*}}{\partial S^i}\end{aligned}$$

Suppose firms are price takers in the market: $P(Y)=P$. In this case, we have solutions from the first order conditions,

$$\begin{aligned}Y_t^{i*}&=Y^{i*}(P_t,w_t,r_t,A_t^i,S_t^i)\\X_{1t}^{i*}&=X_1^{i*}(P_{1t},A_t^i,S_t^i,A_t^{-i},S_t^{-i},\lambda_{1t}^i,\lambda_{1t}^{-i})\\X_{2t}^{i*}&=X_2^{i*}(P_{2t},A_t^i,S_t^i,A_t^{-i},S_t^{-i},\lambda_{2t}^i,\lambda_{2t}^{-i})\end{aligned}\qquad(4.4)$$

The dynamic system for the case of Open-loop Nash Strategy does not change, while the Closed-loop Nash Strategy yields the following system.

$$\dot{\lambda}_1^i = \rho\lambda_1^i - \frac{\partial H^i(.)}{\partial A^i} - \frac{\partial H^i}{\partial Y^{-i}}\frac{\partial Y^{-i*}}{\partial A^i} - \frac{\partial H^i}{\partial X_1^{-i}}\frac{\partial X_1^{-i*}}{\partial A^i} - \frac{\partial H^i}{\partial X_2^{-i}}\frac{\partial X_2^{-i*}}{\partial A^i}$$
$$= [\rho - \frac{\partial h(.)}{\partial A^i} + \mu_1]\lambda_1^i - \frac{\partial g(.)}{\partial A^i}\lambda_2^i - \sigma\frac{C(Y^i, w, r)}{(A^i)^{\sigma+1}(S^i)^{1-\sigma}} - \frac{\partial H^i}{\partial X_1^{-i}}\frac{\partial X_1^{-i*}}{\partial A^i} - \frac{\partial H^i}{\partial X_2^{-i}}\frac{\partial X_2^{-i*}}{\partial A^i}$$

$$\dot{\lambda}_2^i = \rho\lambda_2^i - \frac{\partial H^i(.)}{\partial S^i} - \frac{\partial H^i}{\partial Y^{-i}}\frac{\partial Y^{-i*}}{\partial S^i} - \frac{\partial H^i}{\partial X_1^{-i}}\frac{\partial X_1^{-i*}}{\partial S^i} - \frac{\partial H^i}{\partial X_2^{-i}}\frac{\partial X_2^{-i*}}{\partial S^i}$$
$$= [\rho - \frac{\partial g(.)}{\partial S^i} + \mu_2]\lambda_2^i - \frac{\partial h(.)}{\partial S^i}\lambda_1^i - (1-\sigma)\frac{C(Y^i, w, r)}{(A^i)^{\sigma}(S^i)^{2-\sigma}} - \frac{\partial H^i}{\partial X_1^{-i}}\frac{\partial X_1^{-i*}}{\partial S^i} - \frac{\partial H^i}{\partial X_2^{-i}}\frac{\partial X_2^{-i*}}{\partial S^i}$$

For n firms, we have n sets of the above differential equations. In order to get explicit solutions of firms' technology investments and outputs, we have to solve the above equations jointly with the two constrain equations in (4.1). Ideally, we can solve the above two sets of differential equations (one for Open-loop Nash strategy and one for Closed-loop Nash strategy), get solutions for λ^i_{1t} and λ^i_{2t} as a function of A^i_t S^i_t, A^{-i}_t, S^{-i}_t, w_t, r_t and other parameters, and in turn get the technology investments and outputs of firms as a function of A^i_t S^i_t, A^{-i}_t, S^{-i}_t, w_t, r_t and other parameters. However, in reality, it is very difficult, if not impossible, to solve the partial differential equations (even in the case of two firms). Furthermore, the explicit solution will not change what was illustrated with the first order conditions: the economic and institutional environment variables affect investment decisions, and these factors have ambiguous effects in general. Ascertaining such effects is thus an empirical question in general. However, it is possible that some specific cases have empirical relevance. We study some of them in the next two sections (sections 4.2 and 4.3).

4.1.3 Summary

We have analyzed a firm's investment behaviour when the hardware and software technologies are explicitly taken into account, in the case of n firms with externality. The difficult differential game equations prevent us from getting explicit solutions. However, the analysis showed qualitatively that a firm's investment behaviour is affected by and is conditional on many factors, and should be analyzed under different specific conditions.

Therefore, the theoretical model points to the importance of some factors. But there is no general answer as to the direction of their effect. Ascertaining such effects is thus an empirical question. In order to draw inference from empirical observations, stylized models will be helpful.

In the following two sections (4.2 and 4.3), we will use a simplified two-stage game and a simplified two-period game to illustrate the effect of the following economic and institutional environment variables: a simplified legal system, financial interpenetration between firms, financial interpenetration between firms and banks, and a firm's exposure to foreign competitors[1]. These simplified models illustrate the mechanisms that determine technology investments of firms. They may be useful simplifications of reality, and be used as a basis to perform an empirical study. In this way, we will be able to examine the impact of the economic and institutional environment on the cost performance of a firm and its competitiveness.

[1]The definition of these variables is given in the empirical study chapter, i.e. in Chapter 5.

4.2 A Two-stage Investment Game

In section 4.1, the complexity of the differential game equations prevents us from getting an explicit solution to the general model, and such a solution would not be without ambiguity as far as the effect of the economic and institutional environment on technology investment is concerned. In contrast, while lacking generality, simplified models may bring up the mechanisms which determine technology investments in key circumstances.

In order to examine the impact of the economic and institutional environment on a firm's investment behaviour, and in turn, its cost competitiveness, we will focus on the two-firm case and simplify the mathematical formulation by using a two-stage game[1]. We will explicitly examine the following factors: the legal system, firms' exposure to outside pressure, the relative competitive position of firms, and cooperation between firms through financial inter-relationship. By cooperation, we mean that the two firms exchange information on hardware and software technologies and may make use of their complementary technologies. As a result, they will get a higher economic return from a given investment than in the noncooperative case. Their production decisions continue to be made independently.

In the following analysis, two strategies are considered:

[1]The formulation here is based on Starr and Ho (1969), where a simple discrete, finite-state multistage game is used to illustrate the basic idea of continuous differential games.

Closed-loop Nash strategy, Open-loop Nash strategy. Six cases are analyzed. In order to simplify the analysis, we combine the software and hardware technologies into an "aggregate technology". We will focus on the case where the two firms are symmetric, and produce similar products with closely related technologies. Due to the limitation (more cases mean many repetitious analyses) of this simple discrete, two-stage game, we will use a simplified continuous-time model to analyze more general cases in section 4.3.

At each stage of the game, a firm decides on its investment and gets a payoff. The firm's investment decision is simplified as an action of 1 and 0, which means "invest" and "do not invest" respectively. The common technology level (TS) of the two firms is assumed simply as being 3, 2, 1, 0, -1, etc., compared to their competitors. We will discuss cases where the firms' competitors have different technology levels, such as TS=2 and TS<1. However, we normally assume that the competitors have a TS=1, unless a different TS is given.

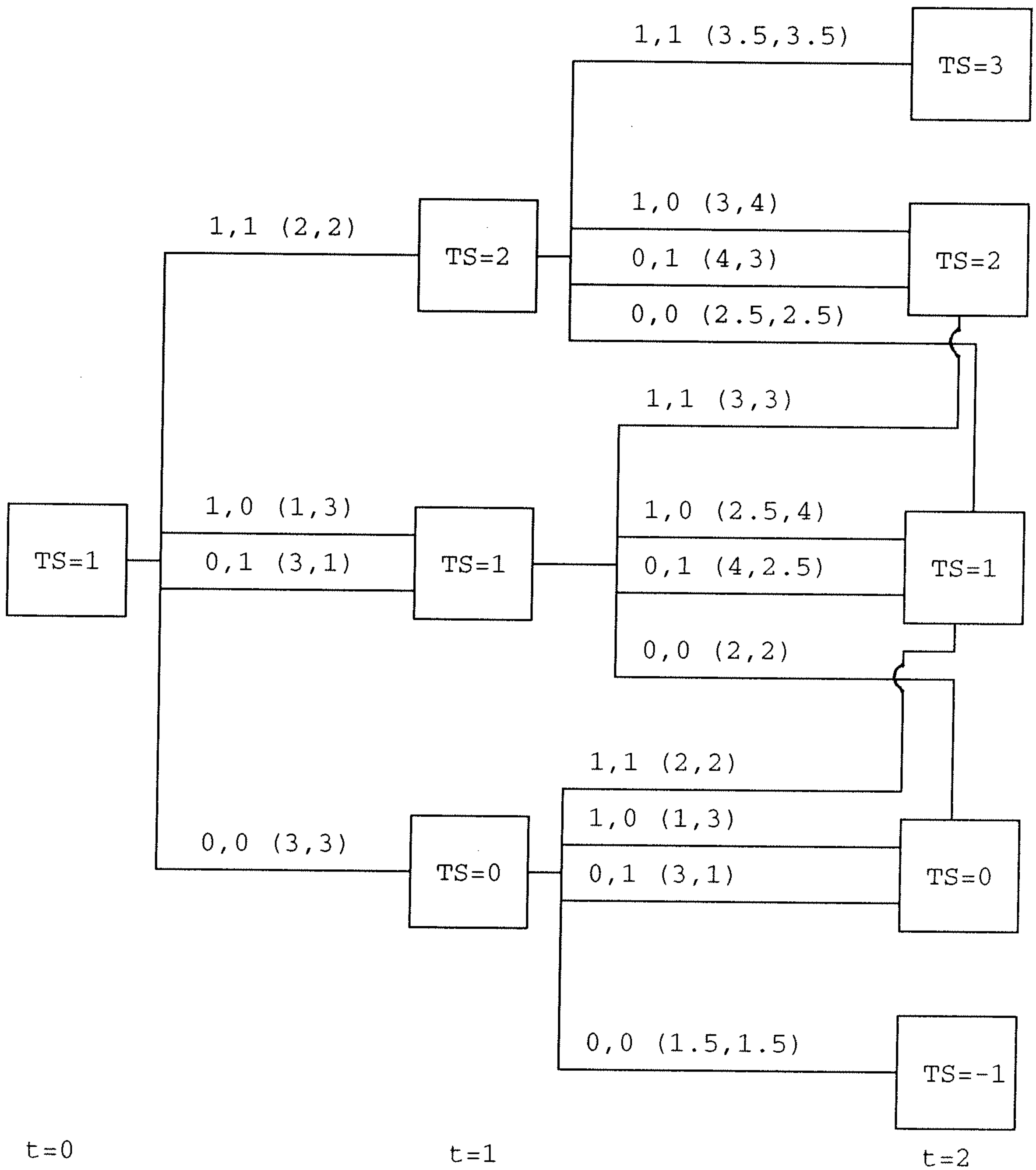
The firms' common technology level depends on their investment behaviour. We assume that the two firms have a common TS=1 at time t=0. When both firms invest at time t=0, they will have a common TS=2 at time t=1; When only one firm invests at time t=0, the two firms will have a common TS=1 at time t=1; When no firm invests at time t=0, the two firms will have a common TS=0 at time t=1. The same principle applies for TS at t=1 (the second stage). When a firm invests, some specific knowledges may be only available to that firm, depending on the legal system (such as patent law) and the firm's relationship with others. This specific knowledge will affect the payoffs that the firm gets from its investment. A two-stage game is shown in Figure 4.1. The net payoffs (profits) of firms are indicated in brackets, and their strategy is presented by 1 or 0 before the bracket.

A firm's profit from its investment is determined by the legal system, its relative competitive position, and the relationship between firms. In the following analysis, it is shown that those variables are important. Some of them are amenable to empirical modelling in chapter 5.

4.2.1 The Basic Case

Suppose that the two firms produce similar products independently for the domestic market. A firm's investment may lead to a high common technological level. The payoff from the investment is affected by the legal system, the patent law in particular. Therefore, the legal system influences the firm's investment decision. We will discuss two sub-cases. One is without an effective legal system and another with an effective legal system. With an effective legal system, the result from a firm's investment is protected for a certain period, and the firm can get a higher payoff from its investment.

Figure 4.1 Two-Stage Game: Without an Effective Legal System



Notation: a, b (c, d)

a: action of firm 1 (a=0 do not invest or 1 invest)
b: action of firm 2 (b=0 or 1)
c: payoff for firm 1 (one-stage)
d: payoff for firm 2 (one-stage)

TS: the common technology level (state)

I. Without an Effective Legal System

In this case, the result of a firm's investment can be obtained by another firm at relatively low cost and high speed. The investment may enhance the common (average) technology level of the two firms, but does not guarantee a higher profit for the "invest" firm. The "invest" firm gets a lower payoff than the "do not invest" firm because of the cost of investment. The two-stage game is shown in figure 4.1. In the case that firm 1 invests and firm 2 does not invest at time t=0, firm 1 gets a net payoff of 1 while firm 2 gets a net payoff of 3. Their common technology level (state) is TS=1 at time t=1. When both firms do not invest at time 0, both get net payoffs of 3, but a common technology level of TS=0. Let us examine the firms' investment behaviours under both Closed-loop and Open-loop strategies.

Closed-Loop Strategy:

When deciding on its investment strategy, a firm analyzes what the profits are associated with different strategies. Such an analysis works in reverse, where the firm first analyzes its payoffs from different investment strategies at time t=1 (the second stage of the game) and, then it chooses the strategy which generates the highest profit; then, with the chosen strategy at the second stage, the firm will analyze its payoffs from different investment strategies at time t=0 (the first stage of the game) and chooses the investment strategy which generates the highest possible cumulative profit from both stages. At each stage, when analyzing its payoff the firm takes its opponent's reaction into consideration. Various possible cases arise according to the value of TS at the beginning of the second stage (t=1) or at the beginning of the first stage (t=0) as well as according to the branch considered for the continuity of the game. For example, at time t=1 and TS=2, there are two equilibrium investment strategies for firm 1 and firm 2: (invest, do not invest) and (do not invest, invest) with respective payoff of (3,4) and (4,3). As a result, when the two firms analyze their equilibrium strategies at t=0 (the first stage) they must consider two possible payoffs associated with the strategy (invest, invest), which are (5,6) and (6,5), the sum from both stages. The analysis is as follows

<u>At t=1</u> (the second stage):

Case 1: TS=2, the game's normal form is

		Firm 2: 0	Firm 2: 1
Firm 1	0	2.5, 2.5	**4, 3**
	1	**3, 4**	3.5, 3.5

There are two Nash Equilibria (3,4), (4,3)

Case 2: TS=1, the game's normal form is

		Firm 2: 0	Firm 2: 1
Firm 1	0	2, 2	**4, 2.5**
	1	**2.5, 4**	3, 3

There are two Nash Equilibria (2.5,4), (4,2.5)

Case 3: TS=0, the normal form of game is

		Firm 2: 0	Firm 2: 1
Firm 1	0	**1.5, 1.5**	3, 1
	1	1, 3	2, 2

There is one Nash Equilibrium (1.5,1.5)

At t=0 (the first stage), firms make investment decisions by examining four possible cases. This is due to two equilibrium strategies at TS=2 and two at TS=1 at the second stage (t=1), combining with possible strategies at the first stage generating 4 cases. Each case corresponds to one of the possible equilibria of the second stage game (t=1). The total payoffs are the sum of stage one and stage two on a particular branch. For example, in the case of both "invest" at the first stage, the sum of the payoff from the first stage and the second stage (two Nash Equilibrium strategies) is (5,6) and (6,5).

Case 1:

		Firm 2 0	1
Firm 1	0	4.5, 4.5	7, 3.5
	1	**5, 5.5**	6, 5

There is one Nash Equilibrium (5,5.5)

Case 2:

		Firm 2 0	1
Firm 1	0	4.5, 4.5	5.5, 5
	1	3.5, 7	6, 5

There is no Nash Equilibrium

Case 3:

		Firm 2 0	1
Firm 1	0	4.5, 4.5	7, 3.5
	1	5, 5.5	5, 6

There is no Nash Equilibrium

Case 4:

		Firm 2 0	1
Firm 1	0	4.5, 4.5	**5.5, 5**
	1	3.5, 7	5, 6

There is one Nash Equilibrium (5.5,5)

Therefore, there are two Closed-Loop Nash Equilibrium

Strategies: (1-0, 0-1) and (0-1,1-0) with payoff (5,5.5) and (5.5,5) respectively. These strategies give a common technology state TS=1 at t=2, which is the same as at time t=0. Therefore, there is no increase of technological level or increase of competitive advantage comparing to their competitors which are assumed to have a TS=1.

Open-Loop Nash Strategy:

By definition, an open-Loop Nash strategy is a strategy decided by a firm at t=0, without considering the possible feedback from its opponent's actions. In this case, we have the normal form of the game as follows.

		Firm 2			
		0-0	0-1	1-0	1-1
Firm 1	0-0	4.5, 4.5	6, 4	5, 3	7, 3.5
	0-1	4, 6	5, 5	5.5, 5	6, 4
	1-0	3, 5	5, 5.5	4.5, 4.5	6, 5
	1-1	3.5, 7	4, 6	5, 6	5.5, 5.5

There is no Nash equilibrium. In other words, there is no open-loop Nash strategy.

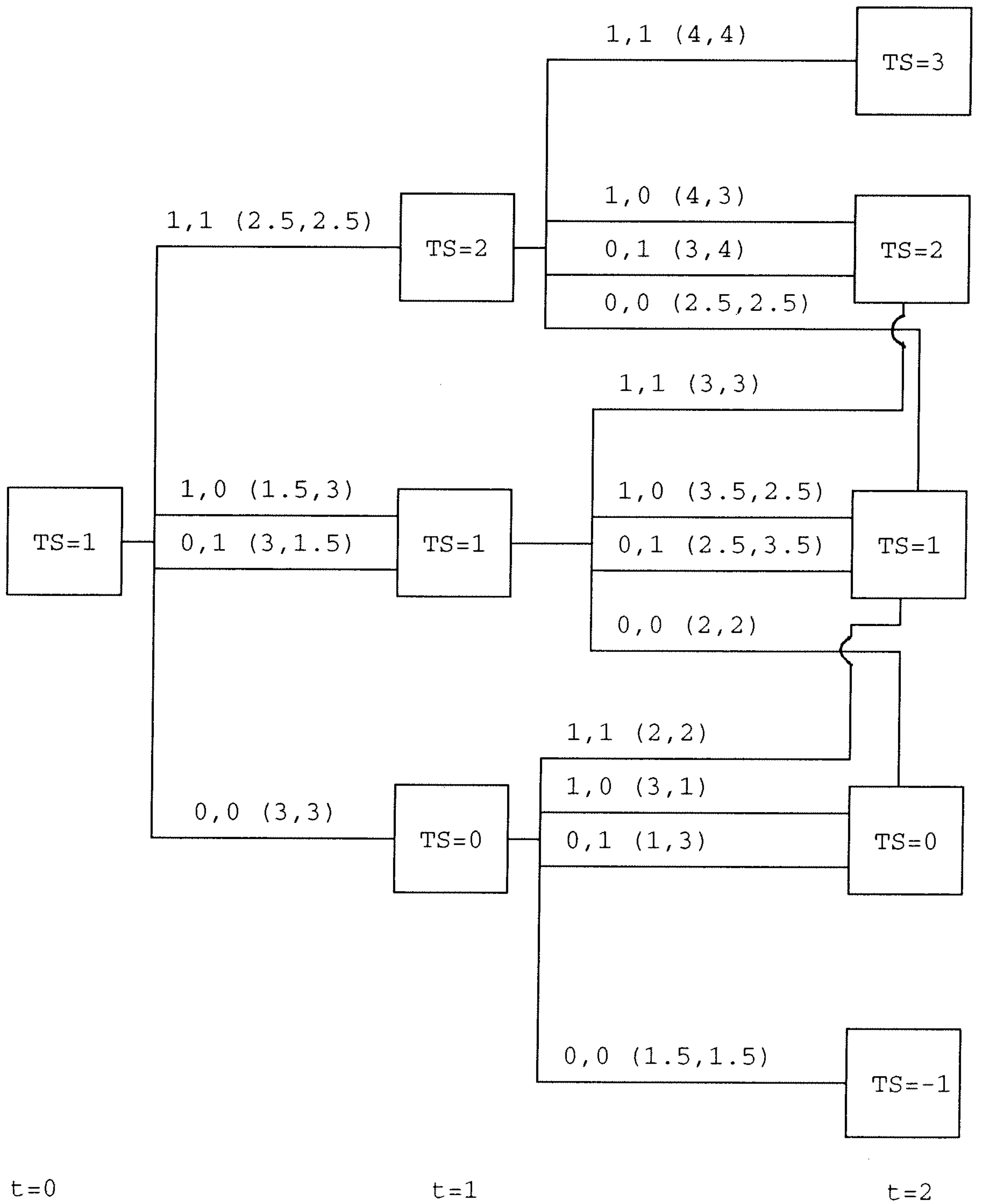
II. With an Effective Pro-Investment Legal System

As opposed to the above case, we assume that a firm's investment result cannot be obtained freely by another firm at a reasonable cost and speed. Payoffs associated with the game are changed accordingly, as indicated in brackets in figure 4.2. With an effective legal system, the "invest" firm has some specific knowledge from its investment and will, in the long-run, get a higher payoff than the "do not invest" firm. We assume the "invest" firm gets a lower net payoff than the "do not invest" firm at the first stage because of the cost of investment, but gets a higher payoff at the second stage because of its accumulated specific knowledge from the investment. For example, in the case of the strategy firm 1 "invest" and firm 2 "do not invest", at the first stage (t=0), firm 1 gets a payoff of 1.5 and firm 2 gets a payoff of 3; at the second stage, firm 1 gets a payoff of 3.5 while firm 2 gets a payoff of 2.5.

Closed-Loop Strategy:

As discussed above, when deciding on its investment strategy, a firm analyzes what are the profits associated with different strategies. Such an analysis works in reverse, where the firm first analyzes its payoffs from different investment strategies at time t=1 (the second stage of the game) and, then it chooses the strategy which generates the highest profit; then, with the chosen strategy at the second stage, the firm will analyze its payoffs from different investment strategies at time t=0 (the first stage of the game) and chooses the investment strategy which generates the highest possible sum profit from both stages.

Figure 4.2 Two-Stage Game: Firms with a Pro-Investment Legal System



At each stage, when analyzing its payoff the firm takes its opponent's reaction into consideration. Various possible cases arise according to the value of TS at the beginning of the second stage (t=1) or at the beginning of the first stage (t=0) as well as according to the branch considered for the continuity of the game. The analysis is as follows.

<u>At t=1</u>(the second stage):

Case 1: TS=2, the game's normal form is

		Firm 2: 0	Firm 2: 1
Firm 1	0	2.5, 2.5	3, 4
	1	4, 3	**4, 4**

There is one Nash Equilibrium (4,4)

Case 2: TS=1, the game's normal form is

		Firm 2: 0	Firm 2: 1
Firm 1	0	2, 2	2.5, 3.5
	1	3.5, 2.5	**3, 3**

There is one Nash Equilibrium (3,3)

Case 3: TS=0, the game's normal form is

		Firm 2: 0	Firm 2: 1
Firm 1	0	1.5, 1.5	1, 3
	1	3, 1	**2, 2**

There is one Nash Equilibrium (2,2)

At t=0 (the first stage), there is one case to be examined to determine each firm's strategy because each branch at the second stage has one equilibrium strategy. A firm examines its total payoff (sum of payoffs from two stages), associated with different strategies and chooses the one which provides the highest possible payoff.

		Firm 2: 0	Firm 2: 1
Firm 1	0	**5, 5**	6, 4.5
	1	4.5, 6	**6.5,6.5**

There are two Nash Equilibria (5,5) and (6.5,6.5)

Therefore, there are two Closed-Loop Nash equilibrium strategies: (0-1,0-1) and (1-1,1-1), with payoffs (5,5) and (6.5,6.5) and an average technology level TS=1, 3 at time t=2 respectively. If the two firms are rational, they will choose the strategy (1-1,1-1), which gives a higher payoff and a higher common technology level at time t=2 than t=0.

Open-Loop Nash Strategy:

As discussed above, an open-Loop Nash strategy is a strategy decided by a firm at t=0, without considering the possible feedback from its opponent's actions. We have the normal form of the game as follows.

		Firm 2			
		0-0	0-1	1-0	1-1
Firm 1	0-0	4.5, 4.5	4, 6	5, 3.5	5.5, 5
	0-1	6, 4	**5, 5**	6.5, 4	6, 4.5
	1-0	3.5, 5	4, 6.5	5, 5	5.5, 6.5
	1-1	5, 5.5	4.5, 6	6.5, 5.5	**6.5, 6.5**

There are two Open-loop Nash equilibrium strategies (0-1,0-1) and (1-1,1-1). These strategies give the respective payoffs (5,5) and (6.5,6.5), and generate average technology levels TS=1 and 3 at time t=2. They are the same as in the Closed-loop strategy cases. For rational firms, they will choose the strategy (1-1,1-1) and get a high payoff and technological progress.

4.2.2 The Case of Exposing Firms to External Competitive Pressures

With increasing globalization, firms produce products not only for domestic markets but also for exports. At the same time, foreign goods may also be imported. Exports provide firms with opportunities to participate in international competition. Imports may also expose domestic firms to international competition indirectly because of various tariff and non-tariff barriers.

Two cases will be examined to illustrate the effect of exports under different external competitive pressures in export markets and the effect of cooperation between firms due to their financial relationship. First, we will examine the case where the two firms do not establish a cooperative relationship. Secondly, we analyze the case where the two firms have a cooperative relationship. The cooperative relationship[2] may result from the direct financial relationship between firms, or from a bank's financial involvement in two firms. As defined in the beginning of this section, cooperation between firms is in the sense that the two firms make use of their complementary technologies so that they can get a higher economic return (payoff) from a given investment than in the noncooperative case. Their production decisions continue to be made independently. We assume that an effective pro-investment legal system is in place.

4.2.2.1 Two Firms having no Cooperative Relationship

Suppose that the two firms act independently when they face external competitive pressures. We will examine the firm's investment behaviour in two sub-cases: when firms face high competitive pressure and when they face low competitive pressure.

I. When Firms face high competitive Pressure

[2] The cooperative relationship here means a long term relationship, which is normally sustained by two firms' financial relationship.

In this case, both firms actively engage in international market through exports. They face high competition in the export market, i.e. with competitors having a TS=2 as opposed to TS=1 assumed before. Payoffs from various investment strategies differ accordingly from the basic case with a pro-investment legal system in section 4.2.1 (figure 4.2). As shown in figure 4.3, for a given investment strategy, a firm gets a lower payoff if it has a low technology state, and the same payoff if it has a relatively high technology state. For example, when the two firms have a common technology state of TS=2, they have the same payoffs as in figure 4.2 (i.e. on the top branch of the game). When the two firms have a common technology level lower than TS=2, their payoffs are adjusted downwards to reflect their comparative disadvantage with respect to their competitors. When the firms' common technology state is less than 1, investment will not increase but reduce the payoff, as shown at the bottom part of figure 4.3. This reflects the fact that investment will be costly, but will not raise the technology state enough to give the firm an advantage over outside competitors.

Closed-Loop Strategy:

As discussed above, when deciding on its investment strategy, a firm analyzes what are the profits associated with different strategies. Such an analysis works in reverse, where the firm first analyzes its payoffs from different investment strategies at time t=1 (the second stage of the game) and, then it chooses the strategy which generates the highest profit; then, with the chosen strategy at the second stage, the firm will analyze its payoffs from different investment strategies at time t=0 (the first stage of the game) and chooses the investment strategy which generates the highest possible cumulative profit from both stages. At each stage, when analyzing its payoff the firm takes its opponent's reaction into consideration. Various possible cases arise according to the value of TS at the beginning of the second stage (t=1) or at the beginning of the first stage (t=0) as well as according to the branch considered for the continuity of the game.

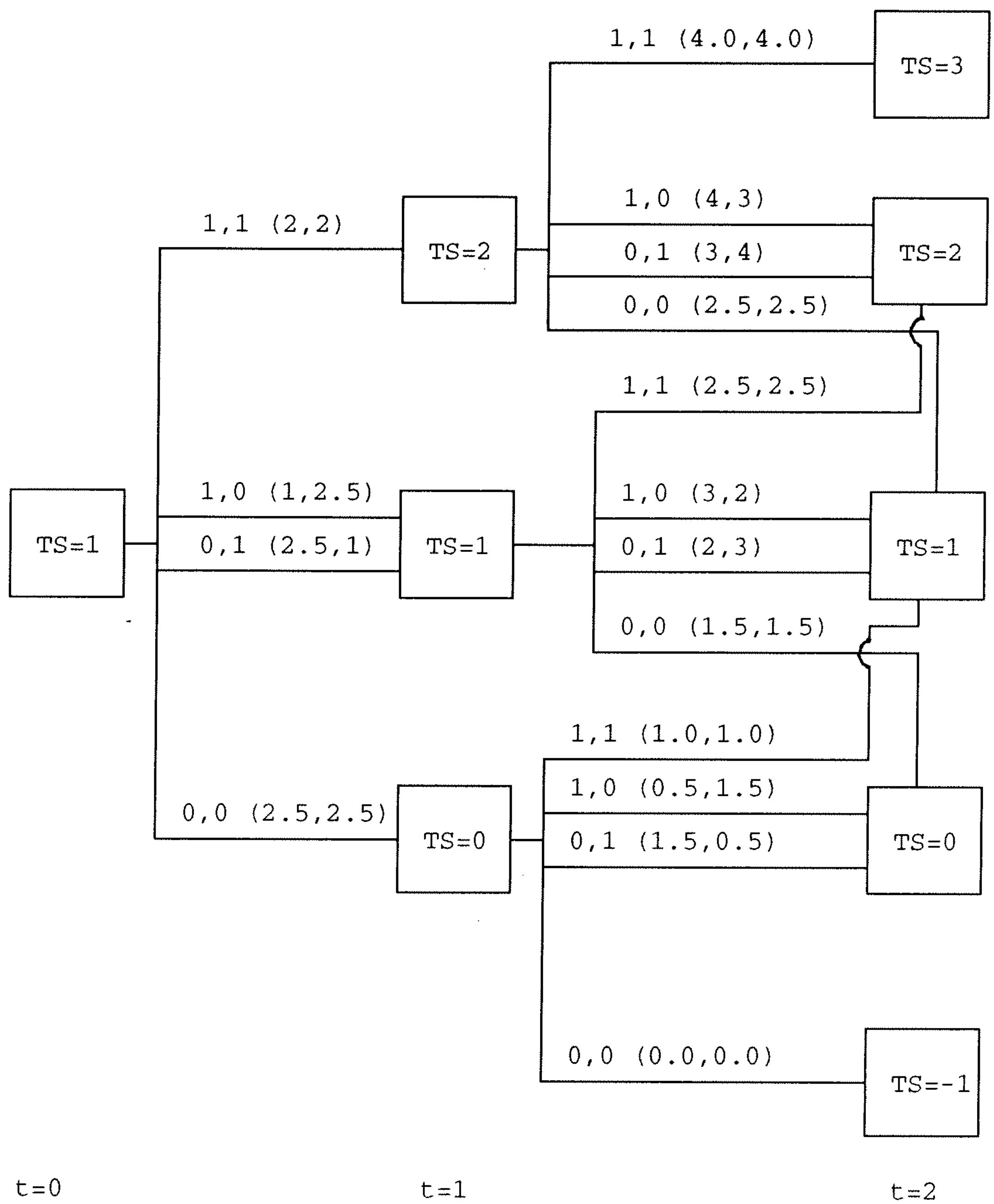
At t=1 (the second stage):

Case 1: TS=2:

		Firm 2: 0	Firm 2: 1
Firm 1	0	2.5, 2.5	3, 4
	1	4, 3	**4, 4**

There is one Nash Equilibrium (4,4)

Figure 4.3 Two-Stage Game: Independent Firms Facing High Competitive Pressure



Case 2: TS=1:

		Firm 2: 0	Firm 2: 1
Firm 1	0	1.5,1.5	2,3
	1	3,2	**2.5,2.5**

There is one Nash Equilibrium (2.5,2.5)

Case 3: TS=0:

		Firm 2: 0	Firm 2: 1
Firm 1	0	0, 0	**1.5, 0.5**
	1	**0.5, 1.5**	1.0, 1.0

There are two Nash Equilibria (1.5,0.5) and (0.5,1.5)

At t=0, firms make decision based on the following two cases.

Case 1:

		Firm 2: 0	Firm 2: 1
Firm 1	0	3, 4	5, 3.5
	1	3.5, 5	**6, 6**

There is one Nash Equilibrium (6,6) with TS=3 at t=2

Case 2:

		Firm 2: 0	Firm 2: 1
Firm 1	0	4, 3	5, 3.5
	1	3.5, 5	**6, 6**

There is one Nash Equilibrium (6,6) with TS=3 at t=2.

Therefore, there is one closed-loop Nash equilibrium strategy (1-1, 1-1). This equilibrium strategy provides the two firms with a payoff of (6,6), and enhances the common technology level to TS=3 at time t=2. Therefore, the two firms have a high technological progress.

<u>Open-Loop Strategy:</u>

As discussed above, an open-Loop Nash strategy is a strategy decided by a firm at t=0, without considering the possible feedback from its opponent's actions. We have the normal form of the game as follows.

		Firm 2			
		0-0	0-1	1-0	1-1
Firm 1	0-0	2.5, 2.5	4, 3	4, 2.5	4.5, 4
	0-1	3, 4	3.5, 3.5	5.5, 3	5, 3.5
	1-0	2.5, 4	3, 5.5	4.5, 4.5	5, 6
	1-1	4, 4.5	3.5, 5	6, 5	**6, 6**

There is one open-loop Nash equilibrium (1-1,1-1) with a payoff of (6,6) and TS=3 at time t=2.

Therefore, being actively exposed to a highly competitive market, a firm will have a high equilibrium investment. This high technology investment generates a relatively high technological progress.

II. When Firms face Relatively Low Competitive Pressure

Suppose firms export to a market where there are less competitive suppliers. That is, the competitors have a technology level lower than TS=1. This may be due to the fact that the two firms have advanced technologies or resource endownment advantages. Accordingly, the two-stage game has adjusted payoffs as shown in figure 4.4, compared to payoffs in figure 4.2. When the two firms have a common technology state TS≥1, their payoffs are the same or adjusted upwards because of increasing market shares without occurring extra costs; when the two firms have a common technology state TS<1, their payoffs are the same or adjusted downwards because of high competitive pressure.

Closed-Loop Strategy:

As discussed above, when deciding on its investment strategy, a firm analyzes what are the profits associated with different strategies. The analysis works backwards. The firm first analyzes its payoffs from different investment strategies at time t=1 (the second stage of the game) and chooses the strategy which generates the highest profit; then, with the chosen strategy at the second stage, the firm will analyze its payoffs from different investment strategies at time t=0 (the first stage of the game) and chooses the investment strategy which generates the highest possible sum profit from both stages. At each stage, when analyzing its payoff the firm takes its opponent's reaction into consideration. Various possible cases arise according to the value of TS at the beginning of the second stage (t=1) or at the beginning of the first stage (t=0) as well as according to the branch considered for the continuity of the game.

At t=1 (the second stage):

Case 1: TS=2:

		Firm 2: 0	Firm 2: 1
Firm 1	0	3, 3	3.5, 4.5
	1	4.5, 3.5	**4.5, 4.5**

There is one Nash Equilibrium (4.5,4.5)

Case 2: TS=1:

		Firm 2: 0	Firm 2: 1
Firm 1	0	2.0,2.0	3.5,4.5
	1	4.5,3.5	**4.0,4.0**

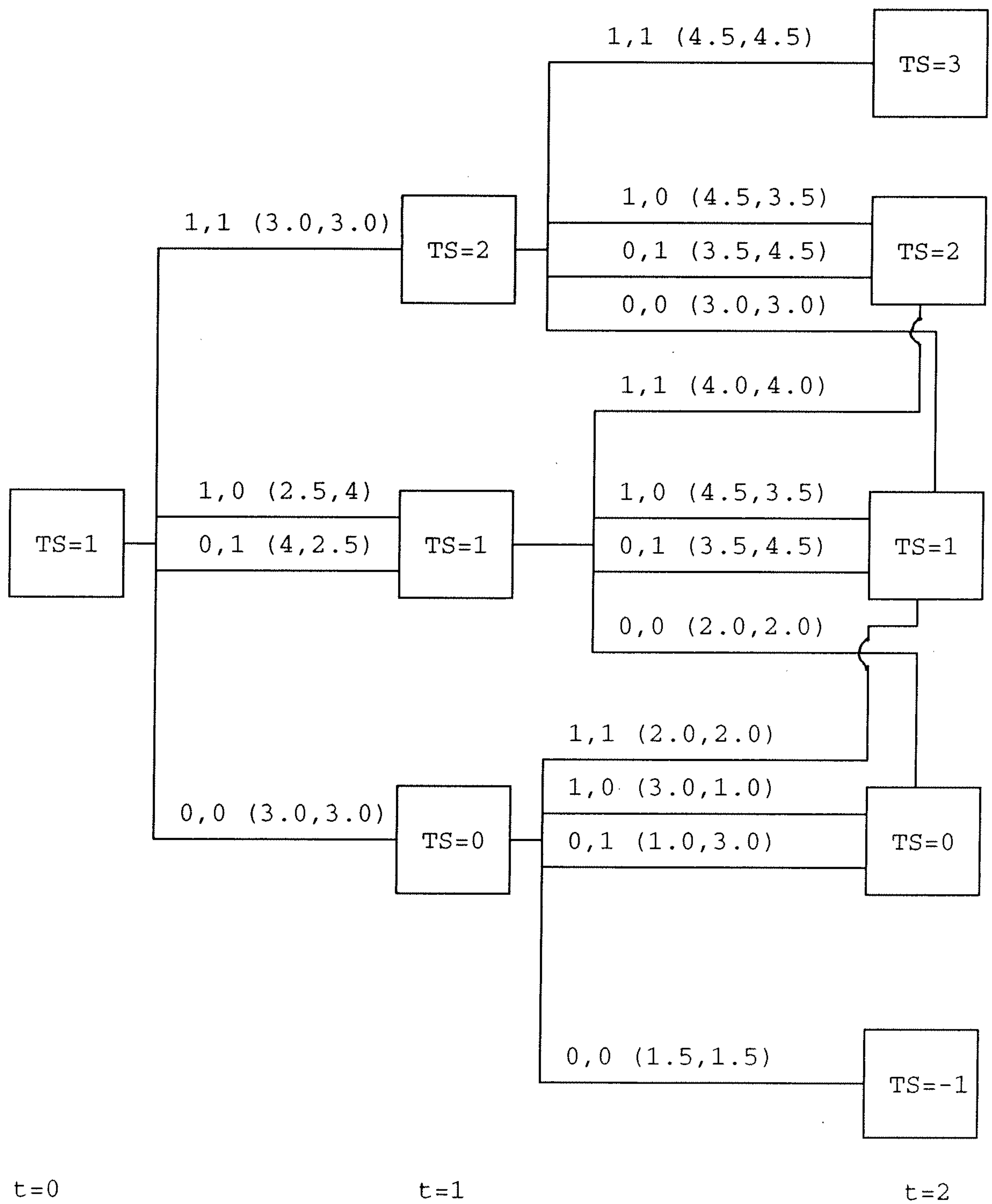
There is one Nash Equilibrium (4.0,4.0)

Case 3: TS=0:

		Firm 2: 0	Firm 2: 1
Firm 1	0	1.5, 1.5	1, 3.0
	1	3.0, 1	**2.0, 2.0**

There is one Nash Equilibrium (2.0,2.0)

Figure 4.4 Two-Stage Game: Independent Firms Facing Low Competitive Pressure



At t=0, firms make investment decisions by examining the following case:

		Firm 2	
		0	1
Firm 1	0	5, 5	**8, 6.5**
	1	**6.5, 8**	7.5, 7.5

There are two Nash Equilibria (8,6.5) and (6.5,8) with TS=2 at t=2

Therefore, there are two Closed-loop Nash equilibrium strategies (1-1,0-1) and (0-1,1-1). These equilibrium strategies provide firms with a respective payoff of (6.5,8) and (8,6.5), and generate a common technology level of TS=2 at time t=2 which is lower than the case where firms export to a highly competitive market.

Open-Loop Strategy:

As discussed above, an open-Loop Nash strategy is a strategy decided by a firm at t=0, without considering the possible feedback from its opponent's actions. We have the normal form of the game as follows.

		Firm 2			
		0-0	0-1	1-0	1-1
Firm 1	0-0	4.5, 4.5	4, 6	6, 4.5	7.5, 7
	0-1	6, 4	5, 5	8.5, 6	**8, 6.5**
	1-0	4.5, 6	6, 8.5	6, 6	6.5, 7.5
	1-1	7, 7.5	**6.5, 8**	7.5, 6.5	7.5, 7.5

There are two open-loop Nash equilibrium strategies (1-1,0-1) and (0-1, 1-1). These strategies provide firms with payoffs (8,6.5) and (6.5,8), and generate a common technology level of TS=2 at time t=2 which is lower than when firms export to a highly competitive market.

The analysis of the above two sub-cases shows that under relatively high competitive pressure firms choose a higher equilibrium investment.

4.2.2.2 Firms Having a Cooperative Relationship

In this increasingly globalized world, firms often pursue cooperative relationships in order to use their complementary technologies and increase their investment efficiency. As defined above, their production decisions continue to be made independently. Cooperation between firms may be secured by their direct financial interpenetration or by financial interpenetration through banks which have long-term financial relationships with both firms. We will discuss two sub-cases which can be compared to the noncooperative cases examined in section 4.2.2.1.

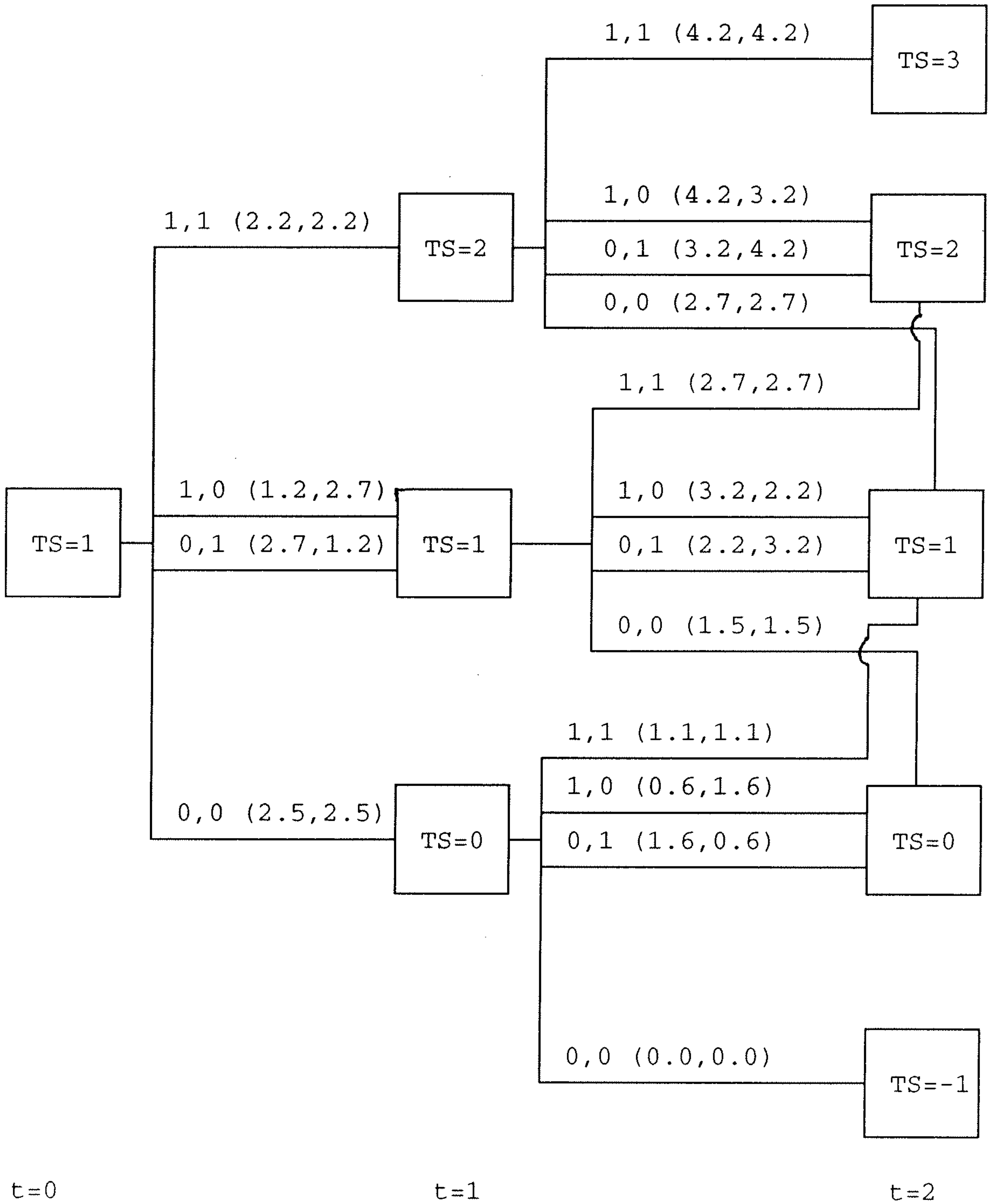
I. When Firms Face High Competitive Pressure

Suppose that two firms export to a strongly competitive market and face high competitive pressure from imports as well. That is, the competitors have a high technology level (TS≥2). The two firms may act jointly and make good use of their complementary technologies. Given that two firms are in closely related businesses, this joint effort will increase their investment efficiency and competitiveness. As a result, for a given investment, cooperative firms will get higher payoffs than noncooperative firms. Adjusted payoffs can be seen in figure 4.5, and are relatively higher compared to figure 4.3 (the noncooperative case). For example, for the strategy of both "invest" at the first stage, the two firms get a payoff of 2.2 in the cooperative case and 2 in the noncooperative case (see figure 4.3).

Closed-Loop Strategy:

When deciding on its investment strategy, a firm analyzes what are the profits associated with different strategies. The analysis works backwards. The firm first analyzes its payoffs from different investment strategies at time t=1 (the second stage of the game) and chooses the strategy which generates the highest profit; then, with the chosen strategy at the second stage, the firm will analyze its payoffs from different investment strategies at time t=0 (the first stage of the game) and chooses the investment strategy which generates the highest possible cumulative profit from both stages.

Figure 4.5 Two-Stage Game: Firms Act Cooperatively When Facing High Competitive Pressure



At each stage, when analyzing its payoff the firm takes its opponent's reaction into consideration. Various possible cases arise according to the value of TS at the beginning of the second stage (t=1) or at the beginning of the first stage (t=0) as well as according to the branch considered for the continuity of the game.

<u>At t=1</u> (the second stage):

Case 1: TS=2, the game's normal form is

		Firm 2: 0	Firm 2: 1
Firm 1	0	2.7, 2.7	3.2, 4.2
	1	4.2, 3.2	**4.2, 4.2**

There is one Nash Equilibrium (4.2,4.2)

Case 2: TS=1, the game's normal form is

		Firm 2: 0	Firm 2: 1
Firm 1	0	1.5, 1.5	2.2, 3.2
	1	3.2, 2.2	**2.7, 2.7**

There is one Nash Equilibrium (2.7,2.7)

Case 3: TS=0, the normal form of the game is

		Firm 2: 0	Firm 2: 1
Firm 1	0	0, 0	**1.6, 0.6**
	1	**0.6, 1.6**	1.1, 1.1

There is two Nash Equilibria (1.6,0.6) and (0.6,1.6).

At t=0, firms make investment decisions by examining the following two cases:

Case 1:

		Firm 2	
		0	1
Firm 1	0	3.1, 4.1	5.4, 3.9
	1	3.9, 5.4	**6.4,6.4**

There is one Nash Equilibrium (6.4,6.4)

Case 2:

		Firm 2	
		0	1
Firm 1	0	4.1, 3.1	5.4, 3.9
	1	3.9, 5.4	**6.4,6.4**

There is one Nash Equilibrium (6.4,6.4)

Therefore, there is one Closed-Loop Nash equilibrium strategy (1-1, 1-1). This strategy provides the two firms with a payoff of (6.4,6.4), and generates a common technology level of TS=3 at time t=2.

Open-Loop Nash Strategy:

An open-Loop Nash strategy is a strategy decided by a firm at t=0, without considering the possible feedback from its opponent's actions. We have the normal form of the game as follows.

		Firm 2			
		0-0	0-1	1-0	1-1
Firm 1	0-0	2.5,2.5	4.1,3.1	4.2,2.7	4.9,4.4
	0-1	3.1,4.1	3.6,3.6	5.4,3.9	5.4,3.9
	1-0	2.7,4.2	3.4,5.9	4.9,4.9	5.4,6.4
	1-1	4.4,4.9	3.9,5.4	6.4,5.4	**6.4,6.4**

There is one open-loop Nash equilibrium strategy (1-1,1-1). This strategy provides the two firms with a payoff of (6.4,6.4), and generates a common technology level of TS=3 at time t=2.

II. When Firms Face Relative Low Competitive Pressure

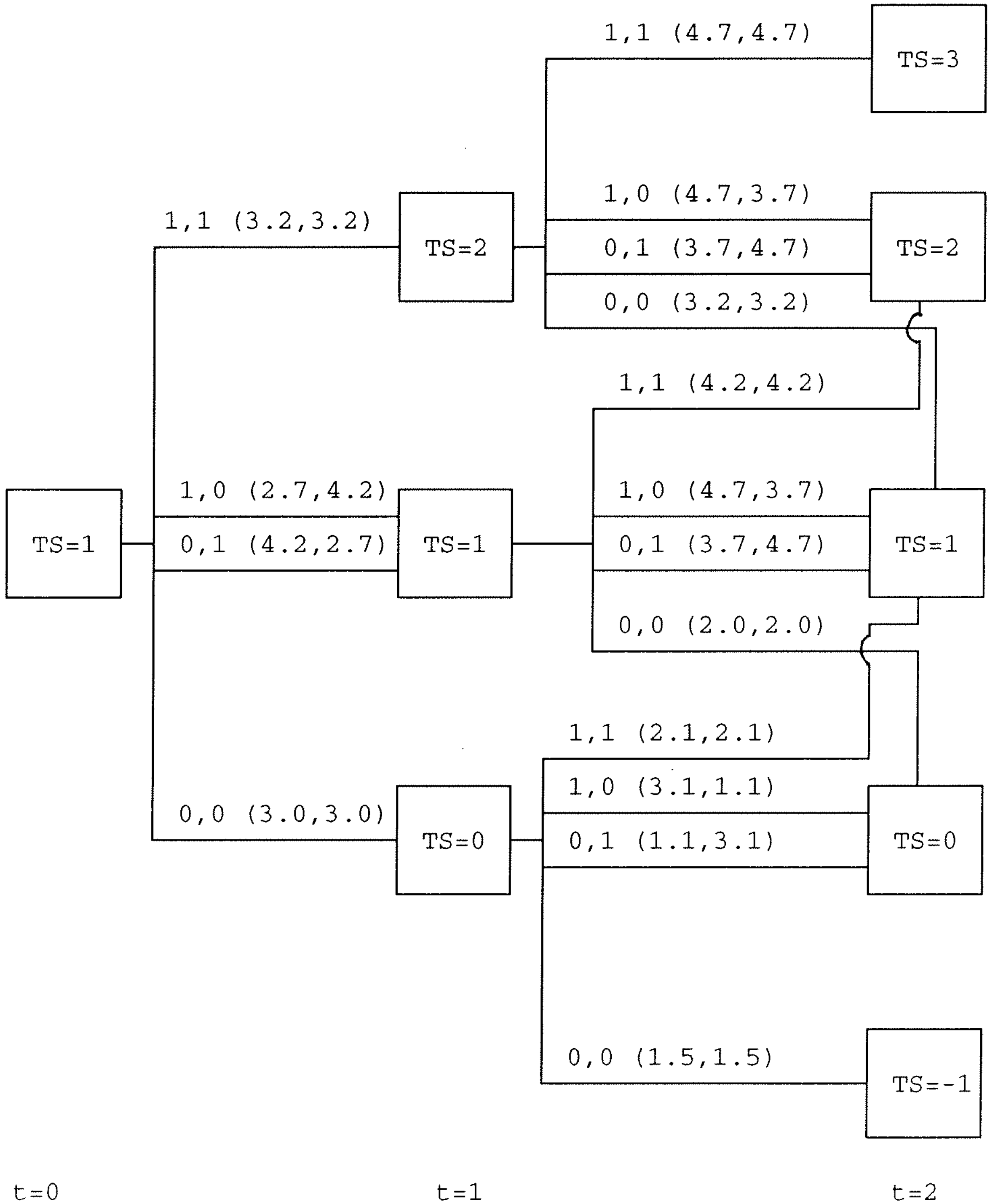
Suppose that the two firms export to a less competitive market and face low competitive pressure. In other words, the competitors have a low technology level (their TS being less than 1 in our formulation). For a given investment, two cooperative firms will get higher payoffs than the noncooperative firms because of the use of some complementary technologies. Therefore, payoffs in the game are adjusted upwards as shown in figure 4.6, compared to payoffs in figure 4.4 for the noncooperative case. For example, for the strategy of both "invest" at the first stage, the cooperative firms have a payoff of 3.2 while the noncooperative firms have a payoff of 3.0. However, low competitive pressure implies that firms feel less pressed to invest as efficiently as in the case of high competitive pressure[3].

Closed-Loop Strategy:

When deciding on its investment strategy, a firm analyzes what are the profits associated with different strategies. Such an analysis works in reverse, where the firm first analyzes its payoffs from different investment strategies at time t=1 (the second stage of the game) and, then it chooses the strategy which generates the highest profit; then, with the chosen strategy at the second stage, the firm will analyze its payoffs from different investment strategies at time t=0 (the first stage of the game) and chooses the investment strategy which generates the highest possible cumulative profit from both stages. At each stage, when analyzing its payoff the firm takes its opponent's reaction into consideration. Various possible cases arise according to the value of TS at the beginning of the second stage (t=1) or at the beginning of the first stage (t=0) as well as according to the branch considered for the continuity of the game.

[3]By activation theory, organisms are subject to environmental stimulation which arouses them to various degrees. The greater the level of environmental stimulation, the higher will be the organism's arousal level. Either too little or too much stimulation will not arouse the organism to perform a task effectively. Too little stimulation does not provide enough incentive, while too much causes anxiety and counter productive behaviour. This is appliable to a firm in its effort to efficiently and optimally invest in both hardware and software technologies.

Figure 4.6 Two-Stage Game: Firms Act Cooperatively When Facing Relatively Low Competitive Pressure



<u>At t=1</u> (the second stage):

Case 1: TS=2, the game's normal form is

		Firm 2: 0	Firm 2: 1
Firm 1	0	3.2,3.2	3.7,4.7
	1	4.7,3.7	**4.7,4.7**

There is one Nash Equilibrium (4.7,4.7)

Case 2: TS=1, the game's normal form is

		Firm 2: 0	Firm 2: 1
Firm 1	0	2.0,2.0	3.7,4.7
	1	4.7,3.7	**4.2,4.2**

There is one Nash Equilibrium (4.2,4.2)

Case 3: TS=0, the game's normal form is

		Firm 2: 0	Firm 2: 1
Firm 1	0	1.5,1.5	1.1,3.1
	1	3.1,1.1	**2.1,2.1**

There is one Nash Equilibrium (2.1,2.1)

At t=0, firms make investment decisions by examining the following case:

		Firm 2: 0	Firm 2: 1
Firm 1	0	5.1,5.1	**8.4,6.9**
	1	**6.9,8.4**	7.9,7.9

There are two Nash Equilibria (6.9,8.4) and (8.4,6.9).

Therefore, there are two Closed-Loop Nash equilibrium strategies (1-1,0-1) and (0-1,1-1). These strategies provide payoffs (6.9.8.4),(8.4,6.9) and generate a common technology level of TS=2 at time t=2.

Open-Loop Nash Strategy:

An open-Loop Nash strategy is a strategy decided by a firm at t=0, without considering the possible feedback from its opponent's actions. We have the normal form of the game as follows.

		Firm 2			
		0-0	0-1	1-0	1-1
Firm 1	0-0	4.5,4.5	4.1,6.1	6.2,4.7	7.9,7.4
	0-1	6.1,4.1	5.1,5.1	8.9,6.4	**8.4,6.9**
	1-0	4.7,6.2	6.4,8.9	6.4,6.4	6.9,7.9
	1-1	7.4,7.9	**6.9,8.4**	7.9,6.9	7.9,7.9

There exist two Nash equilibrium strategies (0-1,1-1) and (1-1,0-1). These strategies provide firms with payoffs (8.4,6.9) and (6.9,8.4) and generate a common technology level of TS=2 at time t=2.

Comparison of the above two sub-cases (in this subsection) shows that two cooperative firms choose lower equilibrium investments under low competitive pressure than under high competitive pressure. Given that the two firms have closely related complementary technologies, firms get higher payoffs from a given investment in the cooperative case than in the noncooperative case.

4.2.3 Summary

Using six cases, we examined the effect of the simplified legal system, the exposure of firms to external competitive pressure (exports), the competitive position of firms in a market, and the cooperative relationship between firms due to their financial relationship. Two strategies were considered when we made the analysis: Closed-loop and Open-loop Nash strategies. These factors all affect the investment behaviours of firms, and in turn, their technological progress.

The results are summarized in table 4.1. The common technology levels of the two firms at time t=2 are given for both a Closed-loop and a Open-loop Nash strategy. The table also gives the result after rational firms eliminate less efficient or less profitable strategies.

Effective patent law encourages a firm's investment, and in turn enhances technological progress for firms. The exposure of firms to high external competitive pressure increases their equilibrium investments and technological progress; Under high competitive pressure, cooperation between firms tends to increase their technology investments, whereas under low competitive pressure, the cooperation does not enhance their technology investments or technological

Table 4.1 Average Equilibrium Technology Level at t=2 with Closed-loop and Open-loop Nash Strategies under different market conditions and environments at t=0 (TS=1), **in the case of 2 symmetric firms**

	Basic Case With Legal System Not Effect	**Basic Case** With Legal System Effective	**No Cooperat Relat.** With Pressure High	**No Cooperat Relat.** With Pressure Low	**With Cooperat Relat.** With Pressure High	**With Cooperat Relat.** With Pressure Low
Close-loop Nash Strategy:						
Number of Equil. Strategies	2	2	1	2	1	2
TS	1	1,3	3	2	3	2
After Elimination of less efficient strategies:						
Number of Equil. Strategies	2	1	1	2	1	2
TS	1	3	3	2	3	2
Open-Loop Nash Strategy:						
Number of Equil. Strategies	0	2	1	2	1	2
TS		1,3	3	2	3	2
After Elimination of less efficient strategies:						
Number of Equil. Strategies	0	1	1	2	1	2
TS		3	3	2	3	2

progress. Given that two firms have closely related complementary technologies, they get higher payoffs from a given investment in the cooperative case than in the noncooperative case.

It is worth mentioning that investment here means an aggregate, optimal investment in both hardware and software technologies. An increase in the common technology level of firms in our formulation is relevant to a decrease in the average cost of firms. In the case of an industrial sector, the increase in the common technology level is closely related to the reduction in the sector's production cost.

With a simple discrete, two-stage game, we examined six cases. The simplified model helps us to understand the mechanisms that explain the decisions of firms, and may help interpret what is going on in the real world. Many more cases can be analyzed in the same way, but the process is repetitious. In order to overcome this shortcoming, we will continue our analysis with a simple, continuous-time model in the next section (4.3), which parameterizes the economic and institutional environment variables.

4.3 A Simple Two-Period Investment Game

The six two-stage games analysed in section 4.2 have illustrated some important factors in technology investment decisions taken by firms. These games have also helped understand the mechanisms that explain decisions of firms. As a complement to the model in section 4.2, in this section, a simplified two-period model[1] is used to analyze these effects parametrically, and focus on more specific issues.

In order to simplify the analysis, focus will be maintained on the two-firm case. Hardware and software technologies are aggregated into a single variable, but the externality resulting from the complementarity of two technologies between firms is taken into account in the analysis. We analyze the impact of a simplified legal system, the effects of financial interpenetrations, as well as exports on technology investment.

With increasing globalization, the price of a firm's product is determined by current supply and demand conditions in both domestic and external markets. Suppose that there are two firms in an industry which produce similar products and, the output price is determined as follows.

$$p = (a_1 - b_1 Q) + (a_2 - b_2 Z) - \phi(LP^f/LP) = a - bQ$$

[1]The problem formulation here is similar to D'Aspremont and Jacquemin (1988), which discusses the effect of cooperative and noncooperative R&D in duopoly with spillovers.

Where

- p - output price
- LP - the average productivity level of the two domestic firms
- Q - total supply of the two firms, $Q=q_1+q_2$
- Z - supply from firms in other countries
- LP^f - the average productivity level for firms in other countries
- a_1, a_2, b_1, b_2, ϕ are positive coefficients
- $a = a_1 + a_2 - b_2Z - \phi(LP^f/LP)$, $b=b_1$

That is, output price is determined by three parts: the domestic market condition (a_1-b_1Q), the export market condition (a_2-b_2Z), and the relative productivity level of domestic and foreign firms $(\phi(LP^f/LP))$

Suppose that a firm's decision is made in two stages. At the first stage, it decides on how much it will invest, and, at the second stage, it decides how much it will produce.

A firm's investment is to upgrade its technology, and reduce its cost of production. The investment exerts an externality to the other firm. This externality, due to technology complementarities, depends on how closely related the two firms' production technologies are and on whether the two firms have a close relationship such as cooperation.

In the following analysis, it is assumed that cooperation between firms results from and is secured by either their direct financial relationship or indirect relationship through a central coordinator such as a bank. In the following discussion, we will define the direct financial relationship between two firms as **financial interpenetration between firms**, and the indirect financial relationship between firms through a third party such as a bank as **financial interpenetration between firms and banks**. When the term (firms') financial interpenetration is used alone, it refers to both types of financial interpenetrations.

It is assumed that an effective legal system is in place. Such a legal system protects the results of a firm's innovation, resulting in higher profits for the firm, for a period of T. However, the protection can not prevent certain spillovers due to imperfections in the legal system as well as certain properties of innovation. To reduce the complexity, the second stage is assumed to consist of T (sub-)periods of production with the same output for each sub-period. Both noncooperative and cooperative behaviours are examined in the following analysis.

Assuming that two firms generate investment and technology externalities toward each other, the spillover coefficient is defined as $\beta=\beta_0$ when the two firms have no financial interrelationship. However, when the two firms have a financial relationship, the spillover coefficient is defined as $\beta=\beta_0+\beta_a$, where β_a is the externality coefficient between firms resulting from their financial relationship.

Furthermore, cooperation between firms, due to their financial relationship, could also change their investment efficiency. An increase in investment efficiency means that it costs a firm less to get a certain reduction of its production cost. When financial relationship makes two technology related firms cooperate, their investment efficiency may be higher. Also, under high competitive pressure, firms may be more efficient in their use of given investment resources, which is equivalent to increasing investment efficiency.

The profit for firm i is composed of three parts: revenue from its product sales in T sub-periods discounted to period one, $y(a-bQ)q_i$, minus production cost in T sub-periods discounted to period one, $y(A-X_i-\beta_i X_j)q_i$, and minus the investment cost at the first stage (period 1), $\gamma X_i^2/2$. That is, the profit for firm i is

$$\begin{aligned}\pi_i &= \sum_{n=1}^{n=T} \delta^n [(a-bQ)q_i-(A-x_i-\beta_i x_j)q_i]-\gamma_i \frac{x_i^2}{2} \\ &= \frac{\delta-\delta^{T+1}}{1-\delta}[(a-bQ)q_i-(A-x_i-\beta_i x_j)q_i]-\gamma_i \frac{x_i^2}{2} \\ &= y[(a-bQ)q_i-(A-x_i-\beta_i x_j)q_i]-\gamma_i \frac{x_i^2}{2}\end{aligned}$$

Where

T - the protected sub-periods
δ - discount factor
$y = (\delta-\delta^{T+1})/(1-\delta)$, $y>1$ and $\partial y/\partial T>0$, $\partial y/\partial \delta>0$.
q_i - output of firm i
A_i - firm i's initial cost of production
x_i - investment in hardware and software technologies by firm i
x_j - investment in hardware and software technologies by firm j
β_i - spillover coefficient from firm j's investment
γ_i - cost coefficient for firm i's investment

Assume that $a>A_i>0$, $0<\beta_i<1$, $Q\le a/b$, $x_i+\beta_i x_j \le A_i$.

Two cases are considered. In the noncooperative case, the two firms make decisions independently. In the cooperative case, the two firms realize the importance of their investment externality and technology complementarity. As a result, they decide to cooperate on their investments, but to make independent production decisions at the second stage. In the following sections, we will examine the investment behaviours of firms, focusing on the Closed-loop Nash strategy.

4.3.1 Investment: The Noncooperative Case

Firms make independent decisions in both stages. Based on a Closed-loop strategy, a firm always incorporates its competitor's reaction in its decision-making. As a result, a firm's decision process is inversed: initially choosing its production or output level at the second stage, and subsequently making an investment decision at the first stage. Its output is determined by the following profit maximization problem.

$$\underset{[q_i]}{MAX}\{\pi_i = y[(a-bQ)q_i-(A_i-x_i-\beta_i x_j)q_i]-\gamma_i\frac{x_i^2}{2}\}$$

The first order condition gives, for firm i

$$q_i=\frac{(a-2A_i+A_j)+(2-\beta_j)x_i+(2\beta_i-1)x_j}{3b}$$

and, for firm j

$$q_j=\frac{(a-2A_j+A_i)+(2-\beta_i)x_j+(2\beta_j-1)x_i}{3b}$$

Substituting into the profit function, we get the problem for the first stage. For firm i:

$$\underset{[x_i]}{MAX}\{\pi_i = y[(a-bQ(x_i,x_j))q_i(x_i,x_j)-(A_i-x_i-\beta_i x_j)q_i(x_i,x_j)]-\gamma_i\frac{x_i^2}{2}\}$$

The first order conditions give:

$$[2(2-\beta_j)^2-9b\gamma_i/y]x_i+2(2-\beta_j)(2\beta_i-1)x_j=-2(2-\beta_j)(a-2A_i+A_j)$$

and

$$[2(2-\beta_i)^2-9b\gamma_j/y]x_j+2(2-\beta_i)(2\beta_j-1)x_i=-2(2-\beta_i)(a-2A_j+A_i)$$

The second order conditions require

$$(2-\beta_j)^2-4.5b\gamma_i/y<0$$
$$(2-\beta_i)^2-4.5b\gamma_j/y<0$$

Thus, we get firm i's investment

$$x_i^*=\frac{(2-\beta_i)(2-\beta_j)(2\beta_i-1)(a-2A_j+A_i)-(2-\beta_j)(a-2A_i+A_j)[(2-\beta_i)^2-4.5b\gamma_j/y]}{[(2-\beta_j)^2-4.5b\gamma_i/y][(2-\beta_i)^2-4.5b\gamma_j/y]-(2-\beta_i)(2-\beta_j)(2\beta_j-1)(2\beta_i-1)}$$

and, firm j's investment

$$x_j^*=\frac{(2-\beta_j)(2-\beta_i)(2\beta_j-1)(a-2A_i+A_j)-(2-\beta_i)(a-2A_j+A_i)[(2-\beta_j)^2-4.5b\gamma_i/y]}{[(2-\beta_i)^2-4.5b\gamma_j/y][(2-\beta_j)^2-4.5b\gamma_i/y]-(2-\beta_j)(2-\beta_i)(2\beta_i-1)(2\beta_j-1)}$$

<u>In the symmetric case</u>, with $A=A_i=A_j$, $\beta=\beta_i=\beta_j$, $\gamma=\gamma_i=\gamma_j$, we have

$$x_i^*=x_j^*=\frac{(a-A)(2-\beta)}{4.5b\gamma/y-(2-\beta)(1+\beta)}$$

$$Q^*=q_1^*+q_2^*=\frac{2(a-A)}{3b}\left[\frac{4.5b\gamma/y}{4.5b\gamma/y-(2-\beta)(1+\beta)}\right]$$

Where

$\beta = \beta_o$

The second order condition is

$$(2-\beta)^2-4.5b\gamma/y<0$$

Stability:

The detailed discussion is given in Appendix 4.A at the end of this chapter. When $b\gamma/y$ decreases, stability requires a higher β. For example, if $(b\gamma/y)=1.2$, stability obtains for $0.068<\beta<1$; if $(b\gamma/y)=1$, stability requires $0.177<\beta<1$. Normally, b, γ and y are greater than 1, and $b\gamma/y$ is greater than or close to 1. If we assume a constant b, stability requires a higher β when the investment efficiency γ increases. On the other hand, if price is very sensitive to output, i.e. if b is big, we need a relative small β to get a stable equilibrium. When the legal system provides a longer period of protection T, y becomes bigger which reduces $b\gamma/y$. As a result, a higher β is required for stability of the equilibrium investment.

4.3.2 Investment: the Cooperative Case

As discussed in chapter 3, globalization increases the complexity of technology. Under varied economic and institutional environments, the technology specializations of firms are different. As a result, they may possess advanced hardware or software technologies. The investment externality effects between firms are often due to their complementary technologies. With different technology specializations, firms can cooperate while they are also competing. In our case, the two firms cooperate on investment at the first stage, and make independent production decisions at the second stage. Therefore, we have the same q_i and q_j as in the noncooperative case, that is

$$q_i=\frac{(a-2A_i+A_j)+(2-\beta_j)x_i+(2\beta_i-1)x_j}{3b}$$

$$q_j=\frac{(a-2A_j+A_i)+(2-\beta_i)x_j+(2\beta_j-1)x_i}{3b}$$

By substituting them into the profit function, we get the first-stage maximization problem, where the two firms maximize their profits jointly,

$$\underset{[x_i,x_j]}{MAX}\{y[(a-bQ(x_i,x_j))q_i(x_i,x_j)-(A_i-x_i-\beta_i x_j)q_i(x_i,x_j)]-\gamma_i\frac{x_i^2}{2}$$
$$+y[(a-bQ(x_i,x_j))q_j(x_i,x_j)-(A_j-x_j-\beta_j x_i)q_j(x_i,x_j)]-\gamma_j\frac{x_j^2}{2}\}$$

By the first order condition, we get

$$x_i=\frac{\Delta_i}{\Delta}$$
$$x_j=\frac{\Delta_j}{\Delta}$$

Where

$$\Delta=4\{[(2-\beta_j)^2-4\beta_j(1-\beta_j)-4.5b\gamma_i/y][(2-\beta_i)^2-4\beta_i(1-\beta_i)-4.5b\gamma_j/y]$$
$$-[-4+5\beta_i+5\beta_j-4\beta_i\beta_j]^2\}$$

$$\Delta_i=4\{-[a-5A_i+4A_j+a\beta_j+4\beta_jA_i-5\beta_jA_j][(2-\beta_i)^2-4\beta_i(1-\beta_i)-4.5b\gamma_j/y]$$
$$+[a+4A_i-5A_j+a\beta_i-5\beta_iA_i+4B_iA_j][-4+5\beta_i+5\beta_j-4\beta_i\beta_j]\}$$

$$\Delta_j=4\{-[a-5A_j+4A_i+a\beta_i+4\beta_iA_j-5\beta_iA_i][(2-\beta_j)^2-4\beta_j(1-\beta_j)-4.5b\gamma_i/y]$$
$$+[a+4A_j-5A_i+a\beta_j-5\beta_jA_j+4B_jA_i][-4+5\beta_j+5\beta_i-4\beta_j\beta_i]\}$$

The second order condition requires:

$$\frac{\partial^2\pi_i}{\partial x_i^2}=\frac{2}{9b}[(2-\beta_j)^2+(2\beta_j-1)^2]-\gamma_i/y<0$$

$$\frac{\partial^2\pi_j}{\partial x_j^2}=\frac{2}{9b}[(2-\beta_i)^2+(2\beta_i-1)^2]-\gamma_j/y<0$$

$$\frac{\partial^2\pi_i}{\partial x_i\partial x_j}=\frac{2}{9b}(-2+7\beta_i+7\beta_j-2\beta_i\beta_j)$$

and

$$\left(\frac{\partial^2\pi_i}{\partial x_i\partial x_j}\right)^2-\frac{\partial^2\pi_i}{\partial x_i^2}\frac{\partial^2\pi_j}{\partial x_j^2}<0 \quad i.e.$$

$$(-2+7\beta_i+7\beta_j-2\beta_i\beta_j)^2-[(2-\beta_j)^2+(2\beta_j-1)^2-4.5b\gamma_i/y][(2-\beta_i)^2+(2\beta_i-1)^2-4.5b\gamma_j/y]<0$$

If $A_i=A_j=A$, we have

$$\Delta=4\{[(2-\beta_j)^2-4\beta_j(1-\beta_j)-4.5b\gamma_i/y][(2-\beta_i)^2-4\beta_i(1-\beta_i)-4.5b\gamma_j/y]-[-4+5\beta_i+5\beta_j-4\beta_i\beta_j]^2\}$$

$$\Delta_i=4(a-A)\{-(1+\beta_j)[(2-\beta_i)^2-4\beta_i(1-\beta_i)-4.5b\gamma_j/y]+(1+\beta_i)[-4+5\beta_i+5\beta_j-4\beta_i\beta_j]\}$$

$$\Delta_j=4(a-A)\{-(1+\beta_i)[(2-\beta_j)^2-4\beta_j(1-\beta_j)-4.5b\gamma_i/y]+(1+\beta_j)[-4+5\beta_j+5\beta_i-4\beta_j\beta_i]\}$$

In the symmetric case, with $\beta_i=\beta_j$, $\gamma_i=\gamma_j$, $A_i=A_j$, we have

$$x_i^{**}=x_j^{**}=\frac{(a-A)(\beta+1)}{4.5(b\gamma/y)-(\beta+1)^2}$$

and

$$Q^{**}=q_1^{**}+q_2^{**}=\frac{2(a-A)}{3b}\left[\frac{4.5b\gamma}{4.5(b\gamma/y)-(1+\beta)^2}\right]$$

Where

$$\beta = \beta_o + \beta_a$$

The second order condition is

$$(1+\beta)^2 - 4.5b\gamma/y < 0$$

Stability:

The detailed discussion is given in Appendix 4.A at the end of this chapter. When $b\gamma/y$ decreases, stability requires a higher β. For example, if $(b\gamma/y)=1.2$, stability obtains for $0.225<\beta<1$; if $(b\gamma/y)=1$, stability requires $0.293<\beta<1$. Normally, b, γ and y are greater than 1, and $b\gamma/y$ is greater than or close to 1. If we assume a constant b, stability requires a higher β when the investment efficiency γ increases. On the other hand, if price is very sensitive to output increase, i.e. if b is bigger, we need a relative small β to get a stable equilibrium. When the legal system provides a longer period of protection T, y becomes bigger which causes a lower $b\gamma/y$. As a result, a higher β is required for stability of the equilibrium investment.

4.3.3 Investment Behaviour under Alternative Environments

In this section, the investment levels in the noncooperative and cooperative cases are compared; the impact of a simplified legal system, as well as financial interpenetration and exports, are examined under various conditions.

1) The Impact of the Legal System

As discussed above, the firm's investment in the symmetric case is

In the noncooperative case

$$x_i^{*}=\frac{(a-A)(2-\beta)}{4.5b\gamma/y-(2-\beta)(1+\beta)}$$

In the cooperative case

$$x_i^{**}=\frac{(a-A)(\beta+1)}{4.5b\gamma/y-(\beta+1)^2}$$

It can be seen that the protection function of the legal system increases the firm's equilibrium investment. That is, an increase in T leads to a higher y, which, in turn, increases the firm's equilibrium investment. This is true whether the firms cooperate or not.

Thus, the only way an increase in legal protection would reduce investment is if it caused a switch from one type of equilibrium to the other. We do not pursue this here.

However, in a dynamic sense, over-protection from the legal system may affect other parameters which might cause a decrease in a firm's long-run investment. An over-protection, which provides a firm with a long period of monopoly profits, reduces competitive pressure on the firm. Under lower pressure, a firm will be less efficient in its use of given investment resources. In other words, γ will be higher.

Therefore, the effect of larger y (due to increase in T) may be more than cancelled out by increases in γ. This, in turn, reduces investment and technological progress.

Therefore, when a legal system provides a reasonable protection of a firm's investment result, it exerts a favourable impact on the firm's investment; when a legal system provides an over-protection of a firm's investment result, it exerts a unfavourable impact on the firm's investment.

2) The Impact of Financial Interpenetration

Financial interpenetration may have several objectives. As discussed in chapter 3, we consider that its main objective is to make firms cooperate. This may occur alone (case 1) or together with other effects. These other effects include: increasing the two firms' investment externality (case 2), increasing the two firms' investment efficiency (case 3), increasing the two firms' investment externality as well as their investment efficiency (case 4).

An increase in financial interpenetration may have 2 effects:

- it may cause the firms to switch to another equilibrium.
- if no switch occurs, it will cause an adjustment to the equilibrium.

We will assume that an increase in financial interpenetration never causes a switch from a cooperative equilibrium to a noncooperative equilibrium.

As indicated above, firms' financial interpenetration may increase the investment externality coefficient β ($\beta=\beta_0+\beta_a$). It may also increase their investment efficiency γ. Let us first investigate the impact of a change in β. Then we will consider various possible financial interpenetration scenarios.

The derivative of x_i^*, the technology investment in the noncooperative case, with respect to β is

$$\frac{\partial x_i^*}{\partial \beta}=\frac{[-4.5b\gamma/y+(2-\beta)^2]\,(a-A)}{[4.5b\gamma/y-(2-\beta)\,(1+\beta)]^2}$$

By the second order condition ($(2-\beta)^2-4.5b\gamma/y<0$), this derivative is negative. Furthermore, in order to determine the shape of $x_i^*(\beta)$ we will examine the second order derivative of x_i^* with respect to β:

$$\frac{\partial^2 x_i^*}{\partial \beta^2}=\frac{-2\,[4.5b\gamma/y-(2-\beta)\,(1+\beta)]\,[4.5b\gamma/y(3-3\beta)-(2-\beta)^3]}{[4.5b\gamma/y-(2-\beta)\,(1+\beta)]^4}\,(a-A)$$

By the second order condition ($(2-\beta)^2-4.5b\gamma/y<0$), this second order derivative has the following signs

$$\frac{\partial^2 x_i^*}{\partial \beta^2}<0,\ if\ \beta\le\frac{1}{2}$$
$$\frac{\partial^2 x_i^*}{\partial \beta^2}>0,\ if\ \beta>\frac{1}{2}$$

Therefore, $x_i^*(\beta)$ is concave when $\beta \leq 0.5$ and convex when $\beta > 0.5$. The derivative of x_i^{**}, the technology investment in the cooperative case, with respect to β is

$$\frac{\partial x_i^{**}}{\partial \beta} = \frac{[4.5b\gamma/y + (\beta+1)^2]\,(a-A)}{[4.5b\gamma/y - (\beta+1)^2]^2}$$

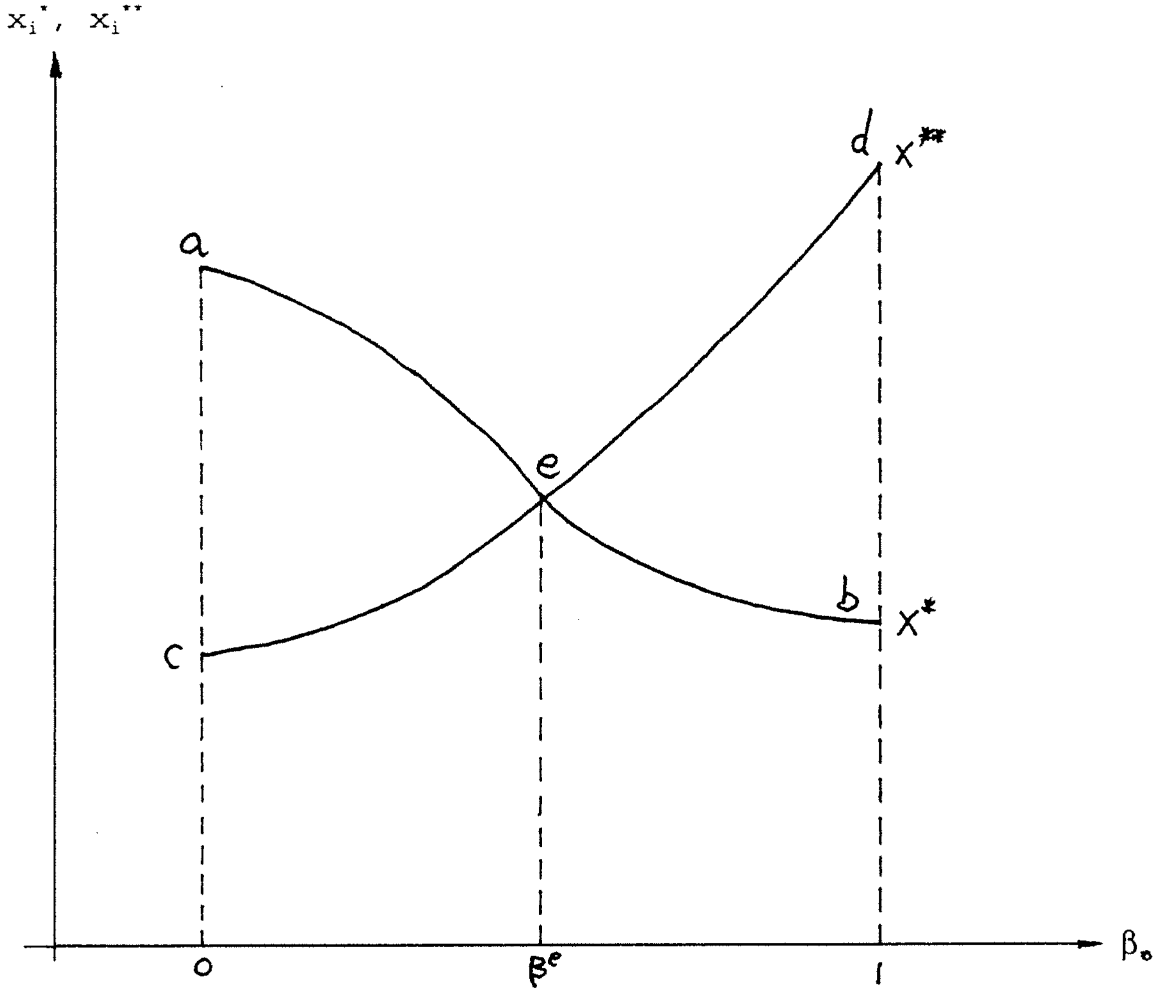
This derivative is positive. Furthermore, in order to determine the shape of $x_i^{**}(\beta)$ we will examine the second order derivative of x_i^{**} with respect to β:

$$\frac{\partial^2 x_i^{**}}{\partial \beta^2} = \frac{2(\beta+1)\,[4.5b\gamma/y-(\beta+1)^2]\{[4.5b\gamma/y-(\beta+1)^2]+2\,[4.5b\gamma/y+(\beta+1)^2]\}}{[4.5b\gamma/y-(\beta+1)^2]^2}(a-A)$$

By the second order condition $((1+\beta)^2 - 4.5b\gamma/y < 0)$, this second order derivative is positive. Therefore, $x_i^{**}(\beta)$ is convex with respect to β.

The above derivatives imply the following results. In the noncooperative case, the equilibrium investment decreases when the externality coefficient increases, i.e. $\partial x_i^*/\partial\beta < 0$; in the cooperative case, the equilibrium investment increases with a rise in the externality coefficient, i.e. $\partial x_i^{**}/\partial\beta > 0$. When financial interpenetration increases the firms' investment efficiency (a smaller γ) and causes no switch of equilibrium, their investments will be higher, i.e. $\partial x_i^*/\partial\gamma > 0$ and $\partial x_i^{**}/\partial\gamma > 0$. When two firms do not have financial interpenetration or the financial interpenetration does not affect their investment externality or investment efficiency (case 1), the relationship between a firm's investment and the externality coefficient is shown in figure 4.7, for both

Figure 4.7 The Relationship between a Firm's Investment and the Externality Coefficient when the Financial Interpenetration Does not Affect the Investment Externality or Investment Efficiency



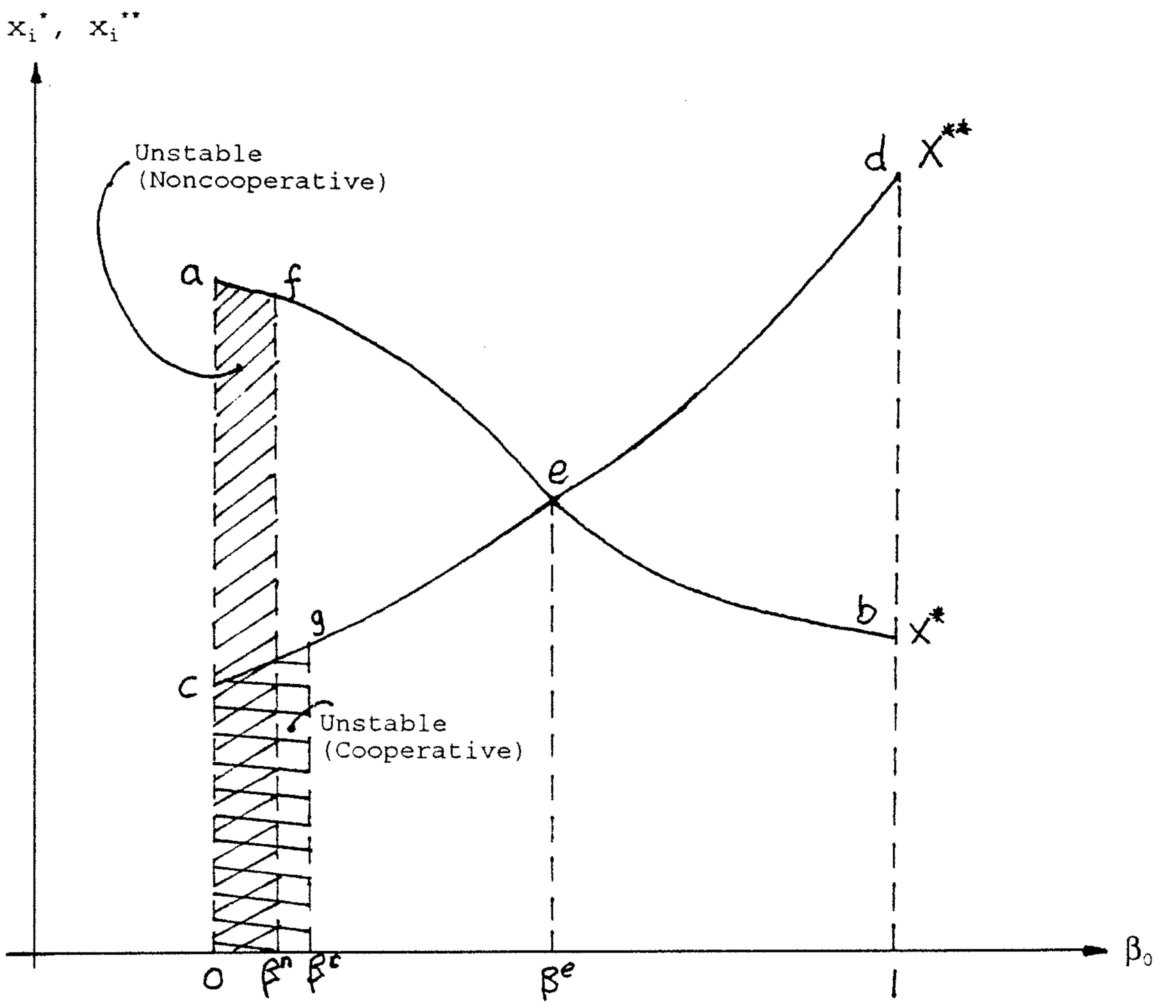
$\beta=\beta_0+\beta_a, \quad \beta_a=0$
$\beta^e=0.5$

the noncooperative and the cooperative cases. At β^e (=0.5), the firms have the same investment when they cooperate as when they do not cooperate. However, when the two firms do have financial interpenetration and the financial interpenetration affects their investment externality or investment efficiency (case 2 or case 3), the relationship between a firm's investment and the externality coefficient is slightly different as shown in figure 4.8, for both the noncooperative and the cooperative cases. At β^e ($\leq$0.5), the firms in both cases have the same investment. In both figures, we use β_0 on the horizontal axis so that x_i^* and x_i^{**} can be comparable, although β for the noncooperative case (=β_0) is different from β in the cooperative case (=$\beta_0+\beta_a$).

In what follows, we will examine the effect of financial interpenetration by analyzing the relationship between the equilibrium investments in the noncooperative and the cooperative cases. Then the four cases are compared.

As discussed in Appendix 4.A, a stable equilibrium investment requires a minimum level of β (β^c in the cooperative equilibrium; β^n in the noncooperative equilibrium). In sections 4.3.1 and 4.3.2, it was shown that β^c and β^n are smaller than 0.5, and $\beta^c>\beta^n$. More specifically, as shown in figure 4.8, the cooperative case requires a $\beta_0>\beta^c$ for the equilibrium investment (curve ged), and the noncooperative case requires a $\beta_0>\beta^n$ for the equilibrium investment (curve feb).

Figure 4.8 The Relationship between a Firm's Investment and the Externality Coefficient when the Financial Interpenetration does Affect the Investment Externality or Investment Efficiency



$\beta=\beta_0+\beta_a$, $\beta_a\geq 0$, $\gamma\downarrow$
$\beta^e<0.5$

Consider a general case here, as shown in figure 4.8. Suppose that two firms do not cooperate and that there is an increase in financial interpenetration. If $\beta_0<\beta^c$, this cannot cause a switch to the cooperative equilibrium because the latter would not be stable. Thus the result will be a movement along fe, i.e. a drop in investment. If $\beta^c<\beta_0<\beta^e$, the switch to the cooperative equilibrium is possible, and would involve a drop in investment. If no switch occurs there is a movement along fe, again a drop in investment. But if the firms cooperate already (not likely at low β_0) there may be a movement along ge. Thus, if β_0 is relatively low ($\leq\beta^e$), an increase in financial interpenetration is likely, but not certain, to cause a drop in investment. Finally, if $\beta_0>\beta^e$, the same arguments imply that investment will increase.

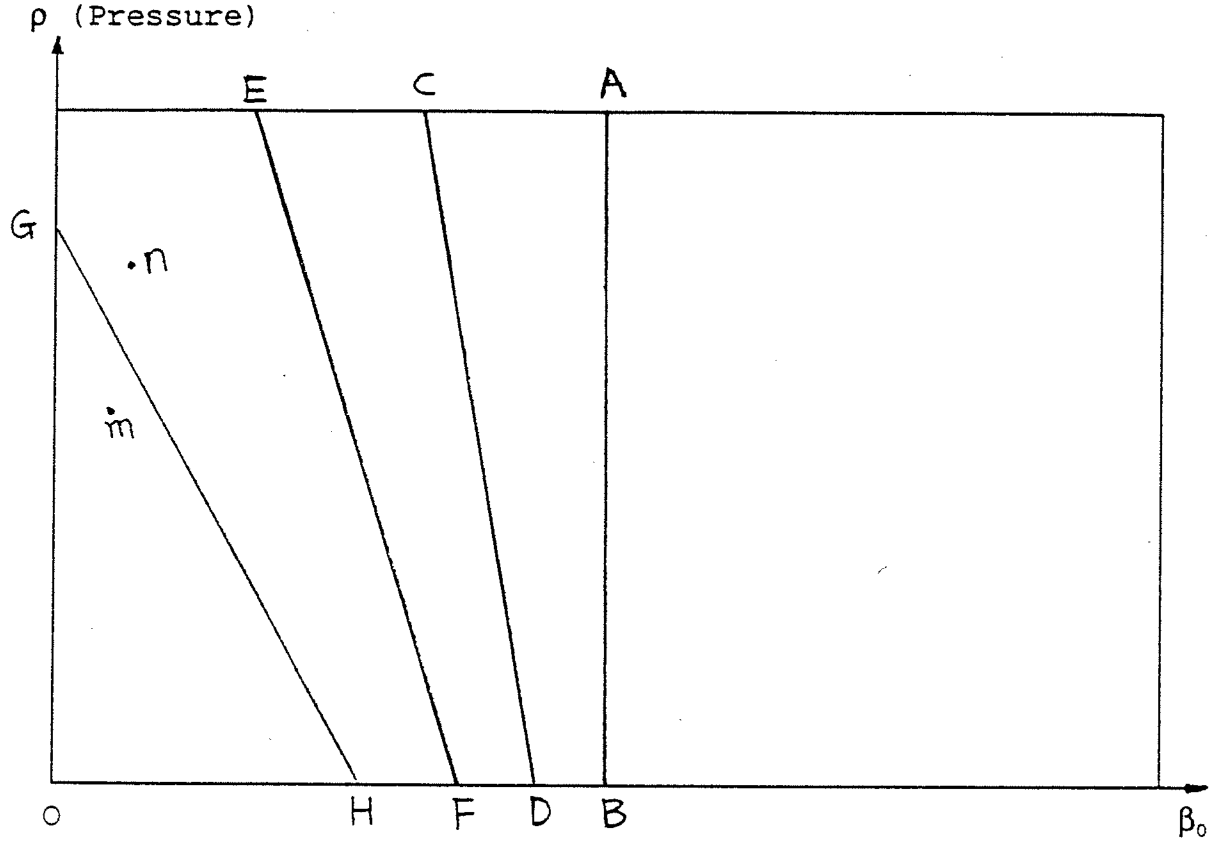
Therefore, to recap, when two firms have a relatively high externality coefficient (β_0), financial interpenetration tends to increase the firm's investment level. In other words, when two firms have closely related (technologies) businesses, their cooperation (due to financial interpenetration) tends to increase their investment level; when two firms do not have closely related businesses, their cooperation is likely to decrease their investment level.

The competitive pressure that firms face will also influence the effect of financial interpenetration. Under high competitive pressure, the investment externality between the two firms and their investment efficiency may be higher, which implies a lower β^e. As a result, financial interpenetration has a positive impact on investment on a wider range of β_0 when the firms face a higher competitive pressure. On the other hand, financial interpenetration has a positive impact on investment on a smaller range of β_0 when the firms face a lower competitive pressure.

The analysis of the effect of financial interpenetration in the 4 cases mentioned at the beginning of this subsection can be performed in the same way as above. That is, financial interpenetration induces firms to cooperate. In case 1, the cooperation between firms occurs alone without affecting their investment externality or investment efficiency; In case 2, the cooperation increases the firms' investment externality (case 2); In case 3, the cooperation increases the two firms' investment efficiency (case 3) and; in case 4, the cooperation increases the two firms' investment externality as well as their investment efficiency (case 4). Results are summarized in figure 4.9. The vertical axis represents the level of competitive pressure (ρ) that firms face, and OP represents the maximum competitive pressure a firm may face. The horizontal axis represents the externality (spillover) coefficient (β_0) when two firms have no financial interpenetration, and OQ represents the maximum externality coefficient.

On each side of curves AB, CD, EF and GH, it indicates different effects of financial interpenetration for case 1, 2, 3 and 4 respectively. To the left of each curve (AB, CD, EF, GH), financial interpenetration may reduce technology investment; on the right of each curve, financial interpenetration enhances technology investment. Because the effect of financial interpenetration in each case is different, the curves AB, CD, EF and GH have different shapes which indicates the different influences of competitive pressure on the effect of financial interpenetration, as shown in figure 4.9. The competitive pressure has the greatest influence on the effect of financial interpenetration in case 4, while it has no influence on the effect of financial interpenetration in case 1. In case 4, the cooperation between firms, due to financial interpenetration, results in an increase in their investment externality and investment efficiency. As a result, the competitive pressure is critical in determining the direction of the effect. For example, at point m where the competitive pressure is low, financial interpenetration is likely to reduce a firm's technology investment, as compared to point n where the competitive pressure is high and financial interpenetration enhances a firm's technology investment.

Fig. 4.9 The Effect of a Rise in Financial Interpenetration on Firms' Technology Investments



Note:

Case 1: $\beta_a=0$,. financial interpenetration makes the two firms cooperate; it affects neither their investment externality ($\beta_a=0$, $\beta=\beta_0$), nor their investment efficiency (γ).

Case 2: $\beta_a>0$, financial interpenetration makes two firms cooperate and increases their investment externality ($\beta_a>0$, $\beta=\beta_0+\beta_a$) but not their investment efficiency (γ).

Case 3: $\beta_a=0$, financial interpenetration makes two firms cooperate and increases their investment efficiency (γ) but not their investment externality.

Case 4: $\beta_a>0$, financial interpenetration firms makes two firms cooperate, increases their investment externality ($\beta_a>0$, $\beta=\beta_0+\beta_a$) and their investment efficiency (γ).

The mechanism by which financial interpenetration between firms affects technology investment is different from the mechanism by which financial interpenetration between firms and banks affects investment.

In the case of financial interpenetration between firms, the firms have direct relationship and communicate directly. This mechanism is closely related to the competitive pressure faced by firms. Different competitive pressures determine the motivation of cooperation or their financial relationship. Under low competitive pressure, their cooperation tends to diversify to unrelated businesses. Therefore, their financial interpenetration tends to reduce technology investment. On the other hand, under relatively high competitive pressure, financial interpenetration between firms tends to induce cooperation of firms in closely related businesses, and to increase their technology investments. Therefore, the mechanism is directly affected by the competitive pressure that firms face.

In the case of financial interpenetration between firms and banks, firms have certain cooperative relationships because of or through banks' involvement. The effect mechanism is closely related to both the competitive pressure that firms face and to the way that banks are involved in the cooperation. The influence of competitive pressure is similar to the case of financial interpenetration between firms. As for the way that banks are involved in firms' cooperation, banks are influential in a firm's decision about cooperation or partnership (with whom it will cooperate). If banks' involvement is to make closely related firms cooperate, the effect tends to enhance firms' investments. If banks' involvement is to make unrelated firms cooperate, the effect tends to reduce firms' investments. Therefore, the mechanism of financial interpenetration between firms and banks is closely related to the competitive pressure and to the way banks are involved in firms' cooperation.

In the empirical study, we will examine the effect of financial interpenetration between firms and financial interpenetration between firms and banks separately. The results will be examined in chapter 5.

In general, the effect of financial interpenetration depends on whether the two firms are in closely related businesses, and whether the external competitive pressure is high. When two firms have closely related businesses, financial interpenetration tends to increase their investments, especially under high competitive pressure. On the other hand, when two firms have unrelated businesses and face low competitive pressure, financial interpenetration is more likely to decrease the firms' investments. Financial interpenetration between two firms directly and through banks' involvement have different mechanisms by which firms' investments are affected.

3) The Impact of Exports

The impact of exports is greatly influenced by the competitive pressure in the export market. When a firm is exposed to the international market, the demand and supply conditions in other countries will affect parameters a, A, b, γ. For simplicity, we assume that the firm sets one product price for both the domestic market and the export market. According to previous analyses, a firm's investment in the symmetric case is as follows.

In the Noncooperative Case:

$$x_i^* = x_j^* = \frac{(a-A)(2-\beta)}{4.5b\gamma/y-(2-\beta)(1+\beta)}$$

In the Cooperative Case

$$x_i^{**} = x_j^{**} = \frac{(a-A)(1+\beta)}{4.5b\gamma/y-(1+\beta)^2}$$

Here, the output price P is equal to $((a_1-b_1Q)+(a_2-b_2Z)-\phi(LP^f/LP))$ or $(a-bQ)$ $(a=a_1+a_2-b_2Z-\phi(LP^f/LP))$. In what follows, we will examine investments in the noncooperative and the cooperative cases and their relationship, under different competitive conditions. Two cases are analyzed according to the level of competitive pressure that a firm faces on the export market: low competitive pressure and high competitive pressure.

We assume that export (and changes in competitive pressure) does not cause a switch either from the cooperative to the noncooperative equilibria or from the noncooperative to the cooperative equilibria. An increase in the competitive pressure affects the following three parameters or groups of parameters: (a-A), b and γ.

Suppose EX is a firm's export, and ρ is the index of pressure on the export market. A high ρ indicates a high competitive pressure. The level of EX determines the values for (a-A), b and γ. Furthermore, the signs and sizes of derivatives $\partial(a-A)/\partial EX$, $\partial b/\partial EX$ and $\partial\gamma/\partial EX$ are dependent on the level of competitive pressure ρ. With high competitive pressure in the export market, an increase in export leads to a lower (a-A) because of highly competitive suppliers in the market, a lower b due to a higher price elasticity in a high competitive environment, and a lower γ due to higher investment efficiency under high competitive pressure. With low competitive pressure in the export market, the opposite is true. Therefore, under a high ρ, we have $\partial(a-A)/\partial EX<0$, $\partial b/\partial EX<0$ and $\partial\gamma/\partial EX<0$; under a low ρ, we have $\partial(a-A)/\partial EX>0$, $\partial b/\partial EX>0$ and $\partial\gamma/\partial EX>0$.

The effect of an increase in export on the equilibrium investment consists of three parts, as shown in the following derivative of the equilibrium investment with respect to exports.

For the noncooperative case

$$\frac{\partial x_i^*}{\partial EX}=\frac{\partial x_i^*}{\partial(a-A)}\frac{\partial(a-A)}{\partial EX}+\frac{\partial x_i^*}{\partial b}\frac{\partial b}{\partial EX}+\frac{\partial x_i^*}{\partial\gamma}\frac{\partial\gamma}{\partial EX}$$

For the cooperative case

$$\frac{\partial x_i^{**}}{\partial EX}=\frac{\partial x_i^{**}}{\partial(a-A)}\frac{\partial(a-A)}{\partial EX}+\frac{\partial x_i^{**}}{\partial b}\frac{\partial b}{\partial EX}+\frac{\partial x_i^{**}}{\partial\gamma}\frac{\partial\gamma}{\partial EX}$$

For both the noncooperative and the cooperative cases, an increase in (a-A) causes a increase in investment level (X^* and X^{**}), a rise in b leads to a drop in investment level (X^* and X^{**}), an increase in γ leads to a decrease in investment level (X^* and X^{**}). That is, we have $\partial X^*/\partial(a-A)>0$, $\partial X^*/\partial b<0$ and $\partial X^*/\partial\gamma<0$, and $\partial X^{**}/\partial(a-A)>0$, $\partial X^{**}/\partial b<0$ and $\partial X^{**}/\partial\gamma<0$.

The total effect of export depends on the level of ρ in the export market. Suppose the export market is a relative large one with a high ρ. In this case, an increase in export will have a relative small effect on (a-A), and relative large effect on b and γ. That is, $\partial(a-A)/\partial EX$ is relative small, comparing to $\partial b/\partial EX$ and $\partial\gamma/\partial EX$. Under a high ρ, the first part (term) is negative (a drop in investment), the second and the third terms are positive (an increase in investment). The sum of the second and third terms likely dominate the first term. As a result, the effect of an increase in export is likely an increase in investment. Under a low ρ, the first term is positive (a rise in investment), the second and the third terms are negative (a drop in investment). The sum of the second and third terms likely dominate the first term. As a result, the effect of a rise in export is likely a decrease in investment. The result is summarized in the following table.

Table 4.2 The Effect of a Rise in Exports on a Firm's Technology Investment

Competitive Pressure	Effect of Export on a Firm's Technology Investment
Low	Likely decrease
High	Likely increase

4.3.4 Summary

As a complement to the model in section 4.2, in this section, a simplified two-period model was used to analyze parametrically the impact of a simplified legal system, the effect of financial interpenetrations and of exposure to external competitive pressure on technology investment. The relationship between the equilibrium investments in the noncooperative and the cooperative cases was examined, in particular, when we analysed the effect of financial interpenetration.

The legal system's function of protecting a firm's investment results encourages a firm's investment. However, in the long run, over-protection may reduce a firm's investment efficiency and discourage the firm's equilibrium investment.

Financial interpenetration (between firms and through banks) may induce two firms to cooperate. Its effect on the firms' technology investment is influenced by the degree of competitive pressure and by whether the firms have closely related businesses. When financial interpenetration makes two unrelated firms cooperate, it is likely to reduce technology investments; otherwise, if no equilibrium switch occurs, it tends to increase technology investments. Under high competitive pressure, there are less restrictive requirement on the relatedness of technologies between firms in order to have a favourable impact from financial interpenetration.

Assuming that changes in exports do not cause any switch in equilibrium, we also examined the effect of exports on a firm's technology investment. The effect depends on the competitive pressure associated with the export. The effect is likely to be unfavourable when exports go to a less competitive market, and favourable when exports go to a relatively competitive market.

Therefore, the direction of the impact of financial interpenetrations and of exports on technological progress cannot be determined without explicitly specifying various conditions or circumstances. They have to be examined according to specific conditions. In this section, we further illustrated that simplified models can help us to understand the mechanisms that explain the firm's decisions, as a complement to the general model in section 4.1. They may be helpful in interpreting empirical results and what is going on in the real world.

4.4 Summary

In this chapter, we examined a firm's investment behaviour when its economic and institutional environment was taken into account. In section 4.1, we discussed the two important aspects of a firm's technology, hardware and software, and analyzed a firm's investment behaviour with respect to the two aspects. Although it illustrated formally how economic and institutional environment variables affect investment decisions, the model of section 4.1 also confirmed an impression gathered from the discussion in chapter 3: these factors have ambiguous effects in general. In order to go further in deepening our understanding of the effect of the economic and institutional environment, we used two simplified stylized models, one in sections 4.2 which used six cases in an easy understandable way, and one in section 4.3 which was used as a complement to section 4.2 to examine more general cases, to analyze a firm's investment behaviour in specific circumstances. As a complement to the general model, simplified models help us to understand the mechanisms that explain the firm's decisions. They may be helpful in interpreting empirical results and what is going on in the real world.

As for the simplified legal system (protection of a firm's innovation result), it exerts favourable impact on the firm's equilibrium investment. However, an over-protection of the legal system may, in the long run, affect the investment negatively.

As for the impact of financial interpenetration (between firms or through banks) on the firms' equilibrium investments, it depends on external competitive pressure as well as on whether the two firms are in closely related businesses. Under high competitive pressure, the impact is more likely to be favourable than under low competitive pressure. When two firms are in closely related businesses, the impact is more likely to be favourable than when they are not, especially under high competitive pressure.

The effect of exports on a firm's technology investment depends on the competitive pressure associated with the export. The effect is likely to be unfavourable when exports are to a less competitive market, and favourable when export is to a relatively competitive market.

In next chapter, we will continue our analysis with an empirical study, based on the mechanisms which were brought up by the general and particularly simplified models. Data from Canadian manufacturing industries are used to perform the study so that our theoretical analysis can be tested with real world observations. The effect of the following economic and institutional environment variables is examined: exports, financial interpenetration between firms, as well as financial interpenetration between firms and banks. The legal system is excluded because of lack of suitable data as well as of its stability during the study period.

Appendix 4.A: Stability of Equilibrium Investment

In what follows, we will discuss the stability of equilibrium investments in both the noncooperative and the cooperative cases.

The Noncooperative Case:

In what follows, we will discuss the stability of firms' equilibrium investments in the noncooperative case. The profit-maximizing investment for firm i is

$$x_i = \frac{-(2-\beta)[(a-A)+(2\beta-1)x_j]}{(2-\beta)^2 - 4.5b\gamma/y}$$

The partial derivative is

$$\frac{\partial x_i}{\partial x_j} = \frac{-(2-\beta)(2\beta-1)}{(2-\beta)^2 - 4.5b\gamma/y}$$

Stability requires

$$\left|\frac{\partial x_i}{\partial x_j}\right| < 1$$

By the second order condition ($(2-\beta)^2-4.5b\gamma<0$), the denominator of $\partial X_i/\partial X_j$ is negative. Therefore, stability requires

$$\frac{(2-\beta)(2\beta-1)}{4.5b\gamma/y-(2-\beta)^2} < 1, \quad \textit{when} \quad \beta \geq 0.5$$

$$\frac{(2-\beta)(2\beta-1)}{4.5b\gamma/y-(2-\beta)^2} > -1, \quad \textit{when} \quad \beta < 0.5$$

1) When $\beta \geq 0.5$: we have

$$(2-\beta)(2\beta-1) < 4.5b\gamma/y-(2-\beta)^2$$

That is

$$\beta^2-\beta+(4.5b\gamma/y-2)>0$$

The roots of the above inequality equation depend on the value of $\Delta=1-4*1*(4.5b\gamma/y-2)=9(1-2b\gamma/y)$. When $\Delta>0$, i.e. $b\gamma/y<0.5$, stability requires $\beta>(1+\Delta^{1/2})/2$; When $\Delta\leq 0$, i.e. $b\gamma/y\geq 0.5$, all assumed β ($\beta\geq 0.5$) satisfies the inequality equation. In other words, wen $\Delta\leq 0$, $\beta\geq 0.5$ ensures the stability of the equilibrium investment.

2) When $\beta<0.5$: we have

$$(2-\beta)(2\beta-1)>(2-\beta)^2-4.5b\gamma/y$$

That is

$$\beta^2-3\beta+(2-1.5b\gamma/y)<0$$

We have $\Delta=9-4*(2-1.5b\gamma/y)=1+6b\gamma/y>0$. The solution of the above inequality equation is $(3-\Delta^{1/2})/2<\beta<(3+\Delta^{1/2})/2$. Because it is assumed $\beta<0.5$, the stability required β is $(3-\Delta^{1/2})/2<\beta<0.5$, .

3) Examples:

Suppose $b\gamma/y=1.2$, we will have the stability required β as follows.

if $\beta<0.5$, stability requires $0.068<\beta<0.5$

if $\beta\geq 0.5$, due to $\Delta\leq 0$, stability requires $0.5\leq\beta<1$

Combining the two, we have $\mathbf{0.068<\beta<1}$

Suppose $b\gamma/y=1$, we will have the stability required β as follows.

if $\beta<0.5$, stability requires $0.177<\beta<0.5$

if $\beta\geq 0.5$, because of $\Delta\leq 0$, stability requires $0.5\leq\beta<1$

Combining the two, we have $\mathbf{0.177<\beta<1}$

Thus, a smaller $b\gamma/y$ implies a higher stability required β. Given b and y, stability requires a higher β when there is an increase in investment efficiency (γ); given γ and y, if price is very sensitive to output increase (a bigger b), it needs a relative smaller β to ensure a stable equilibrium; given b and γ, a longer period of protection T (of the legal system) leads to a bigger y which in turn causes a lower $b\gamma/y$. Under a lower $b\gamma/y$, it needs a higher β for the stability of the equilibrium investment.

The Cooperative Case:

In what follows, we will discuss the stability of firms' equilibrium investments in the cooperative case. Investments x_i and x_j are determined by

The first order condition gives

$$x_i=-\frac{(\beta+1)(a-A)+2(2-B)(2\beta-1)x_j}{(2-\beta)^2+(2\beta-1)^2-4.5b\gamma/y}$$

The second order derivative is

$$\frac{\partial^2\pi}{\partial x_i^2}=-\gamma/y+\frac{2(2-\beta)^2}{9b}+\frac{2(2\beta-1)^2}{9b}<0$$

That is

$$(2-\beta)^2+(2\beta-1)^2-4.5b\gamma/y<0$$

The derivative of x_i with respect to x_j is

$$\frac{\partial x_i}{\partial x_j}=-\frac{2(2-\beta)(2\beta-1)}{(2-\beta)^2+(2\beta-1)^2-4.5b\gamma/y}$$

The stability condition requires the absolute value of the derivative to be less than 1. That is

$$\frac{2(2-\beta)(2\beta-1)}{4.5b\gamma/y-(2-\beta)^2-(2\beta-1)^2}<1,\quad if\ \beta\geq 0.5$$
$$\frac{2(2-\beta)(2\beta-1)}{4.5b\gamma/y-(2-\beta)^2-(2\beta-1)^2}>-1,\quad if\ \beta<0.5$$

1) **When** $\beta<0.5$**:** we have

$$9\beta^2-18\beta+9-4.5b\gamma/y<0$$

Or

We have $\Delta=4-4*(1-0.5b\gamma/y)=2b\gamma/y>0$. The roots of this inequality equation are $(2-\Delta^{½})/2<\beta<(2+\Delta^{½})/2$. Because it is assumed $\beta<0.5$, the stability required β is $(2-\Delta^{½})/2<\beta<0.5$.

2) When $\beta\geq 0.5$: We have

$$\beta^2+2\beta+(1-4.5b\gamma/y)<0$$

We have $\Delta=4-4*(1-4.5b\gamma/y)=18b\gamma/y>0$. The solution of this inequality equation is $(2-\Delta^{½})/2<\beta<(2+\Delta^{½})/2$. Because it is assumed $\beta\geq 0.5$ and $(2+\Delta^{½})/2$ is greater than 0.5, the stability required β is $0.5\leq\beta<1$.

3) Examples:

Suppose $b\gamma/y=1.2$, the stability required β is as follows.

if $\beta<0.5$, stability requires $0.225<\beta<0.5$

if $\beta\geq 0.5$, stability requires $0.5\leq\beta<1$

Combining the two cases gives $\mathbf{0.225<\beta<1}$.

Suppose $b\gamma/y=1$, the stability required β is as follows.

if $\beta<0.5$, stability requires $0.293<\beta<0.5$

if $\beta\geq 0.5$, stability requires $0.5\leq\beta<1$

Combining the two cases gives $\mathbf{0.293<\beta<1}$.

Thus, a smaller $b\gamma/y$ implies a higher stability required β. Given b and y, stability requires a higher β when there is an increase in investment efficiency (γ); given γ and y, if price is very sensitive to output increase (a bigger b), it needs a relative smaller β to ensure a stable equilibrium; given b and γ, a longer period of protection T (of the legal system) leads to a bigger y which in turn causes a lower $b\gamma/y$. Under a lower $b\gamma/y$, it needs a higher β for the stability of the equilibrium investment.

The noncooperative and cooperative cases require different βs for the stability of their equilibrium investments. A comparison of the stability required βs in the noncooperative and cooperative cases shows that, under the same conditions, the cooperative case requires a higher β than the noncooperative case.

Chapter 5 An Empirical Study

To be competitive, a firm must be able to produce a product of a certain quality at a relatively low cost. In chapter 3, we discussed the effect of the financial and legal systems and other economic environment factors on a firm's organizational structure and investment behaviour. In chapter 4, based on the discussion in chapter 3, we first narrowed down the analysis to a firm's investment behaviour in terms of hardware and software technologies; then, simplified models were used to examine the firm's investment behaviour under different economic and institutional environments. It was found that the economic and institutional environments affect investment decisions in general. However, the direction of the effect depends on various circumstances. We have attempted to highlight the most important ones.

The simplified models illustrated the mechanisms which determine the technology investments of firms in various circumstances. Financial interpenetration (between firms and through banks) may induce two firms to cooperate. Its effect on the technology investments of firms is influenced by the degree of competitive pressure and by whether the firms have closely related businesses. When financial interpenetration makes two unrelated firms cooperate, it is likely to reduce technology investments. Under high competitive pressure, there are less restrictive requirements on the relatedness of technologies between firms in order to have a favourable impact from financial interpenetration. The effect of changes in exports on a firm's technology investment depends on the competitive pressure associated with the export. The effect is likely to be unfavourable when export is to a less competitive market, and favourable when exporting to a relatively competitive market. Therefore, the role of the economic and institutional environment is very much an empirical issue.

In this chapter, we will confront the theoretic predictions with empirical results from the real world observations. One way to study these effects are by examining the evolution of costs. A firm's investment behaviour causes differences in costs and, in turn, its competitiveness. We perform an empirical study with data from Canadian manufacturing industries to verify and quantify these effects. More specifically, we will test the theoretic predictions in chapter 4 of the effects of exports, financial interpenetration between firms, and financial interpenetration between firms and banks.

In section 5.0, we first discuss the concept of productivity and its relationship with a cost function. These two concepts are much related and often used to evaluate a firm's economic performance. Then, in section 5.1, we describe the empirical model specification and estimation procedure. The model is based on Baltagi and Griffin (1988) and is to estimate a translog cost function with a general index of technical change. We discuss the empirical results: first examining and comparing the standard results with other studies; then discussing the results on the impact of the economic and institutional environment, which is the main objective of this study. The empirical results seem to indicate that the mechanisms identified with simplified models in chapter 4 also play a role in the real world. Summary is given at the end of this chapter.

5.0 Productivity and Cost

Productivity is a concept that describes the degree of efficiency to transform inputs into outputs. The total productivity describes the ratio of output or index of outputs to the combination or index of all inputs used, while the partial factor productivity measures a ratio of output to the amount used of a single input such as labour. The total factor productivity is defined as

$$TFP=\frac{Y}{X} \tag{5.1}$$

Where

TFP - the total factor productivity
Y - the index of outputs
X - the index of inputs

Technical progress is measured as the shift of the production function or cost function during a period of time. It is conventionally defined as the percentage rate of growth over time of the total factor productivity with the assumption of constant return to scale, i.e.

$$\frac{T\dot{F}P}{TFP}=\frac{\dot{Y}}{Y}-\frac{\dot{X}}{X} \tag{5.2}$$

Where the dot over a variable means its derivative with respect to time.

By virtue of the duality theory, a cost function can represent a production function under certain regularity conditions. The following will use a cost function to illustrate the concept of productivity and technical change.

Suppose a cost function

$$C=g(W_1,\ldots,W_i,\ldots,W_n,Y,t) \tag{5.3}$$

Where

C - the total cost
W_i - price of input i
Y - output
t - time

With differentiation to time and rearrangement, we have

$$\frac{1}{C}\frac{\partial C}{\partial t}=\sum_{i=1}^{n}\frac{W_iX_i}{C}\frac{\dot{W}_i}{W_i}+\frac{\partial g}{\partial Y}\frac{Y}{C}\frac{\dot{Y}}{Y}+\frac{1}{C}\frac{\partial g}{\partial t} \tag{5.4}$$

We define the cost elasticity and technical progress associated with the cost function as

$$-\frac{\dot{B}}{B}=-\frac{1}{C}\frac{\partial g}{\partial t},\ \epsilon_{cy}=\frac{\partial g}{\partial Y}\frac{Y}{C} \tag{5.5}$$

By definition, the total cost is

$$C=\sum_{i=1}^{n} W_i X_i \tag{5.6}$$

By differentiation with respect to time

$$\frac{\dot{C}}{C}=\sum_{i=1}^{n}\frac{W_i X_i}{C}\frac{\dot{W}_i}{W_i}+\sum_{i=1}^{n}\frac{W_i X_i}{C}\frac{\dot{X}_i}{X_i} \tag{5.7}$$

Arranging the above equations, we obtain

$$-\frac{\dot{B}}{B}=\epsilon_{cy}\frac{\dot{Y}}{Y}-\sum_{i=1}^{n}\frac{W_i X_i}{C}\frac{\dot{X}_i}{X_i}=\epsilon_{cy}\frac{\dot{Y}}{Y}-\frac{\dot{X}}{X} \tag{5.8}$$

The relationship between total factor productivity and technical progress is

$$\frac{T\dot{F}P}{TFP}=-\frac{\dot{B}}{B}+(1-\epsilon_{cy})\frac{\dot{Y}}{Y} \tag{5.9}$$

We can obtain a similar relationship between total factor productivity and technical progress when there are quasi-fixed inputs. Details of the derivation is given in Appendix 5.A. This relationship is used to calculate the total factor productivity growth, after the cost function is estimated.

Returns to scale (μ) are the inverse of the elasticity of costs with respect to output[1], i.e. $\mu=1/\varepsilon_{cy}$ (Berndt, 1990).

---

[1]When there is a quasi-fixed input returns to scale are equal to $(1-\partial \ln Cv/\partial \ln K)/(\partial \ln Cv/\ln Y)$ (Caves, Christensen and Swanson, 1981). Since returns to scale are not the major issue to be studied in this thesis, we simply calculate them as the inverse of the elasticity of variable costs with respect to output.

5.1 Empirical Model Specification

Based on the theoretical analysis in chapter 4, a firm's production cost is a function of its equilibrium investment, which is affected by its export, financial interpenetration between firms, financial interpenetration between firms and banks, and the relative competitive position of the domestic firms with respect to foreign firms. The economic and institutional environment affects a firm's investment behaviour, which, in turn, changes the firm's cost and productivity. Although the effect process can be complicated, the final consequence is the impact on a firm's cost of production. Therefore, the cost estimation is a good way to examine the effect.

5.1.1 Model Specification

In the spirit of Baltagi and Griffin (1988), we specify a translog cost function with a general index of technical change A(t). Actually, A(t) is used to replace T the time trend representation of technical change in many translog cost function specifications. The cost is a function of output, input prices, quasi-fixed capital and the economic and institutional environment variables: exports, financial interpenetration between firms, and financial interpenetration between firms and banks. The legal system is excluded because it is relatively stable during the study period. Import penetration is excluded from the cost function because tariff and non-tariff barriers make its pressure effect difficult to quantify. However, import penetration, as well as some trade barriers, are taken into account when empirical results are analyzed.

We have explicitly discussed the concept of hardware and software technology in chapter 4. Hardware technology is closely related to machinery and equipment which is relative quasi-fixed in the short run, while software technology is closely related to organization aspect of a firm which is comparatively more flexible. Taking capital as quasi-fixed, we have a cost function with three variable inputs: labour, materials and energy. That is

$$
\begin{aligned}
\ln C(Y,W,K,A(t),q) = {} & \alpha_0 + A(t) + \sum_i \alpha_i \ln W_i + \alpha_k \ln K + \gamma \ln Y + \sum_m \beta_m q_m \\
& + \frac{1}{2}\sum_i \sum_j \alpha_{ij} \ln W_i \ln W_j + \frac{1}{2}\sum_m \sum_n \beta_{mn} q_m q_n + \frac{1}{2}\gamma^* (\ln Y)^2 \\
& + \sum_i \Phi_i A(t) \ln W_i + \sum_m \varphi_m A(t) q_m + \sum_i \psi_i \ln W_i \ln Y + \sum_m \omega_m \ln Y q_i \\
& + \sum_i \zeta_i \ln Y q_m + \theta A(t) \ln Y + \sum_i \sum_m \rho_{im} \ln W_i q_m \\
& + \frac{1}{2}\alpha_{kk} (\ln K)^2 + \sum_i \alpha_{ik} \ln W_i \ln K + \phi_k A(t) \ln K \\
& + \psi_k \ln K \ln Y + \rho_{km} \ln K\, q_m
\end{aligned}
\tag{5.10}
$$

Assuming perfect competition in the input market and cost minimization behaviour, share equations are obtained by using Shephard Lemma,

$$
S_i = \alpha_i + \alpha_{ik} \ln K + \sum_j \alpha_{ij} \ln W_j + \phi_i A(t) + \psi_i \ln Y + \sum_m \rho_{im} q_m, \quad i = L, M, E \tag{5.11}
$$

Where

i, j - index for input prices, L, M, E
m, n - index for economic and institutional environment

variables EX, FF, BF, m,n=1,2,3
Y - output
W_i - input price, W_L, W_M, W_E
q_m - firm's environment variable, q_1=EX, q_2=FF, q_3=BF

Direct estimation of the above functions is impossible since A(t) is not observable and must be estimated. Following Baltagi and Griffin (1988), by using time-specific dummy variable for 1966-86 (D_t), an equivalent function can be estimated.

$$\begin{aligned}\ln C(Y,W,K,q,D_t) = &\sum_t \eta_t D_t + \sum_t \sum_i \alpha^*_{it} lnW_i D_t + \sum_t \alpha^*_{kt} lnK D_t + \sum_t \theta^*_t D_t lnY \\ &+ \sum_t \sum_m \varphi^*_{mt} D_t q_m + \frac{1}{2}\sum_i \sum_j \alpha_{ij} lnW_i lnW_j + \frac{1}{2}\sum_m \sum_n \beta_{mn} q_m q_n \\ &+ \frac{1}{2}\gamma^* (lnY)^2 + \sum_i \psi_i lnW_i lnY + \sum_i \sum_m \rho_{im} lnW_i q_m + \sum_m \varpi_m lnY q_m \\ &+ \frac{1}{2}\alpha_{kk} (lnK)^2 + \sum_i \alpha_{ik} lnW_i lnK + \psi_k lnK\, lnY + \sum_m \rho_{km} lnK\, q_m \end{aligned} \quad (5.12)$$

With the corresponding share equations

$$S_i = \sum_t \alpha^*_{it} D_t + \alpha_{ik} lnK + \sum_j \alpha_{ij} lnW_j + \psi_i lnY + \sum_m \rho_{im} q_m, \quad i=L,M,E \quad (5.13)$$

The above two sets of functions are equivalent if and only if

$$\begin{aligned} \eta_t &= \alpha_0 + A(t) \\ \alpha^*_{it} &= \alpha_i + \Phi_i A(t) \\ \alpha^*_{kt} &= \alpha_k + \phi_k A(t) \\ \theta^*_t &= \gamma + \theta A(t) \\ \varphi^*_{mt} &= \beta_m + \varphi_m A(t) \end{aligned} \quad (5.14)$$

The estimate of A(t) can be derived by imposing the above restrictions on the second set of equations. Furthermore, taking the initial year as the base year for A(t), i.e.

A(1)=0, allows us to identify α_0, α_i, α_k, γ, β_m.

Furthermore, technical change is

$$\dot{T} = A(t)-A(t-1)+\sum_i \phi_i[A(t)-A(t-1)]\ln W_i+\phi_k[A(t)-A(t-1)]\ln K$$
$$+\theta[A(t)-A(t-1)]\ln Y$$

That is, technical change can be decomposed into three components: the effects of pure technical change, A(t)-A(t-1); the effects of non-neutral technical change, $\Sigma\phi_i$[A(t)-A(t-1)]lnW_i+ Φ_k[A(t)-A(t-1)]lnK, and; the effects of scale augmentation, θ[A(t)-A(t-1)]lnY. This is similar to the case in a translog cost function with a time trend representation of technical change.

The homogeneity and symmetry conditions are

$$\begin{aligned} &\sum_i \alpha_i=1 \\ &\sum_i \alpha_{ij}=\sum_j \alpha_{ji}=0 \\ &\sum_i \phi_i=0 \\ &\sum_i \psi_i=0 \\ &\sum_i \rho_{im}=0 \\ &\alpha_{ij}=\alpha_{ji} \\ &\beta_{mn}=\beta_{nm} \end{aligned} \qquad (5.15)$$

We have used likelihood ratio tests to test the above specification of the translog cost function against others. In particular, we tested against the specification of translog cost function with sector specific constant terms and sector specific terms for capital stock. These tests can not reject the translog cost function specified above.

5.1.2 Data Description

The most disaggregated data available for this study are the data of the two-digit (Standard Industrial Classification SIC) manufacturing industries in Canada. All data are converted into 1970 SIC. These data include output, labour, capital stock, materials, energy, exports, financial interpenetration between firms, and financial interpenetration between firms and banks. The main data sources are Statistics Canada. Due to the availability and reliability of the data, we have selected 17 two-digit manufacturing industries between 1966 and 1986. They are

Food and Beverage (F&B)
Rubber and Plastics Products Industries (Rub)
Leather (Leath)
Textile Industries (Text)
Knitting Mills (Knit)
Clothing Industries (Cloth)
Wood Industries (Wood)
Furniture and Fixture Industries (Furn)
Paper and allied industries (Paper)
Primary metal industries (Prim)
Metal Fabricating (MetalF)
Machinery industries (Mach)
Transportation equipment industries (Transp)
Electrical Products (Elect)
Non-metallic mineral products industries (Non-Met)
Petroleum and Coal products (Petrol)
Chemical and chemical products industries (Chem)

Details and data on these sectors are given in Appendix A. Gross output is measured as the total activities shipments and converted to real output by deflating it with the output price index from Statistics Canada. Cost of labour is measured as the total wages and salaries paid to production workers and other related workers. Price of labour is calculated as cost per hour and normalized to one for the same base year as for materials and energy. Capital stock is calculated by the perpetual inventory method by a benchmark capital stock and constant investment data from Statistics Canada. Cost of materials is measured as the total expenses on materials. The price index of materials is the gross domestic product index. Cost of energy is measured as the expenses on fuel and electricity. The price index is calculated as the Divisia index of different components. The cost shares of labour, materials and energy are obtained as the ratios of their respective cost to the total costs (of labour, materials and energy).

Firms' economic and institutional environment variables include exports (EX), financial interpenetration between firms (FF), and financial interpenetration between firms and banks (BF). The export variable is defined as export divided by the total shipments of an industry. Financial interpenetration between firms as the ratio of all firms' investment in their affiliated firms divided by total long-term assets in the industry. Financial interpenetration between firms and banks is the long-term bank loans to the industry divided by total long-term liability of the industry. Import penetration and trade barriers (tariff and non-tariff barriers) are often incorporated when the effect of institutional environment variables is discussed.

5.2 Empirical Estimation

The cost equation and share equations are estimated simultaneously to increase the efficiency of the estimated coefficients. With a data set of 357 observations, estimation of the cost function is performed by using the iterative Zellner efficient estimation method on a system of two cost shares (labour and energy) plus the cost function. By the Zellner efficient estimation method, the estimated coefficients are invariant to which share equation is deleted from the system of equations. The usual symmetry restriction and homogeneity restriction are imposed in the estimation. Materials cost share equation is excluded because of the adding-up property of cost shares. The preliminary estimation indicates the existence of autocorrelation. The final estimation takes into account autocorrelation with a reduced data set of 340 observations (each industry is reduced by one observation). The estimated autocorrelation coefficient for each industry is calculated from the estimated residuals from the preliminary iterative Zellner efficient estimation (Maddala, 1977). With the estimated autocorrelation coefficients, we reestimate the system of 3 equations with iterative Zellner efficient estimation, with the 1967's general index of technical change A(67) set to zero.

Estimated coefficients are given in table 5-1[2]. Among 62 estimated coefficients, 51 are significant. The translog cost function satisfies the monotony condition. However, concavity is violated[3].

We also computed and performed significance tests[4] on the shadow value of capital ($\partial C/\partial K$), the cost elasticity of exports ($(\partial C/\partial EX)(EX/C)$), the cost elasticity of financial interpenetration between firms ($(\partial C/\partial FF)(FF/C)$) and the cost elasticity of financial interpenetration between firms and banks ($(\partial C/\partial BF)(BF/C)$). The results are discussed in the next section (section 5.3).

---

[2]Nonlinear estimation can be sensitive to different starting values; however, we found that our results are robust to alternative starting values. We also used sector specific dummy variables to test the robustness of the model with respect to differences in technologies between sectors. All tests allow us to accept the cost function as specified.

[3]Concavity violations are often observed in econometric cost function estimations. Although it may be disturbing theoretically, in many studies it is showed that the violation does not affect other results. For example, Fuss and Waverman (1990a) estimate the time trend translog cost function for the motor vehicle industry in U.S. and Japan. They find autocorrelation in the share equations and the violation of concavity. They make a reestimation by imposing parameter constraints to ensure concavity and adding a first-order autocorrelation specification for the share equations. The reestimation finds that the cost and efficiency comparisons are not affected by the imposition of concavity. Gagné and Ouellette (1994) investigate the behaviour of three of the flexible functional forms used in applied econometrics, the translog, the symmetric McFadden and the symmetric generalized Barnett. Using Monte Carlo simulations, they assess the ability of these forms to test theoretical properties and to measure technological characteristics. It is found that although the elasticities of substitution and the curvature with a translog cost function specification often diverge from theoretic properties, other measurements are quite reliable. This is consistent with Fuss and Waverman (1990a), where imposing concavity on the translog cost function does not affect the main results.

[4]Based on the method given in Toevs (1982), we calculated the variance and t-ratio, by which we can know the significance of the estimated elasticities. Toevs derives the approximate variance formulas based on the first-order Taylor's approximation to the true but unknown variance.

Table 5-1 Estimates of the Coefficients of the cost function

Variable	COEFFICIENT	Estimate	T-RATIO
const	α_0	-4.0065	-1.540
General Index of Technical Change: for 1967-1986			
	A(68)	-1.2043	-2.437
	A(69)	-1.3954	-2.653
	A(70)	-0.6991	-1.495
	A(71)	-1.4526	-2.562
	A(72)	-0.8647	-1.936
	A(73)	-1.3700	-2.760
	A(74)	-1.4234	-2.388
	A(75)	-1.0058	-2.199
	A(76)	-1.3967	-2.666
	A(77)	-1.7272	-2.851
	A(78)	-2.2372	-3.136
	A(79)	-1.6778	-3.099
	A(80)	-1.5681	-3.089
	A(81)	-1.2518	-2.645
	A(82)	-2.2632	-3.255
	A(83)	-1.5373	-3.036
	A(84)	-2.0672	-3.125
	A(85)	-2.1029	-2.925
	A(86)	-3.3667	-3.283
$0.5(LnK)^2$	α_{KK}	0.1369	3.838
$(LnW_L)(LnW_M)$	α_{LM}	-0.2162	-73.808
$(LnW_L)(LnW_E)$	α_{LE}	-0.0030	-2.847
$(LnW_M)(LnW_E)$	α_{ME}	-0.0133	-5.413
$(LnK)(LnW_L)$	α_{KL}	-0.0309	-7.092
$(LnK)(LnW_E)$	α_{KE}	0.0227	14.156
$0.5(LnY)^2$	γ^*	-0.0151	-4.081
$(lnK)(LnY)$	Ψ_K	-0.0752	-3.218
$Ln(W_M)(LnY)$	Ψ_M	0.0704	10.516
$Ln(W_E)(lnY)$	Ψ_E	-0.0166	-8.292
LnK	α_K	-0.4509	-1.610
LnW_L	α_L	1.3870	16.630
LnW_E	α_E	0.0090	0.355
LnY	γ	1.8224	6.334
A(t)LnK	Φ_K	0.0696	2.565
$A(t)LnW_L$	Φ_L	0.0236	2.910
$A(t)LnW_E$	Φ_E	-0.0008	-0.450
A(t)LnY	θ	-0.1270	-5.955

Table 5-1 Estimates of the Coefficients of the cost function (Cont'd)

Variable	COEFFICIENT	Estimate	T-RATIO
EX	$\beta 1$	3.9483	3.410
FF	$\beta 2$	0.1671	0.152
BF	$\beta 3$	1.9586	1.921
A(t)EX	φ_1	-0.0368	-0.412
A(t)FF	φ_2	0.3681	2.243
A(t)BF	φ_3	0.4698	2.440
$0.5(EX)^2$	β_{11}	-0.1317	-0.227
$0.5(FF)^2$	β_{22}	-0.8344	-1.190
$0.5(BF)^2$	β_{33}	1.9705	3.464
(EX)(FF)	β_{12}	-1.0531	-2.240
(EX)(BF)	β_{13}	-0.3994	-1.318
(FF)(BF)	β_{23}	1.0251	2.567
(EX)LnY	$\zeta 1$	-0.2322	-3.088
(FF)LnY	$\zeta 2$	-0.0988	-0.746
(BF)Ln(Y)	$\zeta 3$	-0.2245	-2.169
(EX)LnK	ρ_{K1}	-0.0195	-0.871
(FF)LnK	ρ_{K2}	0.1903	1.806
(BF)LnK	ρ_{K3}	0.1500	1.833
(EX)LnW_L	ρ_{L1}	0.5673	3.623
(FF)LnW_L	ρ_{L2}	-0.0008	-0.053
(BF)LnW_L	ρ_{L3}	-0.0155	-1.426
(EX)LnW_M	ρ_{M1}	-0.0583	-3.486
(FF)LnW_M	ρ_{M2}	0.0050	0.334
(BF)LnW_M	ρ_{M3}	0.0126	1.095

Log(L)= 3169.192
Chi-Square (χ^2)= 5086.80
Adjusted R^2 : 0.9994 for cost function; 0.9640 for labour cost share; 0.8047 for energy cost share
No. of Coefs: 62
No. of Obs.: 340

5.3 Empirical Results

We will first discuss briefly some standard results. Then, we will discuss extensively the results associated with the effect of economic and institutional environment variables, which is the major objective of this study.

The estimated returns to scale are generally between 1 and 2, with some industries having a value less than one in some years. It is found that relatively capital intensive industries have relatively higher returns to scale. This result is consistent with other studies. Frank et al (1988) show that the return to scale for pulp and paper industry is between under one to over two (most are between 1 and 2), depending on model specification. With a translog cost function, Frank et al (1988) estimate a return to scale of 1.7 for the pulp and paper industry, comparing to around 1.6 of our estimation for the paper and allied industries. Mohnen et al (1993) estimate a return to scale of 1.43 for the pulp and paper industry and 1.39 for wood industry. Our estimate for the return to scale for the wood industry is around 1.4. Fuss and Waverman (1990b) find a return to scale of 1.17 for the Canadian motor vehicle industry. Using a translog cost function with a time trend for technical change index, Afza (1988) estimates, with data between 1960 and 1984, a return to scale of 10 for Canada (this unreasonably high return to scale may be due to other factors) and 1.8 for the U.S. for the automotive assembly industry, and 1.22 for Canada and 1.33 for the U.S. for the automotive parts industry. Our estimation of the return to scale for transportation equipment industry is approximately 1.6.

As for the shadow value of capital stock, it has the expected sign in most industries, although there are a few industries having small negative significant value. The negative value occurs in a few industries with a relative high capital intensity, such as paper and allied products, primary metal, non-metallic products, petroleum and coal products, chemicals and chemical products. This may be due to overcapacity or some machinery and equipment obsoleteness in some industries during the 1970s. This is often due to that a firm needs time to adjust its equipment.

Industries with estimated total factor productivity growing during the 1967-86 period include food and beverage, textile, clothing, wood, machinery, primary metal, transportation equipment, non-metallic products, petroleum and coal products, chemical and chemical products; Industries with estimated total factor productivity decreasing during 1967-86 include rubber and plastics, leather, knitting mills, furniture, metal fabricating, and paper and allied industries, and electrical products. The total factor productivity of the manufacturing industry as a whole, as an average of the 17 industries, increases during 1967-1986. Although we do not find a completely comparable calculation, our comparison with some available studies show basic consistency of our results with others. Frank et al (1988) find an average TFP growth rate of 0.13% during 1973-80 for the pulp and paper industry (about 80% of total paper and allied industries), which is quite consistent with our 0.61% for paper and allied industries during 1973-81. Mohnen et al (1993) estimate a TFP growth rate of 1.24% for wood industry between 1965 and 1988, while our estimate is 1.04% between 1967 and 1986. Fuss and Waverman (1990b) estimate, with a standard time trend translog cost function, an average TFP growth rate of 1.2% during 1970-1984 for the Canadian motor vehicle industry, which is consistent with our estimates of 2.30% for the transportation equipment industry.

Our estimation also shows that total factor productivity growth is mainly due to scale economy. Most sectors did not experience technological progress during 1967-86. Our results are consistent with Daly and MacCharles (1986) who show that the productivity gaps between Canada and U.S. in manufacturing industries are due to small and short production runs in Canada. Canadian manufacturers have easy access to technologies available in the United States. Using a translog cost function with a time trend, Afza (1988) finds that technical change has a cost increasing effect on Canadian automotive assembly industry, and a cost reducing effect on Canadian automotive parts industry, while the effects for the American counterpart industries are cost-reducing. Detailed results on the total factor productivity are given in Appendix B.

As for elasticities of substitution, in most industries their own substitution elasticities are positive for labour and materials and their own substitution elasticities are negative for energy. As an average of the 17 industries, the manufacturing industry has a positive own substitution elasticity for labour, a small positive own substitution elasticity for materials, and a negative own substitution elasticity for energy. The unsatisfactory sign of the own elasticities of substitution is not likely to affect the validility of other results (see footnote 2).

5.3.1 The Effect of Firm's Environment Variables

The objective of this study is to examine the effect of a firm's economic and institutional environment on its investment behaviour and, in turn, on its cost of production and competitiveness. In chapter 4, the theoretical analysis shows that the environment variables affect a firm's investment behaviour, but the direction of the effect is undetermined unless more specific conditions are specified. The estimation here confirms the prediction of the theoretic part in the sense that the environment variables exert a significant effect on cost, and the direction of the effect varies across sectors. In order to examine the effect of environment variables, we classify the sectors by their exposure to external competition, and the tariff protection. Based on the classification in "The Sectoral and Regional Sensitivity of Ontario Manufacturing Industries to Tariff Reductions - Canada-US Free Trade Agreement" (Government of Ontario, 1987), we classify the exposure to external competition[5] as follows.

---

[5]We distinguish the concept of external competition and external competitive pressure in the following discussion. The external competition means the degree of a firm's exposure to competition, while the external competitive pressure means the degree of real pressure which results from the competition. Some firms may be exposed to competition, but the pressure from the competition is low because of its relative good competitive advantage. The pressure is the factor which affects the motive of two firms' cooperation: invest to upgrade their technology or maintain their monopoly profit.

1) Ex<20% and Im<20%: low active and low passive exposure to external competition

2) Ex<20% and Im>20%: low active and high passive exposure to external competition

3) Ex>20% and Im<20%: high active and low passive exposure to external competition

4) Ex>20% and Im>20%: high active and high passive exposure to external competition

As far as each sector's exposure to real competitive pressure is concerned, it is determined by the sector's relative market position, export, import, tariff and non-tariff barriers. For example, the high tariff and non-tariff barriers reduce the competitive pressure from import exposure. Therefore, we further classify the sectors by incorporating other factors to obtain the adjusted external competitive pressure, taking account of tariff and non-tariff barriers, the endowment advantages of sectors, etc.

Table 5-2 summarizes the characteristics of all sectors, in particular, the tariff, economic environment in terms of export and import as well each sector's total shipments to its Canadian market ratio. These characteristics will be considered when we evaluate the competitive pressure faced by each sector.

---

the competition is low because of its relative good competitive advantage. The pressure is the factor which affects the motive of two firms' cooperation: invest to upgrade their technology or maintain their monopoly profit.

Table 5-2 The Economic Environment of all Sectors, 1967-1986

Industry	EX (%)	IM (%)	Tariff (%)	SH/CM (%)
F&B	<20	<20	6.2	102.4
Cloth	<20	<20	21.5	92.7
Furn	<20	<20	17.6	97.8
MetalF	<20	<20	11.9	91.1
Non-Met	<20	<20	6.9	91.8
Petrol	<20	<20	1.7	102.8
Rub	<20	>20	13.7	88.4
Leath.	<20	>20	18.4	73.6
Text	<20	>20	12.5	79.2
Knit	<20	>20	25.3	72.3
Elect	<20[a]	>20	12.0	78.3
Chem	<20[a]	>20	8.5	91.1
Wood	>20	<20	4.2	173.3
Paper	>20	<20	6.8	200.7
Prim	>20	>20	6.5	135.8
Mach	>20	>20	8.9	53.5
Transp	>20	>20	3.2	96.6

Note: a - Ex>20% since 1979 for electrical products industry and since 1977 for chemical industry respectively

SH/CM - ratio of a sector's total shipments to the Canadian market value of that sector between 1966 and 1984

Tariff rates are from Lester and Morehen (1988), the non-tariff equivalent for food and beverage industries is 6.9% (such as restrictions on imported alcoholic beverages)

In the following sub-sections, we will examine the impact of the environment variables: exports, financial interpenetration between firms, and financial interpenetration between firms and banks. Sectors are divided into three groups according to their exposure to external competitive pressure. However, the criterion used to classify sectors is different between the case of the effect of exports and the cases of the effect of financial interpenetration between firms and financial interpenetration between firms and banks. In the case of the effect of exports, sectors are classified according to the external competitive pressure in the export market (associated with exporting). In the case of the effect of financial interpenetration between firms and financial interpenetration between firms and banks, sectors are classified according to competitive pressure (a sector faces) associated with both exporting and import penetration.

1) Analysis of the Cost Elasticity of Export Orientation

The cost elasticity of exports is the proportional change in cost divided by the proportional change in exports, i.e. $(\partial C/\partial EX)(EX/C)$. The term exports is defined as the ratio of export and total shipment of the sector.

The analysis in chapter 4 showed that a firm's export may exert either positive or negative impact on its technology investment and, in turn, its cost of production, depending on the degree of its exposure to external competitive pressure associated with exporting. When a firm is actively exposed to a market with high external competitive pressure, exports are likely to have a favourable impact on investment and costs of production. With low external competitive pressure, exports are not likely to exert any favourable impact on the cost of production.

Many factors determine a firm's exposure to external competitive pressure. A firm may export to capture a specialized market niche by its special design features, therefore face little direct competitive pressure; a firm may export due to a given endowment advantage (such as Canadian resource-based industries) or its dominant technology position, and face low competitive pressure; a firm may export actively and face relatively strong competitive pressure, which presses it to actively update its technology.

According to the characteristics of the sectors given in table 5-2, sectors are divided into three groups by their exposure to external competitive pressure from exports: sectors exporting and facing low external competitive pressure, resource-based, and sectors exporting and facing high external competitive pressure. The sectors facing low external competitive pressure are sectors with relatively high tariff, low export and low import penetration, or with a low shipment to Canadian market ratio. An example of the latter is the machinery industry which traditionally relies on imports to meet demand (Carmichael, 1978); its shipment (including exports) to Canadian market ratio is around 50 per cent. This may indicate that the machinery industry exports to non-competitive markets while import is from competitive markets and exerts low competitive pressure.

For electrical products and chemical products industries (the border line sectors), their exports increased to more than 20 per cent by the late 1970s (1979 for electrical products industry and 1977 for chemical products industry); in the electrical products industry its export had continuous increased during the study period while in the chemical products industry its export kept increasing until 1980 and then started decreasing. Therefore, we treat the chemical product industry as facing low external pressure, but we divide the electrical products industry into two parts according to the competitive pressure it faced: the first part before late 1970s when facing low competitive pressure and the second part after the late 1970s when facing high competitive pressure.

Our findings on the cost elasticity of exports (ε_{ex}) are summarized in table 5-3. Detailed results for each sector for the period 1967-1986 are given in Appendix B.

The first group consists of sectors which export and face low external competitive pressure. Most of these sectors are protected by relatively high tariffs. A firm's export may be to target a niche market, and avoid strong competition. The export has a positive or neutral impact on cost. As for the food and beverage industry, which has a tariff rate of 6.2 per cent plus a tariff equivalent of quantitative restrictions of 6.9 per cent, the export has no significant effect. However, competition as well as competitive pressure from U.S. have been increasing. Both export and import in the sector kept increasing during the study period with export exceeding import.

The second group consists of the resource-based sectors, which have a relative high shipment to Canadian market ratio. These sectors are Canada's traditionally export-oriented industries (Carmichael, 1978) and have relatively strong endowment advantages. For example, in 1984, the total shipments are twice the Canadian market for wood, and paper and allied industries (three times for pulp & paper). Therefore, these sectors face low external competitive pressure when exporting. The export in these industries does not exert a favourable impact on the cost of production.

Table 5-3 Cost Elasticity of Exports, 1967-86

Industry	Tariff(%)	Sign & Significance
1. Sectors exporting and facing low external competitive pressure		
F&B	6.2	(-)
Cloth	21.5	(+)*
Furn	17.6	(+)*
MetalF	11.9	(B)
Non-Met	6.9	(+)
Rub	13.7	(+)*
Leath.	18.4	(+)*
Text	12.5	(+)
Knit	25.3	(+)*
Mach	8.9	(+)*
Elect[a]	12.0	(+)
Chem	8.5	(B)
2. Resource-based sectors		
Wood	4.2	(+)*
Paper	6.8	(-)
Prim	6.5	(B)
Petrol	1.7	(+)
3. Sectors exporting and facing high external competitive pressure		
Elect[b]	12.0	(-)*
Transp	3.2	(-)*

Note: 1. Notations: (+) positive; (-) negative; (B) positive and negative; * significant

2. a the sector before the late 1970s
b the sector after the late 1970s

The third group consists of sectors which export and face high external competitive pressure. For the whole study period, the transportation equipment industry faced high external competitive pressure, and the export exerted a favourable impact on cost.

Generally speaking, the result for the cost elasticity of exports supports the prediction in chapter 4: if a firm's export is due to previously given advantages and the firm faces low external competitive pressure, the export is not likely to have a negative (favourable) impact on cost; if a firm exports to a market with relatively high competitive pressure, the export is likely to exert a negative (favourable) impact on cost. In practice, it appears that the transportation equipment industry was the sole industry where such conditions were unambiguously met over the whole period.

2) Analysis of the Cost Elasticity of Financial Interpenetration between Firms

The cost elasticity of financial interpenetration between firms is the proportional change in cost divided by the proportional change in the financial interpenetration between firms, i.e. $(\partial C/\partial FF)(FF/C)$. Financial interpenetration between firms is defined as the ratio of all firms' investments in their affiliated firms to the total long-term assets in a sector.

As shown in chapter 4, financial interpenetration between firms induces their cooperations directly, and affects their investment behaviour and in turn the cost of production. When cooperative firms are closely related (having complementary technologies), cooperation increases their investment externality (β) and improves their investment efficiency (γ), resulting in higher technology investments. However, different competitive pressures influence the motivations of their cooperations. Under low competitive pressure, their cooperation tends to be more often in diversification to unrelated businesses. Therefore, financial interpenetration is likely to reduce firms' technology investments. Under relatively high competitive pressure, financial interpenetration between firms tends to induce cooperation of firms in closely related businesses, and to increase firms' technology investments. In our empirical study here, the competitive pressure[5] could result from both active export and import, especially when tariff and non-tariff protections are low. We will examine if the empirical results are consistent with the analysis in chapter 4.

As for a firm's exposure to competitive pressure, classification of sectors is different from the case in the elasticity of exports, as indicated at the beginning of this section (section 5.3.1). When analyzing the effect of exports, we divided sectors by the external competitive pressure resulting from a firm's export (in export market). When discussing the effect of financial interpenetration

[5]When discussing the elasticity of export orientation, we refer to the external competitive pressure from firms' active exposure in the exported market. Here, we refer to the competitive pressure which can be from both firms' active export or import penetration of foreign firms when tariff and non-tariff barriers are low.

between firms, we divide sectors by the external competitive pressure resulting from both exports and imports. When a sector has a relatively high export and a high import penetration (and protection is low), a rational firm will normally expect that it is in a highly contestable or competitive market and faces high competitive pressure. This is especially so since the late 1970s when globalization increased quickly. For example, there was a sevenfold increase in the volume of world trade between 1970 and 1987 (Johnston, 1990). By their exposure to external competitive pressure or a contestable market, sectors are divided into three groups: sectors facing low competitive pressure or being in a low contestable market, resource-based sectors, and sectors facing high competitive pressure or being in a highly contestable market. The electrical products industry is divided into two parts: before and after the late 1970s. This industry started to face high competition or be in a highly contestable market in the late 1970s.

As for the first group of sectors, with low competitive pressure or in a less contestable market, financial interpenetration between firms exerts unfavourable or no significant impact on the cost of production.

Table 5-4 Cost Elasticity of Financial Interpenetration between firms, 1967-86

Industry	Tariff	Sign and Significance
1. Sectors facing low competitive pressure or in a low contestable market		
F&B	6.2	(+)*
Cloth	21.5	(B)
Furn	17.6	(+)*
MetFab	11.9	(+)*
Non-Met	6.9	(+)*
Rub	13.7	(+)*
Leath.	18.4	(B)
Text	12.5	(+)*
Knit	25.3	(+)*
Elect[a]	12.0	(+)*
Chem	8.5	(+)*
2. Resource-based sectors		
Wood	4.2	(B)
Paper	6.8	(B)
Prim	6.5	(B)
Petrol	1.7	(+)*
3. Sectors facing high competitive pressures or in a highly contestable market		
Elect[b]	12.0	(-)*
Mach	8.9	(-)*
Transp	3.2	(-)*

Note: 1. Notations: (+) positive; (-) negative; (B) with positive and negative; * significant
2. a before the late 1970s; b after the late 1970s

The second group is composed of the resource-based sectors. These sectors have strong endowment advantages, and face low competitive pressure. Financial interpenetration between firms exerts unfavourable or no significant impact on costs.

The third group faces high competitive pressure or is in a highly contestable market. With negative cost elasticities of financial interpenetration between firms, the financial interpenetration has favourable impact on the cost of production.

The empirical results here are consistent with the prediction in the theoretic part of chapter 4: financial interpenetration between firms induces cooperation between firms and the motivation of the cooperation is influenced by the level of competitive pressure, different motivations affect the technology investment and in turn the cost of production differently. Under relatively high competitive pressure, cooperation tends to be among firms with closely related businesses. As a result, the financial interpenetration between firms exerts a favourable impact on cost. On the other hand, under relatively low competitive pressure (in a less contestable market), financial interpenetration between firms is likely to exert unfavourable or no significant impact on cost.

3) Analysis of the Cost Elasticity of Financial Interpenetration between Firms and Banks

The cost elasticity of financial interpenetration between firms and banks is the proportional change in cost divided by the proportional change in the financial interpenetration between firms and banks, i.e. $(\partial C/\partial BF)(BF/C)$. Financial interpenetration between firms and banks is defined as the ratio of the long-term bank loans to a sector divided by total long-term liability of the sector.

As discussed in chapter 3, the financial system has two important roles in influencing a firm's investment behaviour, and, in turn, its cost of production. One is to provide a firm with needed financing at low cost; another is to provide firms with relevant information and to coordinate different firms' investments, such as helping firms to make good use of their complementary technologies. In section 4.3 of chapter 4, we discussed differences in the mechanisms by which financial interpenetration between firms and financial interpenetration between firms and banks affect firms' investments. In the case of financial interpenetration between firms and banks, firms have certain cooperative relationships because of or through banks' involvement. Both competitive pressure and the way banks are involved influence the impact of financial interpenetration between firms and banks. The influence of competitive pressure is similar to financial interpenetration between firms. Under high competitive pressure, firms tend to cooperate with closely related businesses and focus more on enhancing the competitiveness of their core operation. As a result, the effect tends to be favourable.

Banks's involvement may either make firms with closely related businesses cooperate or make firms with unrelated businesses cooperate. As a result, the effect of financial interpenetration between firms and banks is influenced differently. If banks' involvement is to make firms with closely related businesses cooperate, the effect tends to increase firms' investment efficiency (γ) and their externality (β), resulting in higher technology investments. If banks' involvement is to make firms with unrelated businesses cooperate, the effect is likely to reduce firms' investments. Real world examples were given in section 3.3 of chapter 3 about American banks' involvement in mergers and acquisitions in the late 1960s. We will examine our empirical results and compare them with our theoretic analysis.

Here, we quantify the bank's involvement by a measure called financial interpenetration between firms and banks, as defined at the beginning of this subsection. Although this measure is not a sufficient condition for a bank's active involvement in a firm's investment decision, it is a necessary condition in most cases if there is a bank's involvement. For example, long-term bank loans to a well-performing, profitable firm may just be market transactions. On the other hand, long-term bank loans to a firm in trouble due to strong competitors may indicate that the bank is actively involved in the firm's investment or restructuring decisions.

The result on cost elasticities of financial interpenetration between firms and banks is summarized in table 5-5. As discussed in the case of the elasticity of financial interpenetration between firms, sectors are divided into three groups: sectors facing low competitive pressure or being in a less contestable market, resource-based sectors, and sectors facing high competitive pressure or being in a highly contestable market.

Models in chapter 4 imply different impacts of financial interpenetration between firms and banks depending on whether two cooperative firms are in closely related businesses. In order to verify if our empirical results conform with the prediction, each sector is further divided into two sub-periods (1967-76 and 1977-86). We do this for two reasons. First, there are two types of merger and acquisition activities during the study period. The first type is the conglomerate merger wave of the 1960s which was to increase the extent of firms' diversification and peaked in early 1970s. The second type is the divestiture wave of the merger and acquisition activities from the mid-1970s. As Ravenscraft and Scherer (1987) documented, by the mid-1970s conglomerate firms began to divest the unrelated lines of business they had acquired during the 1960s. A substantial fraction of corporate control transactions in the 1970s were divestitures of previously-acquired units, i.e. the "back to basics" restructuring. Many banks actively involved themselves in firms' merger and acquisition activities (Chandler, 1990). To summarize, mergers and acquisitions during the first subperiod were among firms with less related businesses while mergers and acquisitions during the second subperiod were among firms with more closely related businesses.

Secondly, the division of the study period into two subperiods makes our results comparable to other similar studies. For example, Ravenscraft and Scherer (1987) discuss the impact of merger and acquisition activities on firms' performance. Their results will be compared to the results in this chapter.

The results in table 5-5 seem to be consistent with the theoretic prediction in chapter 4. The effect depends on whether a firm's diversification is related to its core business and on a sector's exposure to external competitive pressure. As discussed above, during the two subperiods (1967-1976 and 1977-1986), merger and acquisition activities were different types: mergers among firms with less related businesses during the first subperiod and among firms with relatively related businesses in the second subperiod. The models in chapter 4 imply different effects for the two subperiods. This is confirmed by the empirical results, which are documented as follows.

Cost elasticities for most sectors are significant in the second sub-period; there are more unfavourable impacts than favourable ones during the first sub-period; there are more favourable impacts than unfavourable ones during the second sub-period. There are more favourable impacts in the second subperiod than in the first subperiod. For example, favourable impacts occur in 79.8 per cent of sectors in the second subperiod while in only 29.6 per cent of sectors in the first subperiod.

The empirical results also show that differences in competitive pressures cause different impacts. Under high competitive pressure, the effect tends to be favourable in more sectors. For example, for the second subperiod, the effect is favourable in 76.7 per cent of all sectors in the first group, while in 84 per cent of all sectors in the third group. For the first subperiod, the difference is even more significant: the effect is favourable in 13.5 per cent of all sectors in the first group, while in 83.3 per cent of all sectors in the third group. As discussed in chapter 4, this may be due to the fact that under high competitive pressure, managers' intention focuses more on the firm's core business operation. Even when the firm tends to diversify, it is more often in closely related businesses. These are the cases for machinery industry, transportation equipment industry, and primary metal industry.

Our results are consistent with the reality of the characteristics of merger and acquisition activities in North America, as well as with other studies. Ravenscraft and Scherer (1987) analyze the impact of merger and acquisition on firm's efficiency. They find that on average efficiency losses resulted from mergers in the 1960s and early 1970s, and that some efficiencies did result from mergers during the second round of mergers. During the second round of mergers, the activity is divestitures or sell-offs by an earlier acquirer who sold unrelated businesses. Although the study is for the U.S., it is applicable to Canada because the merger activity in Canada mirrors that in the U.S. (Green, 1990).

Table 5-5 the Cost Elasticity of Financial Interpenetration between Firms and Banks during the two Sub-periods

Industry	1967-776		1977-86	
	Total Signif	Neg Signif	Total Signif	Neg Signif
1.Sectors facing low competitive pressure or in a less contestable market				
F&B	1	0	4	4
Cloth	5	5	9	9
Furn	3	0	5	5
MetalF	2	0	5	2
Non-Met	9	0	6	1
Rub	3	0	6	4
Leath.	1	0	4	1
Text	3	0	7	7
Knit	5	0	4	4
Elect[a]	2	0		
Chem	3	0	6	6
Sub Total	**37**	**5**	**56**	**43**
Neg as % of the total		**13.5**		**76.7**
2.Resource-based sectors				
Wood	2	1	6	4
Paper	1	0	6	4
Prim	1	0	9	9
Petrol	1	0	7	6
Sub Total	**5**	**1**	**28**	**23**
Neg as % of the total		**20**		**82.1**
3.Sectors facing high competitive pressure or in a highly contestable market				
Elect[b]			7	3
Mach	5	4	8	8
Transp	7	6	10	10
Sub Total	**12**	**10**	**25**	**21**
Neg as % of the total		**83.3**		**84**
TotalSect	**54**	**16**	**109**	**87**
Neg as % of the total		**29.6**		**79.8**

Note:

a the sector before the late 1970s
b the sector after the late 1970s

Our result is also consistent with the result of Lichtenberg (1992). It is another way to test the two hypotheses: industrial diversification has a negative impact on the total factor productivity, and industrial diversification has decreased since late 1970s. With plant-level Census Bureau data in U.S., Lichtenberg finds that total factor productivity is inversely related to the degree of diversification. It is also shown that the extent of American firms' diversification has declined significantly during the second half of the 1980s. The newly-created firms during the study period were much less diversified than those that disappeared. Firms that continue to exist reduced the number of industries in which they operated.

The empirical results support the theoretic analysis in chapter 4. That is, a bank can play an active role in affecting the firm's investment behaviour. However, whether the effect is favourable or unfavourable depends on whether the bank helps the firm to diversify or to restructure around closely related businesses. In the latter case, the effect tends to be favourable. The effect is also influenced by the competitive pressure faced by a sector. Under high pressure, the effect tends to be more likely to be favourable.

5.4 Summary

We have estimated a cost function for Canadian manufacturing industries in order to study the impact of economic and institutional environment variables. The results are consistent with the theoretic analysis in chapter 4 and seem to indicate that the mechanisms identified with the simplified models also play a role in the real world. They are summarized in table 5-6.

Table 5-6 The Impact on a firm's cost of exports, financial interpenetration between firms, financial interpenetration between firms and banks

	Export	Financial Interpenetration	
		Between Firms	Between firm&bank
Competitive Pressure:			
High	Favourable	Favourable	More likely Favourable
Low	Most Unfavourable	Most Unfavourable	More likely Unfavourable

As for the impact of export, when a firm actively exposes itself to a market where high competition prevails, the export is likely to exert favourable impact on the cost of production. If a firm exports due to previously given advantages and faces low external competitive pressure, the export is not likely to provide a favourable impact on the cost. In practice, it appears that the transportation equipment industry was the sole industry where such conditions were unambiguously met over the whole study period: it exports and faces high competitive pressure.

Financial interpenetration between firms induces cooperation between firms. Motives of the cooperation are influenced by competitive pressure. As a result, the degree of competitive pressure determines whether the effect on cost is favourable or unfavourable. The empirical results conform with the theoretic analysis in chapter 4. Under relatively high competitive pressure, firms' cooperation tends to encourage them to diversify to closely related businesses, resulting in a favourable impact. Under relatively low competitive pressure, the effect is likely to be unfavourable.

Financial interpenetration between firms and banks induces cooperation between firms indirectly. Our empirical results also conform with the theoretic analysis in chapter 4. The effect of financial interpenetration between firms and banks depends on whether the bank helps the firm to diversify or to restructure around its core operation (to closely related business). In the latter case, the effect tends to be more often favourable, while in the former case, the effect is more often unfavourable. The effect is also influenced by the competitive pressure faced by a sector. Under high competitive pressure, the effect is more often favourable; Under low competitive pressure, the effect is more often unfavourable.

Therefore, the empirical results confirm the importance of the factors discussed earlier. Lack of more disaggregate, detailed information prevents the empirical study from answering all relevant questions put forward by the theoretic models, such as the increasing complexity of technologies and optimization of hardware and software technologies. Case studies can be used to answer some of these questions. Without being able to have information for all sectors, we carry out a case study for the transportation equipment industry in next chapter. More specifically, we will use a specific case study to complement the empirical results obtained in this chapter. and to illustrate concepts discussed in chapter 4. As a result, we will be able to further verify the theoretic prediction of the effect of the economic and institutional environment identified with the simplified models.

Appendix 5.A The Relationship between Total Factor Productivity and Technical Progress With Quasi-fixed Inputs

Suppose we have a production function with one output, n variables and m quasi-fixed variables. The production function is represented by

$$Y=F(v_1,...,v_n;f_1,...,f_m;t)$$

Where
- Y - the output
- v_i - variable input i, i=1,...,n
- f_j - quasi-fixed input j, j=1,...,m

With differentiation with respect to time t, we have

$$\frac{\dot{Y}}{Y}=\sum_{i=1}^{n}\frac{\partial F}{\partial v_i}\frac{v_i}{Y}\frac{\dot{v}_i}{v_i}+\sum_{j=1}^{m}\frac{\partial F}{\partial f_j}\frac{f_j}{Y}\frac{\dot{f}_j}{f_j}+\frac{1}{Y}\frac{\partial F}{t} \qquad (5A.1)$$

We define the technical progress associated with production function as

$$\frac{\dot{A}}{A}=\frac{1}{F}\frac{\partial F}{\partial t}=\frac{1}{Y}\frac{\partial F}{\partial t}$$

The output elasticity with respect to input X_i and cost elasticity are defined as

$$\epsilon_i=\frac{\partial F}{\partial X_i}\frac{X_i}{F}=\frac{\partial Y}{\partial X_i}\frac{X_i}{Y}, \quad \epsilon_{cy}=\frac{\partial C}{\partial Y}\frac{Y}{C}$$

Minimizing-cost behaviour of a firm implies

$$\frac{\partial Y}{\partial v_i}=\frac{W_i}{\frac{\partial C}{\partial Y}}; \qquad \frac{\partial Y}{\partial f_j}=\frac{Z_j}{\frac{\partial C}{\partial Y}}$$

where

W_i - the market price of input i
Z_j - the implicit price of quasi-fixed input j
C - the total implicit cost of a firm

The total implicit cost of a firm is defined as

$$C=\sum_{j=1}^{n} W_i v_i+\sum_{j=1}^{m} Z_j f_j$$

Substituting the above defined cost elasticity and technical progress associated with production function into (5A.1), we have

$$\frac{\dot{Y}}{Y}=\frac{\dot{A}}{A}+\epsilon_{cy}{}^{-1}\sum_{i=1}^{n}\frac{W_i v_i}{C}\frac{\dot{v}_i}{v_i}+\epsilon_{cy}{}^{-1}\sum_{j=1}^{m}\frac{Z_j f_j}{C}\frac{\dot{f}_j}{f_j} \qquad (5A.2)$$

We define

$$\frac{\dot{V}}{V}=\sum_{i=1}^{n}\frac{W_i v_i}{C}\frac{\dot{v}_i}{v_i}; \quad \frac{\dot{F}}{F}=\sum_{j=1}^{m}\frac{Z_j f_j}{C}\frac{\dot{f}_j}{f_j}$$

Rearranging the above equation gives

$$\frac{\dot{Y}}{Y}=\frac{\dot{A}}{A}+\epsilon_{cy}{}^{-1}\frac{\dot{V}}{V}+\epsilon_{cy}{}^{-1}\frac{\dot{F}}{F} \qquad (5A.3)$$

We define the growth rate of total factor productivity as

$$\frac{T\dot{F}P}{TFP}=\frac{\dot{Y}}{Y}-\frac{\dot{V}}{V}-\frac{\dot{F}'}{F'} \qquad (5A.4)$$

With

$$\frac{\dot{F}^{/}}{F^{/}}=\sum_{j=1}^{m}\frac{W_j f_j}{C^{/}}\frac{\dot{f}_j}{f_j};\ C^{/}=\sum_{i=1}^{n}W_i v_i+\sum_{j=1}^{m}W_j f_j$$

Where

W_j - the price of quasi-fixed input j in the market

C′ - the total cost of production in the market

$$\frac{T\dot{F}P}{TFP}=\frac{\dot{A}}{A}+[\epsilon_{cy}{}^{-1}-1]\ [\frac{\dot{V}}{V}+\frac{\dot{F}^{/}}{F^{/}}]+\epsilon_{cy}{}^{-1}[\frac{\dot{F}}{F}-\frac{\dot{F}^{/}}{F^{/}}] \qquad (5A.5)$$

Combining the above equations and rearrangement of the equation, we obtain

With a similar derivation, we can obtain a similar relationship with a cost function. That is,

$$\frac{T\dot{F}P}{TFP}=-\epsilon_{cy}^{-1}\frac{\dot{B}}{B}+[\epsilon_{cy}{}^{-1}-1]\ [\frac{\dot{V}}{V}+\frac{\dot{F}^{/}}{F^{/}}]+\epsilon_{cy}{}^{-1}[\frac{\dot{F}}{F}-\frac{\dot{F}^{/}}{F^{/}}] \qquad (5A.6)$$

The growth of total factor productivity consists of three parts: technical progress, economies of scale and the effect of quasi-fixed inputs.

Chapter 6 A Specific Case Study: The Automotive Industry

In this chapter, we use the automotive industry as a case study to illustrate what we have discussed up to now. This industry is the major sector in the transportation equipment industry, which is characterized by relative homogeneity in terms of product and technology. In Canada, the automotive industry represents 85 per cent of the transportation equipment industry. It consists of both motor vehicle manufacturing and motor vehicle parts & accessories manufacturing. It is possible to obtain more information on the auto industry than on any other of the industries studied in Chapter 5. The auto industry makes up such a high share of the transportation equipment sector that it may almost be identified with that sector.

Consequently, we are going to submit the automotive industry to additional analysis in order to verify whether or not the result of chapter 5 may be interpreted in terms of what is known about the industry. The analysis in this chapter is also used to further verify the predictions of the simplified models in chapter 4.

The empirical estimation of chapter 5 for the transportation equipment industry indicates that exports, financial interpenetration between firms and financial interpenetration between firms and banks all exert favourable impacts on the firm's cost or productivity.

In section 6.1, we review the general information with emphasis on the complexity of technology in the automotive industry and the interrelationship between firms under external competitive pressure, especially with recently increasing globalization. Then, in section 6.2, we attempt to link this information to the theoretical model and the empirical results. We also review the financial interpenetration between firms and firms' relationship with financial institutions such as banks in both Canada and the U.S., with effort to link them with the empirical results in chapter 5. Finally, we have the summary for this chapter in section 6.3.

6.1 General Review of the Automotive Industry[1]

In this section, we review some general information and facts on the automotive industry in relation to our discussion in chapter 3 and chapter 4. In chapter 3, we discussed the economic and institutional environment of a firm. It was shown that globalization has been increased greatly since the second world war. Globalization has increased competition to firms and the complexity of technology. In a new economic and institutional environment, a competitive firm must be able to adjust its technology investment, in particular, its organizational form including its relationship with other

[1]This section is based on Womack et al (1990). American carmakers have learned a great deal from their Japanese counterpart since the beginning of 1980s.

firms. In chapter 4, we discussed the concept of hardware and software technologies, and analysed a firm's investment behaviour under different economic and institutional environments. The economic and institutional environment variables exert effect on a firm's investment, but the direction of the effect depends on specific circumstances. For example, under high competitive pressure, the financial interpenetration between firms with closely related businesses increases a firm's technology investment level, and in turn, its competitiveness. The reviewed facts on the automotive industry show that what has happened in this industry is consistent with our previous discussion.

Increasing globalization has increased the complexity of technology in the automotive industry. In comparison to the beginning of this century, the automotive industry has become much more sophisticated and complex. At present, it requires the engineering and fabricating of more than 10,000 discrete parts first, which must then be assembled into about 100 major components such as engines, transmissions, steering gears, suspensions. Finally, the assembly of the major components into a complete vehicle is accomplished in an assembly plant. It is a major challenge to make all parts come together at the right time with highest quality and lowest cost possible (Womack et al, 1990).

The complexity of technology implies that there are hardly two companies that use an identical production technology and organization method to produce the same product or similar products. Different economic and institutional environments lead to different technology evolutions of firms. For example, American and Japanese carmakers do not have the same production technology.

The major difference between American and Japanese carmakers lies on their emphasis on hardware and software technologies. The former puts more emphasis on advanced equipments (the hardware technology), while the latter emphasizes not only the advanced equipments, but also the optimal organization of the suppliers, assemblers, and distributors.

In the American system, car manufacturers, suppliers and distributors have a business relationship characterized as short-term, market-transaction type. There is no cooperative-oriented financial interrelationship between firms, no exchanges or communications on information such as on advances in manufacturing techniques. As a result, an assembler might ensure that suppliers have low profit margins, but not that they steadily decrease the cost of production through improved organization and process innovations, i.e. adaptive or dynamic efficiency.

On the other hand, in the Japanese system, carmakers, suppliers and distributors often have certain types of financial interpenetrations which make their relationship cooperative-oriented. Suppliers are organized into functional tiers, which are assigned with different responsibilities. Firms are encouraged to exchange information for mutual benefits. This long-term cooperative relationship is often sustained by their inter-shareholdings.

There is difference in the specializations between firms on the software and hardware technologies. This difference leads to different combinations of the two technologies, which may result in different performances. Womack et al (1990) find significant difference not only in the productivity and product quality between American and Japanese carmakers, but also among American automakers themselves. After comparing a GM with a Ford assembly plant, they find that a large productivity difference existed between the two. The productivity level at the GM plant was 48 per cent lower than at Ford, mainly due to its organizational practice.

With increasing globalization, there are more and more cooperative arrangements between automakers, especially between American and Japanese ones. These arrangements are often maintained by their financial interrelationship. In North America, it is found that the cooperation has increased both competition and productivity (Wolf and Globerman, 1992). These real world observations are consistent with our discussion in chapter 3. Increasing globalization increases the complexity of technology and competition among firms. In the new environment, many competitors can also cooperate with each other.

6.2 The Effect of Environment Variables in the Canadian and American Automotive Industry

In this section, we will review and link the automotive industry's performance with the economic and institutional environment variables used in the econometric study of chapter 5. These include exports, financial interpenetration between firms, and financial interpenetration between firms and banks.

The automotive industries in Canada and the U.S. are closely linked, as a result of the Auto Pact in 1965. For example, over 90 per cent of the trade in the Canadian automotive industry was with the U.S. during the study period, due to the very low import tariffs between both countries (about 3 per cent for Canada and 1 per cent for the U.S. (Lester and Morehen, 1988)).

6.2.1 The Canadian Automotive Industry

The following discussion will focus on the restructuring of Canadian auto industry during the 1960s. We will link the performance of this industry with the empirical results in chapter 5.

Prior to the Auto Pact, the Canadian auto industry was a domestic-oriented, inefficient manufacturing sector (Fuss and Waverman, 1992). It competed against imports with the aid of high trade barriers (17.5 per cent tariff plus domestic content rules). There were significant productivity differentials between Canadian and U.S. automobile producers in the 1950s and early 1960s. Production declined continuously due to strong competitions from France, West Germany and the U.K. As a result, the Bladen Royal Commission was set up to study the industry and the Auto Pact between Canada and the United States was signed in 1965.

The Auto Pact provided the basis for free trade in automobile products. The Pact eliminated duties and tariffs on finished vehicles and original equipment shipped by producers between the two countries if they met certain domestic content provisions. However, imports (into Canada) from outside North America remained subject to substantial tariff barriers and domestic content rules.

To a great extent, the situation faced by the Canadian automobile industry in the late 1950s and early 1960s was similar to that faced by the American automobile industry in the late 1970s. Both faced strong foreign competitive pressure and required restructuring to increase their competitiveness. In what follows, we will examine the role of exports, financial interpenetration between firms, and financial interpenetration between firms and banks[2], in the

---

[2]Financial interpenetration is used as our measure of firms' cooperation. The cooperation may take other forms such as strategic alliances which were discussed in chapter 3. Financial interpenetration is the base for a healthy long-term cooperation. For example, equity cross-holding tends to build stronger and more comprehensive strategic alliances. Interviews and surveys of industry

successful restructuring of the industry.

Table 6-1 shows the elasticities of exports, financial interpenetration between firms, and financial interpenetration between firms and banks for the Canadian transportation equipment industry, which were obtained in chapter 5. All three variables exert a favourable impact on the cost of production in the transportation equipment sector.

Table 6-1 Cost Elasticities of Exports, of Financial interpenetration between firms, and of Financial interpenetration between firms and banks for Transportation Equipment Industry, 1967-86:

Year	ε_{ex}	T-ratio	ε_{ff}	T-ratio	ε_{bf}	T-ratio
1967.	-0.0880	-1.1719	0.0617	1.6121	0.0449	1.4768
1968.	-0.0888	-1.3106	-0.0231	-0.7406	-0.0227	-1.4432
1969.	-0.1099	-1.4146	-0.0419	-1.2511	-0.0300	-2.1314
1970.	-0.1273	-1.0080	-0.0113	-0.2994	-0.0073	-0.3732
1971.	-0.1649	-1.6408	-0.0309	-0.8719	-0.0458	-0.9053
1972.	-0.2261	-1.8037	-0.0103	-0.2144	0.0102	0.1717
1973.	-0.1671	-1.5392	-0.0243	-1.1088	-0.0570	-2.1596
1974.	-0.1688	-1.8519	-0.0263	-0.9517	-0.0566	-2.1203
1975.	-0.1891	-1.8341	-0.0178	-0.5503	-0.0288	-1.5470
1976.	-0.2108	-1.8487	-0.0463	-1.3517	-0.0431	-2.6891
1977.	-0.2511	-1.8204	-0.0668	-1.8738	-0.0763	-3.0095
1978.	-0.2408	-1.6630	-0.0938	-2.4072	-0.0814	-4.1169
1979.	-0.2255	-1.9156	-0.0346	-1.4691	-0.0893	-3.0975
1980.	-0.1669	-1.4503	-0.0178	-1.2363	-0.0687	-3.3790
1981.	-0.1916	-1.4846	-0.0111	-0.6611	-0.0509	-2.3883
1982.	-0.2219	-1.1770	-0.0460	-2.1602	-0.1287	-4.1899
1983.	-0.2834	-1.4786	-0.0256	-1.2102	-0.0867	-2.3924
1984.	-0.2824	-1.4279	-0.0529	-2.2534	-0.0621	-4.9790
1985.	-0.3374	-1.7563	-0.0977	-2.3534	-0.0589	-4.2834
1986.	-0.3040	-1.3413	-0.1328	-3.5650	-0.1228	-5.0152

---

periodicals conducted by Wolf (1991) indicate that equity participation encourages extensive cooperations, while non-equity relationship moderates cooperation. The Ford-Mazda strategic alliance involves equity relationships, while Ford-Nissan and GM-Toyota tie ups without. Wolf and Globerman (1992) find that, in the former pair of alliances, there tends to be many projects undertaken mutually, and they often require quite intimate knowledge of one partner by the other. The asset exchanges involved are complex and linked across projects. In the latter pair of alliances, there are specific projects undertaken which are generally not linked and tend to stand apart from either company. Of course, equity sharing may be increased as cooperation develops. The definition of strategic alliances was given in chapter 3.

I. The Role of Exports under High Foreign Competition

The Auto Pact was implemented gradually. During the transition period between 1962 and 1965, the adjustment went smoothly through a sequence of changes to the tariff structure, which allowed duty remission on selected parts. Two duty remission plans were implemented by the Canadian government during 1962-1963, with a goal of increasing Canadian export and production efficiency. In November 1962, a 25 per cent import duty on engine blocks and automatic transmissions was imposed. This duty could be recouped by auto manufacturers if they could increase their exports of parts beyond a 1961-1962 base year level. In October 1963, the duty remission was extended to all imports of motor vehicles and original equipment parts. As a result of increasing exports (from $9 million in 1962 to $65 million in 1964), the efficiency of the production in the Canadian automotive industry also increased quickly (production increased by about 45 per cent between 1965 and 1969). The increase in production efficiency, resulting from the rise of export, is consistent with our estimated negative, significant cost elasticity of export in chapter 5. That is, under high competitive pressure, exports exert a favourable impact on the cost of production and production efficiency.

II. The Role of Financial Interpenetration between Firms and Financial Institutions

During the restructuring of the Canadian auto industry, both financial institutions (by providing loans guaranteed by the Canadian government) and financial interpenetration between firms played active roles.

Under the government's Automobile Adjustment Assistance Program, low interest capital loans (through banks) were provided to enable "efficient" firms to retool and expand production to meet the competitive challenge of expanded markets. That is, financial institutions were involved by providing loans to firms which restructured around their core operations. Furthermore, temporary assistance benefits (from the government) were given to workers (being laid off as a result of the effects of the Auto Pact) so that the restructuring process of the firm was facilitated. This was equivalent to increase a firm's investment efficiency.

Financial interpenetration between firms also played important roles in the reorganization and rationalization of production and the restructuring of capital in the Canadian auto industry. The financial relationship was mainly between the American and Canadian firms (Holmes, 1983). Each of the U.S. auto makers reorganized its Canadian production so that an optimum production mix and resulting economies of scale were achieved. Rather than producing a multitude of different models in short production runs to supply Canadian demand exclusively from Canadian plants, the manufacturers were able to concentrate the production of a relatively few models into their Canadian plants to serve both the U.S. and Canadian markets.

This financial penetration from the American firms not only involved the transfer of effective equipment (hardware technology), but also the adoption of more efficient management forms (software technology). American firms were involved in the reorganization of most existing assembly plants and auto parts plants, as well as in the establishment of some new plants (Holmes, 1983). For example, Ford converted its Windsor facility into a major engine plant embodying the latest high-speed, automated, metal working machinery in 1965. The reorganization involved a capital investment of over $50 million. About half the existing capital equipment was removed from the plant, and replaced by far fewer pieces of automated equipment. After reorganization, the plant produced only one engine block and only eight varieties of engine, in contrast to 7 and 186 respectively before the reorganization. As a result, Ford Canada grew by 40 per cent between 1964 and 1966.

The facts here are consistent with our analysis in chapter 4. Under high competitive pressure, increased financial interpenetration between firms with closely related businesses led to higher (technology) investments and investment efficiency. Similarly, the involvement of banks (through government support policy) in the restructurings of firms around their core operations exerted a favourable impact on their costs of production.

Thus the successful restructuring of the auto industry was largely the combined result of increased competitive pressure resulting from freer trade, and of an environment inducing cooperation and investment. The investments were both of the hardware type (machinery) and of the software type (plant reorganization).

These findings (higher production efficiency) are consistent with our empirical results in chapter 5, which indicated a TFP growth rate of 17 per cent between 1967 and 1973. Automobile production and trade between Canada and the U.S. increased quickly during the mid-1960s and early 1970s, as shown in table 6-4.

Table 6-2 Automobile (Passenger Car) Production, Export, Import ('000 units)

	Domestic Production	Import From Total	U.S.	Germ.	Japan	Export to: Total	U.S.
1955	375	49	27	6	0	12	0
1960	326	171	28	37	0	17	0
1965	707	136	46	39	5	78	46
1966	685	189	115	28	3	190	115
1969	1026	458	291	31	50	715	676
1970	923	405	252	36	65	733	697
1974	1167	665	495	29	112	840	810
1975	1054	679	552	28	73	777	723
1979	988	707	589	33	60	650	590
1980	847	701	495	31	158	613	549
1981	803	724	473	20	200	566	524
1982	808	542	334	16	153	704	684
1983	969	744	532	24	165	867	854
1984	1022	863	601	27	176	1103	1086

Source: Table 2.4 in Fuss and Waverman (1992)

The positive impact of the restructuring is also confirmed by other studies. Fuss and Waverman (1986) estimate that the Canadian automobile producers were 27 per cent less efficient than those of the U.S. during 1962-1964. This efficiency difference was reduced to 19 per cent in 1970-1972. Afza (1988) finds that both Canadian and American auto producers had increasing returns to scale during 1960-1984. However, the Canadian automobile assembly industry represents quite higher economies of scale than the U.S. The difference is contributed to the shutdown of inefficient plants and to increased utilization of the efficient plants in Canada. The Canadian assembly industry's total factor productivity (TFP) increased by 34 per cent between 1967-69 and 1972-1974 periods, as compared to a 12.7 per cent in the U.S. assembly industry. During 1960-1984, the performance of the Canadian parts industry is better than that of the U.S. This is consistent with our estimated TFP growth rate of 15 per cent for the transportation equipment industry between 1968 and 1973.

6.2.2 The American Automotive Industry

Although adjustments faced by the industry after the second oil shock are mostly documented from an American point of view, the remarks that follow apply to the Canadian auto industry just as well. The second oil shock in 1979 put a strong requirement on restructuring the Canadian, as well as the American auto industry. This industry's second restructuring started in the U.S. in early 1980s as discussed below. The main competitors were auto makers from Japan.

Starting at the end of the 1970s, American automakers have faced strong competition from the Japanese. Under strong competitive pressure, American automakers realized the importance to reorient their emphasis on the software and hardware technologies, especially on their production organizations. Although American automakers are presently almost as efficient as the Japanese, the restructuring process is worth reviewing. It supports our theme in this study.

I. Differences in Exposure to Competitive Pressure and Different Technology Investments

When facing strong Japanese competition in both export market (in Canada) and domestic market, all American automakers realized that they needed to reform their production process and increase their technology investments. However, there were differences in how they proceeded. These varied reactions resulted from their differences in exposure to the competitive pressure, which in turn was due to their difference in technology specializations.

GM first used strategic alliances to acquire the Japanese production technology, by setting up a joint venture assembly plant (the New United Motor Manufacturing Inc.) with Toyota in 1984. Each partner had a 50% share. Toyota was responsible for running the plant and for parts procurement. The existing production technology in a previously closed GM plant, as well as unemployed GM workers and members of the United Automobile Workers Union, were used. However, Toyota used flexible machinery as contrasted to GM's "dedicated automation". The operation was soon very successful in terms of both productivity and quality. GM officials were clearly impressed, however, what they ultimately observed was not what they expected to learn. It was found that Toyota's secret of success did not lie in the technology used in the assembly plant, but rather in the way the workers and machines were organized.

The relatively low competitive pressure GM faced was an important factor that made its reaction less effective. GM's market position was not strongly challenged by the Japanese. The reason was that GM had a high share in high-rank, luxury car market while the Japanese cars were small, and at middle and low rank in the market. The competitive pressure to GM was not as strong as to Ford and Chrysler whose traditional market positions were directly challenged. As a result, top management in GM did not investigate carefully the reason behind the Japanese success, and was not convinced by the Japanese way. Instead of investing in motivating its human resources, it continued to rely on vast investments in high-tech machinery to overcome its lack of competitiveness with the Japanese. These investments in advancing hardware technology on the whole proved to be a failure (Womack et al, 1990). And transferring the Japanese organizational know-how to its many plants and management levels has proved to be a long, arduous task for GM.

Ford case was different. It was in a financial crisis during the late 1970s and early 1980s, partly as a result of a sharp cyclical downturn, but also because of the inroads Japanese producers were making into Ford's traditional markets. With high competitive pressure from the Japanese, Ford closely examined its hardware and software technologies. It decided to learn as much as possible from its Japanese partner, Mazda. Ford had had a strategic alliance with Mazda since 1969 and had a 25% equity holding in Mazda since 1979.

As for Chrysler, after a remarkable recovery from a brush with bankruptcy, it started to deepen its relationship with Mitsubishi and investigated the experience of Japanese companies seriously. For example, it planned to form a joint venture with Mitsubishi in Bloomington, Indiana, in 1985.

In a similar economic and institutional environment, differences in exposure to competitive pressure may result from the different experiences of firms, technology specializations and development paths. As discussed in chapter 4, these differences cause different technology investments and, in turn, variation in performances of firms. This is confirmed by the experience of American carmakers, e.g. in the case of GM, Ford and Chrysler..

Under less pressure, GM seemed to have chosen a path that did not emphasize cooperation, but automation. Under high competitive pressure, Ford concentrated on increasing the productivity of its slimmed-down work-force. While GM was determined to minimize the role of people, Ford's goal was to maximize the contribution of people. The outcome was that GM's highly automated stamping plants produced half as many stamped parts per worker as Ford's. The disappointing performance of GM was partly because its presses were poorly operated. Although both GM and Ford are able to compete with their Japanese counterparts successfully, their costs are different.

II. The Role of Financial Interpenetration between Firms

The role of financial interpenetration between firms took effect mainly through joint ventures between American and Japanese companies, such as the joint venture between GM and Toyota, Ford and Mazda.

In the case of Chrysler, financial interpenetration between firms was not possible due to Chrysler's obvious financial difficulty. However, the role of financial interpenetration between firms took the form of the cooperation between employees who were from Chrysler and Ford, as well as between Chrysler and its suppliers. For example, Iacocca got many excellent ex-Ford employees, who brought over with them experience and knowledge on the Ford system, especially on various aspects of the software technology.

As implied by our model, the favourable impact of financial interpenetration on a firm's performance was more marked for firms under higher competitive pressure (Ford, Chrysler) than under low competitive pressure such as in the case of the more secure GM. This is confirmed by the evidence reviewed.

The financial interpenetration between Ford and Mazda provided a great help in Ford's restructuring. Upon visiting Mazda's plant in Japan in 1981, Ford was convinced that it had to make drastic changes in its utilization of human resources in North American operations. Ford used Mazda as a tutor in bringing lean production to its own plants. For example, Mazda's wholly-owned Flat Rock plant was used as a laboratory to observe Mazda's assembly operations. Ford learned a great deal about increasing productivity by encouraging teamwork along with engineering advances. For instance, workers in Walton Hill Metal Stamping Plant have helped reduce labour and overhead costs by an average of 3.2% per year since 1985.

Therefore, financial interpenetration between Ford and Mazda speeded up Ford's learning. As a result, Ford could produce about as many vehicles in the U.S. in late 1980s as it did in the late 1970s with half as many workers.

On the other hand, although GM established a successful joint venture with Toyota, it did not learn from the Japanese partner as effectively as Ford. Under relatively low pressure, GM did not carefully analyze the factors behind Toyota's higher performance. As a result, GM did not make good use of the useful complementary technologies and assets from Toyota. Therefore, GM's restructuring was significantly more costly and longer, as compared to Ford.

III. The Role of Financial Institutions

During the restructuring of American automakers, banks also played an important, positive role.

The role of banks can be seen more clearly from Chrysler's restructuring. At first, the attitude of the banks was negative. At the end of 1979 when the federal government's Loan Guarantee Act was passed by Congress, Chrysler owed about US $4.75 billion to over four hundred banks and insurance companies. When Chrysler's problem became public, all the banks wanted Chrysler to declare bankruptcy and to get as much as they could for their loans.

In order to get the cooperation of the banks, Chrysler prepared a "memo of liquidation". This memo made it clear that in event of a bankruptcy, all the loans would be tied up for between five and ten years in the courts, and that the banks would lose a significant percentage of their investment. Furthermore, under the Michigan Law, the interest rates on the outstanding loans would drop to 6 percent a year until the matter was resolved. This made the banks realize that it was in their best interest to cooperate with Chrysler and to grant the concessions that would keep Chrysler in business.

After many lengthy rounds of discussion, Chrysler and banks reached a comprehensive agreement, whereby the banks would cooperate with Chrysler through further financial support, and Chrysler, in return, offered the banks 12 million stock warrants. The financial involvement of the banks greatly reduced the cost of restructuring, and insured cooperations from other important players such as suppliers.

IV. The Role of Other Factors

During the restructuring of the American auto industry, there were some other factors which played important roles as well. These factors which were not emphasized explicitly in chapter 3 and 4 include government and cooperation between employees of a firm. In the following paragraphs, we will discuss these factors and attempt to link them with our models, using Chryster[3] as an example.

Government, as discussed in chapter 3, can play an important role in fostering an appropriate economic and institutional environment. It may also act as a quasi-bank by

[3]The following information on the restructuring of Chrysler is based on Iacocca (1984)

providing financial support to firms under special conditions. These two roles were played well by the American government during the restructuring of the auto industry.

The American government played a important role by exposing the American automakers to the Japanese competitive pressure, in spite of political pressures by various groups to protect the American auto industry through tough trade barriers. The American government's only response was to negotiate the Voluntary Restraint Agreement (VRA) with the Japanese government, which limited the increase of the Japanese competitive pressure. Consequently, American carmakers had certain time to realize and to react to the new economic environment. The government also relaxed its antitrust law (more appropriate institutional environment) to allow joint ventures between American and Japanese automakers, so that the Japanese lean production technology could be learned quickly.

During the restructuring of Chrysler, governments' financial supports from the governments reduced financing costs and helped cooperation from other important players such as banks and suppliers. The government played a role which would be played by banks under normal conditions. The federal government behaved as a quasi-bank in making a loan guarantee to Chrysler. Chrysler's assets were taken as collateral, and a number of strings were attached to the loan. The purpose was to assure that truly cooperative efforts could be attained among important players. The conditions included:

- Chrysler's current lenders were required to extend US $400 million in new credit and $100 million in concessions on existing loans.
- Foreign lenders were required to extend an additional $150 million in credit.
- Chrysler had to raise an additional $300 million through the sale of assets.
- Suppliers had to provide Chrysler with at least $180 million, of which $100 million was in the form of stock purchase.
- State and local governments with Chrysler plants had to provide $250 million.
- Chrysler had to issue $50 million in new stock.
- Union members had to come up with $462.2 million in concessions.
- Nonunion employees had to contribute $125 million in pay cuts or freezes.

The important role of cooperation between employees is consistent with our discussion in chapters 3 and 4. Cooperation between employees (cooperation within a firm) was part of our concept of software technology. An optimal software technology implies a continuous adjustment of resources and their relationship in a firm according to the new economic and institutional environment. Employees from various companies may have different specific knowledges on software and hardware technologies. Their cooperation could play the role which is played by financial interpenetration between firms. Cooperation from Chrysler's employees facilitated the improvement of its organizational efficiency (the software technology). It also speeded up the learning and adaption of efficient organizational forms used by other carmakers such as Ford. To a great extent, the cooperation played the role which would be played by financial interpenetration between firms if obtained.

The cooperative efforts from Chrysler (its managers and workers), governments, as well as its banks and suppliers were all critical in achieving a successful restructuring. By the middle of 1983, Chrysler was solidly on its feet again, when it reported an operating profit of $925 million, the best by far in its history. As for efficiency, Chrysler needed to sell 1.1 million cars and trucks to break even in 1983, down from 2.3 million in 1979. Chrysler paid back all government's guaranteed loans of 1.2 billion, 7 years before it came due. Furthermore, Chrysler launched many new automotive products, such as the first American-built front-wheel-drive sports cars, new minivans, and a new front-wheel-drive sedan.

6.3 Summary

The review in section 6.1 showed that production technology in automotive industry has become more and more complex with globalization and economic development. Increasing competition and complexity implies many opportunities and importance of cooperation between competitors.

In the new economic and institutional environment, financial interpenetration (joint ventures) can be used for various goals. The Japanese automakers used it to firmly establish themselves in the American market with relatively low cost. American automakers used it to learn the lean production techniques quickly, resulting a fast increase in their productivity. As a result, the competition of this industry in North America has become more intense (Wolf and Globerman, 1992). These real world observations are consistent with our analysis in chapters 3 and 4: with increasing globalization and high competition, competitors can cooperate and compete at the same time. Financial interpenetration is one way to secure their cooperative relationship, and get their performance enhanced.

Examination of the automotive industry in Canada and the U.S. confirmed the empirical results in chapter 5 and the prediction of the theoretic analysis in chapter 4. The automotive industry (transportation equipment industry) fits into our classified case discussed in chapter 4: firms have closely related businesses (technologies) and face relatively high competitive pressure. In this case, export, financial interpenetration between firms and financial interpenetration between firms and banks exert a significant favourable impact on the firm's cost performance.

We also discussed some other factors which were found to exert a favourable impact on the firm's performance. Although these factors were not explicitly emphasized in our theoretic model, they were discussed in chapter 3 and implicitly dealt when we discussed the concept of software and hardware technologies in chapter 4. Government, as discussed in chapter 3, can play an important role in fostering an appropriate economic and institutional environment. It may also act as a quasi-bank by providing financial supports to firms under special conditions. These two roles were played well by the American government during the restructuring of the auto industry. The important role of cooperation between employees is consistent with our discussion in chapter 3 and 4. Cooperation between employees (cooperation within a firm) was part of our concept of software technology. An optimal software technology implies a continuous adjustment of resources and their relationship in a firm according to the new economic and institutional environment. Employees from various companies may have different specific knowledges on software and hardware technologies. Their cooperation could play the role which is played by financial interpenetration between firms.

Chapter 7 Summary and Conclusions

Globalization increases competition and the complexity of technology. A competitive firm has to have not only highly sophisticated machinery and equipment, but also the efficient way to organize all its internal resources as well as resources available from outside: research and development, product design, manufacturing, marketing, after-sale services, relevant information collection and its utilization. It is important to optimize continuously the hardware and software aspects of a firm's technology.

In the real world, many factors influence a firm's optimal reactions and decisions. For this study, we have focused on some traditionally overlooked factors. More specifically, we examined the effect of a firm's economic and institutional environment on its investment behaviour and, in turn, on its cost performance and competitiveness.

The effect of the economic and institutional environment was examined first with a general model. It was formally shown that the economic and institutional environment affects a firm's investment, but the direction of the impact varies with specific conditions and circumstances. Then, with two simplified models, we illustrated the mechanisms by which a firm's investment is affected by the economic and institutional environment. The theoretical predictions were confronted with results from the empirical study and with the analysis of information gathered for the transportation equipment industry (as a specific case study). The results are summarized as follows.

1) The economic and institutional environment variables affect a firm's investment decision in general. The direction of the effect depends on various circumstances and varies across sectors. These theoretical predictions were confirmed by the empirical results and the information presented in the case study.

2) The impact of exports (export orientation) on the technology investments of firms depends on the competitive pressure in the export market. When the competitive pressure is high in the export market, the effect is likely to increase a firm's technology investment. When the competitive pressure is low in the export market, the effect is likely to decrease a firm's technology investment. This is due to the fact that a firm has a higher efficiency in its investment and its utilization of complementary technologies (from other firms) under high competitive pressure than under low competitive pressure. The effects of these higher efficiencies are likely to dominate the effects from other factors, resulting in an increase in technology investments. The empirical results, along with the specific case study, confirmed the theoretical predictions. It was found that sectors which actively exported to markets with high competition, exports exert a favourable impact on their costs of production. When their exports were to less competitive markets, the effect was more likely to be unfavourable on the cost.

3) Financial interpenetrations induce cooperations between firms. The impact of financial interpenetration depends on whether the cooperative firms have closely related technologies. The mechanism by which financial interpenetration between firms affects technology investment is different from the mechanism by which financial interpenetration between firms and banks affects investment.

In the case of financial interpenetration between firms, the firms have direct relationship and communicate directly. This mechanism is closely related to the competitive pressure faced by firms. Different competitive pressures determine the motivation of cooperation or their financial relationship. Under low competitive pressure, their cooperation tends to diversify to unrelated businesses. Therefore, their financial interpenetration tends to reduce technology investment. On the other hand, under relatively high competitive pressure, financial interpenetration between firms tends to induce cooperation of firms in closely related businesses, and to increase their technology investments. Therefore, the mechanism is directly affected by the competitive pressure that firms face.

In the case of financial interpenetration between firms and banks, firms have certain cooperative relationships because of or through banks' involvement. The effect mechanism is closely related to both the competitive pressure that firms face and to the way that banks are involved in the cooperation. The influence of competitive pressure is similar to the case of financial interpenetration between firms. As for the way that banks are involved in firms' cooperation, banks are influential in a firm's decision on with whom it will cooperate. If banks' involvement is to make closely related firms cooperate, the effect tends to enhance firms' investments. If banks' involvement is to make unrelated firms cooperate, the effect tends to reduce firms' investments. Therefore, the mechanism of financial interpenetration between firms and banks is closely related to the competitive pressure and to the way banks are involved in cooperations between firms.

These theoretical predictions were confirmed by the empirical results, as well as the specific case study. For example, in the empirical study, it was found that, during the two subperiods (1967-1976 and 1977-1986), there were different types of merger and acquisition activities: mergers among firms with less related businesses during the first subperiod and among firms with relatively related businesses in the second subperiod. During these two subperiods, the effect of financial interpenetration between firms and banks was different. It was found that the effect was more often favourable in the second subperiod than in the first subperiod. Furthermore, it was found that the effect of financial interpenetration between firms and banks was more towards favourable on costs in sectors facing a high competitive pressure than in sectors facing a low competitive pressure.

In summary, the theoretic models illustrated formally how economic and institutional environment variables affect the investment decisions of firms. The theoretic predictions were confirmed by both the empirical results and the specific case study. Furthermore, the empirical results indicated that the simplified models (as a complement to the general model in chapter 4) are useful simplifications of reality and helpful in interpreting what is going on in the real world.

However, due to lack of specific, detailed information on each sector or at firm level, we have not be able to study the direct relationship between the technology investments of firms and various factors discussed in chapter 4 such as the degree of technology complementarities between firms (β_0) in a sector. Instead, we studied the relationship indirectly through examining the cost performance of a sector. With more disaggregate data available, we expect that the direct relationship varies across industries.

As for policy implications, government can play an important role in influencing the private firm's investment behaviour through fostering an appropriate economic and institutional environment. However, the intervention must be adjusted according to changing environments of firms. This can be achieved by frequent communications with private organizations and incorporation of newly feedback information in its decision-making process.

Further research is recommended as to perform current study at a more disaggregated level, such as at firm level. In addition, with a more disaggregated data base, we can study the varied relationships between technology investment levels of firms with the economic and institutional environment variables in different industries. These different relationships may be due to the fact that in different industries firms have different degrees of technology complementarity between firms (β_0). A study can also be performed to analyze the investment behaviours of firms when they have different economic and institutional environment variables. For example, firms can be divided into two subgroups: one with high exports, high financial interpenetration between firms and high financial interpenetration between firms and banks, while another with relatively low levels of those environment variables. All these will provide a deeper understanding of the mechanisms by which these variables determine the investment decisions of firms.

Furthermore, an international comparison study among Canada, Germany, Japan and U.S. would be helpful in understanding the effect of different institutional setups and state interventions.

REFERENCES

Adams, Water and James W. Brock, Dangerous Pursuits - Mergers & Acquisitions in the Age of Wall Street, 1989

Afza, Talat, The U.S.- Canadian Auto Pact of 1965: A Case Study of Sectoral Trade Liberalization, Unpublished Ph.D. Dissertation, Wayne State University, 1988

Akerlof, George, "Procrastination and Obedience", American Economic Review, May 1991

Alam, M. Shahid, Governments and Markets in Economic Development Strategies, Lessons from Korea, Taiwan, and Japan, Praeger Publishers, 1989

Alkhafaji, Abbass F., Restructuring American Corporations - Causes, Effects, and Implications, Quorum Books, 1990

Altman, Morris, "Interfirm, Interregional, and International Differences in Labour Productivity: Variations in the Levels of X-Inefficiency as a Function of Differential Labour Costs", in

Klaus Weiermair and Mark Perlman (ed), Studies in Economic Rationality - X - Efficiency Examined and Extolled, The University of Michigan Press, 1990

Amsden, Alice H., Asia's Next Giant - South Korea and Late Industrialization, Oxford Univ. Press, 1989

Amsden, Alice H. "The Paradigm of Late Industrialization", Political Economy, Vol.3, No.2, 1987

Aoki, Masahiko, "Managerialism Revisited in the Light of Bargaining - Game Theory", International Journal of Industrial Organization 1, 1983

Aoki, Masahiko, The Co-operative Game theory of the Firm, 1984

Aoki, Masahiko, Information, Incentives, and Bargaining in the Japanese Economy, Cambridge University Press, 1988

Aoki, Masahiko, "Toward An Economic Model of the Japanese Firm", Vol.28(1), JEL, 1990

Aoki, Masahiko and Ronald Dore (eds), The Japanese Firm: the Sources of Competitive Strength, Oxford Univ. Press, 1994

Aoki, Masahiko and Hugh Patrick (eds), The Japanese Main Bank System: Its Relevancy for Developing and Transforming Economies, Oxford Univ. Press, 1994

Arrow, K.H., Chenery, B.Minhas and R. Solow, "Capital-Labour Substitution and Economic Efficiency", Review of Economics and Statistics, XLIII, Aug. 1961

Awanohara, Susumu, "Question of Faith - Japan Challenges World Bank Orthodoxy", Far Eastern Economic Review, March 12, 1992

Bagchi, Amiya Kumdr, "East Asian Capitalism - An introduction," Political Economy, Studies in the Surplus Approach, Vol.3, No.2, 1987

Balakrishnan, Srinivasan and Mitchell P. Koza, "Information Asymmetry, Adverse Selection and Joint-Ventures", Journal of Economic Behaviour and Organization 20, 1993

Baldwin, J.R. and P.K. Gorecki, "Entry and Exit to the Canadian Manufacturing Sector: 1970-1979," Discussion Paper No. 225, Economic Council of Canada, 1983

Baldwin, John R. and Paul Gorecki, The Determinants of Canadian Tariff Structure Before and After the Kennedy Round: 1966, 1970, Discussion Paper No. 280, Economic Council of Canada, 1985

Baldwin, John R. and Paul Gorecki, "Mergers and Merger Policy in Canadian Manufacturing Sector: 1971-1979", Discussion Paper No.297, Economic Council of Canada, 1986

Baldwin, John R. and Paul Gorecki, "Plant Creation Versus Plant Acquisition: the Entry Process in Canadian Manufacturing", International Journal of Industrial Organization 5, March 1987

Baltagi, B.H. and J.M. Griffin, "A General Index of Technical Change", Journal of Political Economy, 96(1), 1988

Barro, Robert, "Economic Growth in a Cross Section of Countries", NBER WP No. 3120, Sept. 1989

Benhabib, Jess and Boyan Jovanovic, "Externalities and Growth Accounting," A.E.R., Vol.81(1), March 1991

Berglof, Erik and Enrico Perotti, "The Governance Structure of the Japanese Financial Keiretsu", Journal of Financial Economics, Vol. 36, 1994

Bernier, Ivan and Andree Lajoie, Law, Society and the Economy, Volume 46, Series of Studies for Royal Commision on the Economic Union and Development Prospects for Canada, 1986

Bernstein, J.I., Research and Development, Tax Incentives, and the Structure of Production and Financing, Ontario Economic Council Research Studies, Univ. of Toronto Press, 1986

Best, Michael H., The New Competition - Institutions of Industrial Restructuring, Harvard University Press, 1990

Birkholz, Charles R. and Jim Villella, The Battle to Stay Competitive - Changing the traditional workplace, The Delco Moraine NDH story, Productivity Press, Cambridge, Mass. Norwalk, Connecticut, U.S., 1990

Bok, Derel C., "Harvard's Bok Urges Changing Expensive, Inefficient, legal System", in the Chronicle of Higher Education, May 4, 1983

Bolton, Patrick and Joseph Farrell, "Decentralization, Delay, and Coordinations", Journal of Political Economy, Vol.98, No.4 1990

Brander, James, "Comparative Economic Growth: Evidence and Interpretation", Innis Lecture, Canadian Journal of Economics, November 1992

Buono, Anthony F. and James L. Bowditch, The Human Side of Mergers and Acquisitions: Managing Collisions between people, cultures, and organizations, Jossey-Bass Inc., Publishers, 1989

Business Week, "Do Mergers Really Work?", 1985

Carmichael, Edward A., Canada's Manufacturing Sector Performance in the 1970s, The Conference Board in Canada, 1978

Carrington, John C. and George T. Edwards, Financing Industrial Investment, the MacMillan Press Ltd., 1979

Caves, Douglas W., Laurits R. Christensen and Joseph A. Swanson, "Productivity Growth, Scale Economies, and Capacity Utilization in U.S. Railroads, 1955-74", AER, Dec. 1981

Caves, Richard E., "Mergers, Takeovers, and Economic Efficiency: Foresight VS Hindsight", International Journal of Industrial Organization 7, March 1989

Caves, Richard E. and David R. Barton, Efficiency in U.S. Manufacturing Industries, The MIT Press, 1990

Chandler, Alfred D., "The Enduring Logic of Industrial Success", Harvard Business Review, Vol. 90, No.2, 1990

Chandler, Alfred D., "Organizational Capacities and the Economic History of the Industrial Enterprise", Journal of Economic Perspectives, Vol.6, No.3, 1992

Chen, Tain-Jy, "Technical Change and Technical Adaption of Multinational Firms: the Case of Taiwan's Electronics Industry", Economic Development and Cultural Change, Vol.40, No.4, July 1992

Cheung, Steven N.S., The Myth of Social Cost, Cato Institute, 1987

Chinloy, Peter, The Cost of Doing Business: Legal and Regulatory Issues in the United States and Abroad, Praeger Publishers, 1989

Chow, Gregory C., Econometric Analysis by Control Methods, John Wiley & Sons, 1981

Coase, R.H., The Firm, the Market and the Law, The University of Chicago Press, 1988

Cooke, Terence E., International Mergers and Acquisitions, Basil Blackwell, 1988

Cowling, Keith et al, Mergers and Economic Performance, Cambridge Univ. Press, 1980

Cowen, Tyler (Ed.), The Theory of Market Failure - A critical Examination, George Mason Univ. Press, 1988

Daly, Donald J. and D.C. MacCharles, Canadian Manufactured Exports: Constraints and Opportunities, Institute for Research on Public Policy, 1986

D'Aspremont, Claude and Alexis Jacquemin, "Cooperative and Noncooperative R&D in Duopoly with Spillovers", American Economic Review, December 1988

Datta-Chaudhuri, Mrinal, "Market Failure and Government Failure", The Journal of Economic Perspectives, Vol.4, No.3, 1990

Davidson, Kenneth M., Mega-Mergers: Corporate America's Billion-Dollar Takeovers, 1985

Dearden, James, Barry W. Ickes and Larry Samuelson, "To Innovate or Not To Innovate: Incentives and Innovation in Hierarchies", American Economic Review, Dec. 1990

Denison, Edward F., Trends in American Economic Growth, 1929-1982, The Brooking Institution, Washington, D.C., 1985

Denny, M., M. Fuss and Leonard Wavernman, "The Measurement and Interpretation of Total Factor Productivity in Regulated Industries, with an Application to Canadian Telecommunications", in J.G. Cowing and R.E. Stevenson, Productivity Measurement in Regulated Industries, Academic Press, New York, 1981

Denny et al, "Change in Manufacturing Productivity and Competitiveness in Canadian and American Regions 1975-85", Institute for Policy Analysis, WP No. 9126, Univ. of Toronto, 1991

Denny, M. et al, "Productivity in Manufacturing Industries, Canada, Japan and the United States, 1953-1986: was the 'productivity Slowdown' Reversed?, Canadian Journal of Economics, Vol.25, No.3, 1992

Diewert, W.E. and T.J. Wales, "Flexible Functional Forms and Global Curvature Conditions", Econometrica 55, 1987

Diewert, W.E., "Fisher Ideal Output, Input and Productivity Indexes Revisited", University of B.C., Dept. of Economics, Discussion Paper, 89-07, 1989

Diewert, W.E., "The Measurement of Productivity", Bulletin of Economic Research 44(3), 1992

Dosi, Giovanni et al, Technical Change and Economic Theory, Printer Publishers, 1988

Dyer, Davis, et al, Changing Alliances - the Harvard Business School Project on the Auto Industry and the American Economy, Harvard Business School Press, 1987

The Economist Intelligence Unit (EIU), China, Japan & the Asian Nics - Economic Structure and Analysis, 1988

Edwards, J.S.S. and Klaus Fischer, Banks, Finance, and Investment in West Germany since 1970, Discussion Paper 497, London: Centre for Economic Policy Research, 1991

Fama, E.F. and M.C. Jensen, "Organizational Forms and Investment Decisions", Vol. 14, Journal of Financial Economics, 1985

Farrell, M.J. "The Measurement of Productive Efficiency", Journal of Royal Statistical Society, Series A, CXX, Part 3, 1957

Farrell, J. and Garth Saloner, "Coordination through committees and markets", The Rand Journal of Economics, Vol.19, No.2, 1988

Frank, David L. et al, "Economic Performance of the Canadian Pulp and Paper Industry: 1963-1982", Working Paper 107, Faculty of Commerce and Business Administration, UBC, 1988

Frantz, Roger S., "Ex-ante and Ex-post Criticisms of X-efficiency Theory and Literature", in Klaus Weiermair and Mark Perlman (ed), Studies in Economic Rationality - X - Efficiency Examined and Extolled, The University of Michigan Press, 1990

Frankel, Allen B. and John D. Montgomery, "Financial Structure: an Interregional Perspective", Brookings Papers on Economic Activity, 1:1991

Freeman, Chris, Technology Policy and Economic Performance: Lessons from Japan, London: Printer, 1987

Funke, Michael and Sean Holly, "The Determinants of West German Exports of Manufactures: an Integrated Demand and Supply Approach", Review of World Economics, Journal of the Kiel Institute of World Economy, Band 128, Heft 3, 1992

Fuss, M. and L. Waverman, "The Canada-U.S. Auto Pact of 1965: An Experiment in Selective Trade Liberalization", NBER WP No. 1953, 1986

Fuss, M. and L. Waverman, "The Extent and Sources of Cost and Efficiency Differences between U.S. and Japanese Motor Vehicle Producers", Journal of the Japanese and International Economies, Vol.4, Sept. 1990a

Fuss, M. and L. Waverman, "Productivity Growth in the Motor Vehicle Industry, 1970-1984: A Comparison of Canada, Japan, and the United States", in Charles R. Hulten (ed), Productivity Growth in Japan and the United States, The University of Chicago Press, 1990b

Fuss, M. and L. Waverman, Costs and Productivity in Automobile Production - the Challenge of Japanese Efficiency, Cambridge University Press, 1992

Futatsugi, Yusaku, "The measurement of Interfirm Relationships", in Kazuo Sato (Ed), Industry and Business in Japan, M.E. Sharpe, Inc., 1980

Gagne, Robert and Pierre Ouelette, "On the Choice of Functional Forms: A Monte Carlo Experiment", Centre de Recherche Sur Les Transports (C.R.T.), Universite de Montreal, June 1994

Gill, David, The Market for Legal Services, The Fraser Institute, 1988

Globe, D. and L. White, "A Time-Series Analysis of Mergers and Acquisitions in the U.S. Economy, in A. Auerbach (ed), Corporate Takeovers: Cause and Consequences, University of Chicago Press, 1988

Globerman, Steven, Mergers and Acquisitions in Canada: A Background Report, Royal Commission on Corporate Concentration, Study No.34, Ottawa, Supply and Services Canada, 1977

Gold, Thomas B., State and Society in the Taiwan Miracle, M.E. Sharpe, Inc, 1986

Goldberg, Walter H., Mergers: Motives, Modes, Methods, Nichols Publishing Company, 1983

Gomes-Casseres, Benjamin, "Group Versus Group: how alliance networks compete", Harvard Business Review, July-Aug., 1994

Goodman, E.M., "The Japanese Information-Gatherers", Research.Technology Management, Vol.35, No.4, July-August 1992

Gotlieb, Allan E., "Canada-U.S. Relations: Legislation, Regulation, and the Management of Conflict", Canadian Business Law Journal, Vol. 9, 1984

Government of Ontario, The Sectoral and Regional Sensitivity of Ontario Manufacturing Industries to Tariff Reductions: Canada - U.S. Free Trade Agreement, Background Paper, Nov. 1987

Green, Milford B., Mergers and Acquisitions - Geographical and Spatial Perspectives, Routledge, 1990

Greenwald, B. and J.E. Stiglitz, "Externalities in Economies with Imperfect Information and Incomplete Markets", Quarterly Journal of Economics, May, 1986

Gregory, R. and D. James, "Do New Factories Embody Best Practice Technology?"Economic Journal 83, 1973

Griliches, Zvi, Technology, Education, and Productivity, Basil Blackwell, 1988

Grillion, Harold J. and Frank A. Schubert, forth edition, Introduction to Law and the Legal System, Houghton Mifflin Company, 1989

Handfield-Jones, Stephen, Adjusting to New Market Realities - the Canadian Financial Services Industry in Transition, The Conference Board of Canada, Report 31-88, December 1988

Hasegawa, Keitaro, Japanese-Style Management - An Insider's Analysis, Kodansha International Ltd, 1986

Haveman, Robert H., The Economics of The Public Sector (2ed), John Wiley & Sons, Inc, 1976

Hladik, Karen J., International Joint Ventures - An Economic Analysis of U.S.-Foreign Business Partnerships, Lexington Books, 1985

Holmes, J., "Industrial Reorganization, Capital Restructuring and Locational Change", Economic Geography 59, 1983

Horiuchi, Akiyoshi and Q. Sui, "Influence of the Japan Development Bank Loans on Corporate Investment Behaviour", Journal of the Japanese and International Economies, Vol.7, No.4, 1993

Hoshi T., A. Kashyap and D. Scharfstein, "The Role of Banks in Reducing the Costs of Financial Distress in Japan", Journal of Financial Economics, Vol.27, 1990

Hulten, Charles R. (ed), Productivity Growth in Japan and the United States, The University of Chicago Press, 1990

Iacocca, Lee, Iacocca - An Autobiography, Sidgwick and Jackson, 1984

Inman, Robert P., "Markets, Governments, and the 'New' Political Economy," in Handbook of Public Economics, Vol. II, Ed. by Alan J. Auerbach and Martin Feldstein, 1987

Jackson, Thomas L. and Janamitra Devan, "Corruption and the Future of Authoritarian Capitalism in Southeast Asia", Global Economic Policy, Journal of the Geonomics Institute, Vol.2, No.2, Fall, 1990

Johnson, Chalmers, MITI and the Japanese Miracle, Stanford University Press, 1982

Johnston, Cathrine G., Globalization: Canadian Companies Compete, The Conference Board of Canada, Report 50-90-E, Feb. 1990

Jones, Bryan D., "Public Policies and Economic Growth in The American States," Journal of Politics, V.52, No.1, 1990

Jorde, Thomas M. and David J. Teece, "Competition and Corporation: Striking the Right Balance", California Management Review, Spring 1989

Jorde, Thomas M. and David J. Teece, "Innovation and Corporation: Implications for Competition and Antitrust", The Journal of Economic Perspectives IV, Summer 1990

Jorgensen, Jan, "Tracking Mergers and Acquisitions in Canada", Faculty of Management, McGill University, WP No.87-12, 1987

Jorgenson, Dale W., Productivity and U.S. Economic Growth, Harvard University Press, 1987

Kagono, Tadao et all, Strategic VS Evolutionary Management - A U.S.-Japan Comparison of Strategy and Organization, North-Holland, 1985

Kamien, M. and N. Schwartz, "Market Structure and Innovation: A Survey," Journal of Economic Literature, XIII, No.1, 1975

Kang, Jun-koo, "The International Market for Corporate Control - Mergers and Acquisitions of U.S. Firms by Japanese Firms", Journal of Financial Economics, Vol. 34, 1993

Kanter, Rosabeth Moss, "Collaborative Advantage", Harvard Business Review, July-Aug., 1994

Kendrick, John W., Postwar Productivity Trends in the United States, 1948-1969, The National Bureau of Economic Research, 1973

Kendrick, John W., Understanding Productivity - An Introduction to the Dynamics of Productivity Change, The John Hopkins University Press, 1977

Kester, W.Carl, Japanese Takeovers: the Global Contest for Corporate Control, Harvard Business School Press, 1991

Koopmans, Tjalling, Three Essays in the State of Economic Science, McGraw-Hill, New York, 1957

Krainer, Robert E., The Financial System and the Coordination of Economic Activity, 1985

Krause, Lawrence B., Koh Ai Tee and Lee (Tsao) Yuan, The Singapore Economy Reconsidered, The Institute of Southeast Asian Studies, 1987

Krueger, Anne O. and David Orsmond, "Impact of Government On Growth and Trade," NBER WP, No. 3545, Dec. 1990

LeCraw, Donald J. and Donald N. Thompson, Conglomerate Mergers in Canada, Royal Commission on Corporate Concentration, Study No.32, Ottawa, Supply and Services Canada, 1978

LeCraw, Donald J., "Choice of Technology in Low-Wage Countries: a Nonneoclassical Approach", QJE, Nov. 1979

Lester, John and Tony Morehen, "New Estimates of Canadian Tariff Rates by Industry and Commodity", Working Paper No. 88-2, Department of Finance, Government of Canada, 1988

Liang, Neng, "Beyond Import Substitution and Export Promotion: a New Typology of Trade Strategies", The Journal of Development Studies, Vol.28, No.3, April 1992

Lichtenberg, Frank R., "Industrial De-Diversification and Its Consequences for Productivity", Journal of Economic Behaviour and Organization 18, 1992

Lichtenberg, Frank R., Corporate Takeovers and Productivity, the MIT press, 1992

Lim, Linda Y.C., "The State and Private Capital in Singapore's Economic Development," Political Economy, Vol.3, No.2, 1987

Link, Albert N., Research and Development in U.S. Manufacturing, Praeger Publishers, 1981

Link, Albert N., "Productivity Growth , Environmental Regulations and the Composition of R&D", Bell Journal of Economics, Vol.13, 1982

Link, Albert N., Technological Change and Productivity Growth, Harwood Academic Publishers, 1987

Litan, Robert E., What should Bank Do? The Brookings Institution, Washington D.C., 1987

Litan, Robert E., The Revolution in U.S. Finance, The Brookings Institution, Washington D.C., 1991

Loury, Glenn C., "Market Structure and Innovation", Quarterly Journal of Economics, August 1979

Mansfield, E. "Size of Firm, Market Structure, and Innovation," Journal of Political Economy, LXXI, 1963

Marin, Dalia, "Is the export-led Growth Hypothesis Valid for Industrialized Countries", The Review of Economics and Statistics, Vol. LXXIV, Nov. 1992

Margolin, Jean-Louis, Singapour, 1959-1987, Editions L'Harmattan, 1989

Measuring Productivity - Trends and Comparisons from the First International Productivity Symposium, Asian Edition and Asian Productivity Organization,Tokyo, Published by UNIPUB, 1984

McGakey, Richard et al, Financial Services, Financial Centers - Public Policy and the Competition for Markets, Firms and Jobs, Westview Press, 1990

McFetridge, David (ed), Foreign Investment, Technology, and Economic Growth, Calgary: University of Calgary Press, 1991

McMillan, Charles J. The Japanese Industrial System, Walter de Grunter, 1984

Mikkelson, W.H. and R.S. Ruback, "An Empirical Analysis of Interfirm Equity Investment Process", Vol.14, Journal of Financial Economics, 1985

Milgrom, Paul and John Roberts, "The Economics of Modern Manufacturing: Technology, Strategy, and Organization", The American Economic Review, Vol. 80, No.3, 1990

Mohnen, Pierre et al, "Productivity and R&D in Two Canadian Forest Product Industries", Cashier No. 9310, Dept. of Economics, Universite du Quebec a Montreal, 1993

Mohnen, Pierre, The Relationship between R&D and Productivity Growth in Canada and other Major Industrialized Countries, A Research for Economic Council of Canada, Minister of Supply and Services Canada, 1992

Montgomery, Cynthia A., Corporate Diversification, Journal of Economic Perspectives, Vol.8, No.3, Summer 1994

Morley, S.A. and G.W. Smith, "The Choice of Technology: Multinational Firms in Brazil", Economic Development and Cultural Change, XXV, Jan. 1977

Munkirs, John R., The Transformation of American Capitalism: From Competitive Market Structures to Centralized Private Sector Planning, Armonk, 1985

Nadiri, M.I. and I. Prucha, "Estimation of the Depreciation rate of Physical and R&D Capital in the U.S. Total Manufacturing Sector", NBER WP No. 4591, 1993

National Economic Development Council in the UK (NEDC), Transferable Factors in Japanese Economic Success, 1983

Nelson, Richard R. and Sidney G. Winter, An Evolutionary Theory of Economic Change, The Belknap Press of Harvard Univ. Press, 1982

Nelson, Richard R., Understanding Technical Change as an Evolutionary Process, North-Holland, 1987

North, Douglas C. Institutions, Institutional Change and Economic Performance, Cambridge Univ. Press, 1990

Olson, Mancur, The Rise and Decline of Nations, New Haven, CT: Yale University Press, 1982

Olson, M., The Logic of Collective Action, Harvard Univ. Press, 1965

Ouellette, P. and P. Lasserre, "Mesure du Progress Technique: Theories et Methodes," Cashier 8425, Universite de Montreal, 1984

Peebles, Gavin, Hong Kong's Economy, Oxford Univ. Press, 1988

Perry, R., The Future of Canada's Auto Industry, Toronto: Lorimer, 1982

Polinsky, A. Mitchell, An Introduction to Law and Economics, Little, Brown and Company, 1983

Porter, Michael E., "From Competitive Advantage to Corporate Strategy", Harvard Business Review, May-June 1987

Posner, Richard A. Economic Analysis of Law, 2ed, Little, Brown and Company, 1977

Rabushka, Alvin, Hong Kong - A Study in Economic Freedom, Hoover Institution on War, Revolution and Peace, Stanford University, The University of Chicago Press, 1979

Ravenscraft, D. and F.M. Scherer, Mergers, Sell-offs, and Economic Efficiency, Brookings Institution, Washington, D.C., 1987

Rosenberg,N. Inside the Black Box, Cambridge Univ. Press, 1982

Rothwell, Roy and Walter Zegveld, Reindustrialization and Technology, Chapter 5, Longman Group Limited, 1985

Sah, R.K. and J.E. Stiglitz, "The Architecture of Economic Systems: Hierarchies and Polyarchies", American Economic Review, Vol. 76, No.4, 1986

Sah, R.K. and J.E. Stiglitz, "Committees, Hierarchies, and Polyarchies", The Economic Journal, 98, 1988

Samuels, Warren J.(Ed.), Institutional Economics, Vol. 2, Edward Elgar, 1988

Samuels, Warren J., "Interrelationships Between Legal and Economic Processes," in Warren J. Samuels (Ed.), Institutional Economics, Vol. 2, 1988

Sappington, D. and J.E. Stiglitz, "Privatization, Information, and Incentives", Journal of Policy Analysis and Management, Vol. 6, No.4, 1987

Sato, Ryuzo and Gilbert S. Suzawa, Research and Productivity - Endogenous Technical Change, Auburn House Publishing Company, 1983

Schneider, Anne and Helen Ingram, Behavioral Assumptions of Policy Tools, Journal of Politics, V.52, No.2, 1990

Schneider-Lenne, Ellen R., "Corporate Control in Germany", Oxford Review of Economic Policy, Vol.8, No.3, 1992

Sheehey, Edmund J., "Exports and Growth: Additional Evidence", The Journal of Development Studies, Vol.28, No.4, July 1992

Shen,T.Y., "The Estimation of X-Inefficiency in Eighteen Countries", The Review of Economics and Statistics, Vol. LXVI, No. 1, Feb. 1984

Shetty, Y.K. and Vernon M. Buehler (ed), The Quest for Competitiveness, Quorum Books, 1991

Simmon, H. A. "Theories of Decision Making in Economics and Behaviour Science", American Economic Review, June 1989

Simon, Herbert A. "Organization and Markets", Journal of Economic Perspective Vol 5(2), Spring 1991

Skully, Michael T.(ed), Financial Institutions and Markets in the Far East - A study of China, Honkong, Japan, South Korea and Taiwan, St. Martin's Press (NY), 1982

Smith, C.W., "Investment Banking and the Capital Acquisition Process", Vol.15, Journal of Financial Economics, 1986

Srinivasan, T. N. "Neoclassical Political Economy, the state and Economic Development", Asian Development Review, 1985

Stager, David A.A., Lawyers in Canada, University of Toronto Press, 1990

Starr, A.W. and Y.C. Ho, "Further Properties of Nonzero-Sum Differential Games", Journal of Optimization Theory and Applications, Vol. 3, No.4, 1969

Stigler, G., "Theory of Regulation", Bell Journal of Economics, Spring, 1971

Stiglitz, J.E., "Incentives, Information, and Organization Design", Empirica, 1989

Stiglitz, J.E. et al, The Economic Role of the State, Basil Blackwell, 1989

Stiglitz, Joseph E., "Government, Financial Markets, and Economic Development," NBER, WP 3669, April, 1991

Summers, Robert and Alan Heston, "A new Set of international Comparisons of Real Product and Price Level Estimates for 130 Countries, 1950-85", Review of Income and Wealth, Series 34, No.1, March, 1988

Summers, Robert and Alan Heston, "The Penn World Table (Mark 5): An Expanded Set of International Comparisons, 1950-1988", The Quarterly Journal of Economics 106, May 1992

Suzuki, K. "Knowledge Capital and the Private Rate of Return to R & D in Japanese Manufacturing Industries", International Journal of Industrial Organization, No.3, 1985

Tassey, G. "Infratechnologies and the Role of Government", Technological Forecasting and Social Change, 21 (1982)

Teece, David J., "Strategical Alliances and Technology", University of California, Berkley, W.B. Haas School of Business, WP No. 100, 1990

Teece, David J., "Competition, Cooperation, and Innovation - Organization arrangements for regimes of Rapid technological Progress", Journal of Economic Behaviour and Organization 18, No. 1, 1992

Telser, Lester G., "Cooperation, Competition, and Efficiency", Journal of Law & Economics, Vol.XXVIII, May 1985

Tetrault, McCarthy et al, "Securitization in Canada: The Legal Issues", in Raymond H. Rupert (ed.), The Canadian Investment Banking Review, McGraw-Hill Ryerson, 1992

Teubal,Morris and E. Steinmueller, "The Introduction of a Major New Technology - Externalities and Government Policy," in Morris Teubal (Ed.), Innovation Performance, Learning, and Government Policy - Selected Essays, 1987

Timmer,C.P., "Using a Probabilistic Frontier Production Function to Measure Technical Efficiency, " Journal of Political Economy, LXXIX, July-Aug. 1971

Toevs, Alden L., "Approximate Variance Formulas for the Elasticities of Substitution Obtained from Translog Cost Functions", Economics Letters 10, 1982

Tribe, Lawrence H., "Too Much Law, Too Little Justice: An Argument for Delegalizing America,"The Atlantic, July 10, 1979

Vogel, Ezra F., Japan as Number 1, Harvard, 1979

Wall, Toby D., Chris W. Clegg and Nigel J. Kemp, The Human Side of Advanced Manufacturing Technology, John Wiley & Sons, 1987

Wallis, John J. and Douglas C. North, "Measuring the Transaction Sector in the American Economy, 1970-1970", in S.L. Engerman and R.E. Gallman (Eds.), Long-term Factors in American Economic Growth, University of Chicago Press, 1986

Watanabe, Susumu, "On Socio-Institutional Conditions of Japan's Modernization," Political Economy, Vol.3, No.2, 1987

Wavweman, Leonard (ed), Corporate Globalization through Mergers and Acquisitions, The Investment Canada Research Series, The University of Calgary Press, 1991

Weiermair, Klaus and Atipol Bhamich Supapol, "Restructuring, Regrouping, Adjusting: the Case of Canadian Textile and Clothing Industries", Faculty of Administrative

Studies, York Univ., No.2, Feb. 1991

Weston, J.Fred, Kwang S. Chung and Susan E. Hoag, Mergers, Restructuring and Corporate Control, Printice Hall, 1990

Williamson, O.E. "Innovation and Market Structure," Journal of Political Economics, LXXIII, 1965

Williamson, Oliver E., The Economic Institutions of Capitalism - Firms, Markets, Relational Contracting, The Free Press, 1985

Wolf, Bernard M., "Industrial Diversification and Internationalization: Some Empirical Evidence", Journal of Industrial Economics 26, Dec. 1977

Wolf, Bernard M. and Glen Taylor, "Employee and Supplier Learning in the Canadian Automobile Industry: Implications for Competitiveness", in David McFetridge, ed, Foreign Investment, Technology, and Economic Growth, Calgary: University of Calgary Press, 1991

Wolf, Bernard M. and Steven Globerman, "Strategical Alliances in the Automotive Industry: Motives and Implications", WP No.62, Faculty of Administrative Studies, York University, Canada, May 1992

Wolf, Charles, Jr., Markets or Governments, Choosing between Imperfect Alternatives, The MIT Press, 1988

Womack, James P., "Multinational Joint-Ventures in Motor Vehicles," International Collaborative Ventures in U.S. Manufacturing, Edited by David C. Mowery, Cambridge, Mass., Ballinger, 1988

Womack, James P., Daniel T. Jones and Daniel Roos, The Machine That Changed the World, MacMillan Publishing Company, 1990

Worldwide Economic Indicators, various years

Yamamura, Kozo and Yasukichi Yasuba(Ed.), The Political Economy of Japan, Vol.1, the Domestic Transformation, Stanford Univ. Press, 1987

Youngson, A.I., Hong Kong Economic Growth and Policy, Oxford University Press, 1982

Zysman, John, Governments, Markets, and Growth - Financial Systems and the Politics of Industrial Change, Cornell University Press, 1983

Appendix A: The Data Base

This appendix describes the data used for this study. It describes the sources and certain data manipulations. Data for production, capital, labour, energy, intermediate materials, export and import, and financial integration data are described as follows.

1. Outputs

We obtain the value of shipments and other revenues from Statistics Canada publication Catalogue 31-203 *Manufacturing industries of Canada: national and provincial areas annual*, for each two-digit manufacturing industry. The price indexes of output are obtained from StatsCan Cat. 62-543 *Industry Selling price indexes: Manufacturing 1956-1976* and Cat 62-556 *Industrial Product Prices Index*. Since the publications give data in different Standard Industrial Classification (SIC), we convert data in 1960 SIC and in 1980 SIC into 1970 SIC, by using 1971 and 1982 as reference years respectively.

2. Inputs

In this study, four inputs are used in the analysis: labour, capital, energy and materials. Capital is treated as quasi-fixed.

2.1 Labour

Labour costs and man-hour are collected from Statistics Canada publication Catalogue 31-203 *Manufacturing industries of Canada: national and provincial areas annual*, for each two-digit manufacturing industry. We add wages of production and related workers and salaries of non-manufacturing workers to get the total labour cost; the total man-hour is obtained by adding those of the production workers (given in Cat. 31-203) and the non-manufacturing workers (calculated from the given number of employees by assuming 37.5 hr/week work). We convert data in 1960 SIC and in 1980 SIC into 1970 SIC, by using 1971 and 1982 as reference years respectively.

2.2 Capital

Capital is classified by Statistics Canada into four components: building construction, engineering construction, machinery and equipment, and items charged to operating expenses. We follow this classification and collect the data from CANSIM Matrix Numbers 6572-6592 for capital stocks and capital price index from data provided by Investment and

Capital Stock Division of Statistics Canada. Capital stock is estimated by the perpetual inventory method for each component. Total capital is the aggregation of the four components

$$K_{i,t}=I_{i,t-1}+(1-d_i)K_{i,t-1}$$

Where

$K_{i,t}$ - constant $ capital stock of component i at t
$I_{i,t}$ - constant $ investment for component i, at t
$K_{i,t-1}$ - constant $ capital stock of component i at t-1
d_i - the depreciation rate of capital component i, d is equal to 2 divided by the service or economic use life of the ith component

The service price or the rent cost of capital is the economic cost of using one dollar's worth of capital asset for a period of one year. Following Christensen and Jorgenson (1969), the service price is calculated by the following formula, in the discrete version,

$$PXK_{i,t}=\frac{1-U_tZ_{i,t}-K_{i,t}}{1-U_t}[q_{i,t-1}r_t+q_{i,t}d_i-kgr_{i,t}*q_{i,t}]$$

With $Z_{i,t}=\sigma_{i,t}[\frac{1+r_t}{r_t+\sigma_{i,t}}]$

Where

$PXK_{i,t}$ - the rent cost (the service price) of the ith capital component in year t
U_t - corporate income tax rate
$Z_{i,t}$ - present value of depreciation deductions from the ith capital component in year t for the purpose of taxation
K_t - investment tax credit in year t
$q_{i,t}$ - asset price of the ith capital component in year t
$kgr_{i,t}$ - a five-year running average[1] capital gain rate of the ith capital component at t,
$kgr_{i,t} = [\ln(q_{i,t})-\ln(q_{i,t-5})]/5$

[1]A five-year running average capital gain rate is used to calculate service price. This is due to the fact that yearly prices are volatile, and their use may cause service price to be negative in certain years.

r_t - opportunity cost of capital in year t,
the Mcleod Young Weir corporate bound rate
for 10 industrial average is used

d_i - the economic depreciation rate,
d_i=2/(the service or economic use life
of the ith capital component)

$\sigma_{i,t}$ - capital cost allowance rate, i.e. tax depreciation rate

The service prices and real capital stocks of each capital category are aggregated by Divisia index to obtain a aggregate service price and capital stock for a sector (or an industry).

2.3 Energy

The detail energy components are from StatsCan *Cat. 57-206 (for 1962-74), 57-208 (for 1975-85) Consumption of purchased Fuel and Electricity*. However, these publications publish energy consumption data in different details (in terms of detail components and measurement units) in different time periods. Data are given in metric system starting from 1980 on, while they are given in British system in 1962-1979; In 1962-1972, the following components are given: coal and coke, gasoline, natural gas, *fuel oil*, liquefied petroleum gases, electricity, where fuel oil includes kerosene, light fuel oil, heavy fuel oil, diesel oil; From 1973 on, the more detailed components are given: coal and coke, gasoline, natural gas, *kerosene, light fuel oil, heavy fuel oil, diesel oil*, liquefied petroleum gases, electricity. In this study, we use the British system for measurement and aggregate the 1962-72 detailed components by Divisia index method, i.e. coal and coke, gasoline, natural gas, *fuel oil*, liquefied petroleum gases, electricity, where fuel oil includes kerosene, light fuel oil, heavy fuel oil, diesel oil.

Furthermore, since the publications for production Cat. 31-203 give data in different Standard Industrial Classification (SIC), we convert energy data in 1960 SIC and in 1980 SIC into 1970 SIC, by using 1971 and 1982 as reference years respectively. The 1986 data are extrapolations from data in 1984 and 1985.

2.4 Materials

We obtain the value data from Statistics Canada publication Catalogue 31-203 *Manufacturing industries of Canada: national and provincial areas annual*, for each two-digit manufacturing industry. The price index of materials is gross domestic product price index. We convert data in 1960 SIC and in 1980 SIC 1970 SIC, by using 1971 and 1982 as reference years respectively.

3. Data for Exports and Imports

We measure the degree of a firm's exposure to foreign competition by its export orientation (exports) and import penetration from other countries.

The export orientation of a manufacturing industry is measured by the ratio of exports and shipments, i.e. Ex=Exports/Shipments, and import penetration by Im=Imports/(Canadian Market). These data are collected from Department of Regional Industrial Expansion (1985, 1987): Manufacturing Trade and Measures 1966-1984 (by 1970 SIC), and 1981-1986 (by 1980 SIC). The original sources are from Statistics Canada Publication Cat. 65-004 Exports by Commodity. All data are converted into 1970 SIC so that they are compatible with other data. The data are available from 1966 to 1986.

4. Data for Financial interpenetrations

Financial interpenetrations data are obtained from Statistics Canada publication Cat. 61-207 Corporation Financial Statistics Annual. Data are available from 1965 on.

The financial interpenetration between two firms is measured by the ratio of Investment in Affiliates to Total Long-term Asset. The financial penetration from banks is measured by the ratio of Long term Bank Loan to Total Long term Liability. We have compiled the data for 1966-1986.

5. Data

The following gives data on financial interpenetration between firm and bank, financial interpenetration between firms, export orientation, and import penetration for the selected 17 2-digit manufacturing industries in Canada, between 1966 and 1986. Other data are available from the autor.

Financial interpenetration between firm and bank is the long-term bank loans to the industry divided by total long-term liability of the industry; Financial interpenetration between firms as the ratio of all firms' investments in their affiliated firms divided by total long-term assets in the industry; The export orientation variable is defined as export divided by total shipments of the industry; Import penetration is defined as import divided by total Canadian market for the industry.

5.1 Export Orientation (%), 1966-86

Export Orientation (%), 1966-86

Year	F&B	RUB	Leath	Text	Knit	Cloth	Wood	Furn
1966	9.60	4.10	4.40	4.80	1.80	2.20	38.90	2.10
1967	9.10	4.80	4.80	3.90	1.90	2.10	39.10	1.90
1968	9.00	4.10	5.50	4.60	1.50	2.90	42.30	2.00
1969	9.30	4.10	5.50	4.30	2.40	4.30	40.90	3.60
1970	9.70	4.90	6.80	5.00	2.90	4.80	43.00	4.80
1971	9.70	4.40	5.70	5.00	2.30	5.10	43.20	4.50
1972	9.70	5.30	5.90	4.60	2.50	5.20	45.70	4.20
1973	11.10	7.10	6.70	5.60	2.40	6.00	46.90	4.90
1974	8.60	6.60	5.20	6.20	2.10	5.60	39.50	4.60
1975	8.50	6.80	6.50	4.80	1.50	4.40	33.20	4.20
1976	9.50	10.10	7.50	5.00	1.80	4.00	41.50	4.50
1977	11.10	9.00	8.80	5.70	1.60	4.40	49.80	6.00
1978	11.60	10.00	9.40	6.30	1.80	4.60	53.40	7.00
1979	12.40	10.90	7.90	7.00	1.60	5.00	54.30	8.70
1980	11.70	11.00	7.90	8.20	1.40	5.80	50.20	9.50
1981	12.70	13.50	7.50	7.90	1.60	6.30	46.50	10.10
1982	12.50	16.30	9.10	7.90	1.50	5.90	52.40	12.30
1983	11.70	17.20	8.60	6.80	1.30	5.20	51.90	14.10
1984	12.40	19.20	6.70	7.70	1.40	6.50	55.40	18.40
1985	12.30	19.60	7.20	7.90	1.50	6.80	53.30	20.40
1986	13.70	23.20	7.50	8.80	2.10	7.90	54.00	23.10

Export Orientation (%), 1966-86

Year	Paper	Prim	MetP	Mach	Trans	Elec	NonM	Petr	Chem
1966	49.90	42.20	2.70	33.00	31.20	9.20	5.30	1.00	14.40
1967	49.50	47.60	3.00	36.10	46.20	10.30	5.50	1.20	14.50
1968	50.40	49.20	3.40	33.50	56.60	13.30	5.70	1.60	14.10
1969	52.40	43.20	3.20	35.40	60.20	13.30	6.50	1.90	15.10
1970	52.40	53.40	3.80	38.20	68.60	15.80	7.50	2.80	16.50
1971	51.20	45.30	4.10	39.50	66.10	13.30	6.60	3.40	15.50
1972	49.90	42.70	4.90	39.20	68.90	13.00	7.30	6.10	15.70
1973	50.20	45.30	4.80	43.20	67.30	14.10	8.70	7.10	15.30
1974	52.40	43.80	5.50	43.40	62.40	14.30	7.90	7.30	16.40
1975	54.40	38.90	5.20	46.30	64.10	13.50	6.70	5.70	15.40
1976	55.20	45.30	5.10	44.90	68.60	14.30	7.10	3.10	17.90
1977	55.80	44.60	6.40	49.00	74.30	14.70	8.80	2.40	20.50
1978	55.60	47.50	7.00	52.00	75.50	17.90	10.90	6.00	25.40
1979	57.90	44.60	7.50	52.40	69.30	20.60	12.30	11.00	28.00
1980	58.90	60.90	7.00	49.30	69.00	21.40	10.70	11.20	28.40
1981	57.70	54.30	7.30	51.40	71.30	23.20	10.50	8.40	27.90
1982	56.00	49.70	7.30	52.20	83.90	24.00	11.00	6.60	24.20
1983	52.40	49.30	8.60	58.70	83.50	27.40	11.00	7.90	24.80
1984	55.80	51.70	9.00	60.40	85.20	36.00	13.80	8.90	27.00
1985	54.90	44.10	6.70	56.50	84.30	33.70	12.90	9.50	27.60
1986	56.70	60.30	9.30	61.10	87.00	34.80	12.90	6.80	28.40

5.2 Import Penetration (%), 1966-86

Import Penetration (%), 1966-86

Year	F&B	RUB	Leath	Text	Knit	Cloth	Wood	Furn
1966	6.60	14.50	14.40	25.20	11.30	5.10	8.00	5.10
1967	6.20	14.50	15.10	22.70	12.00	5.40	8.00	5.10
1968	6.40	16.50	18.50	22.10	15.00	6.60	9.30	5.50
1969	7.20	17.60	19.80	22.60	18.40	7.20	9.10	5.70
1970	7.00	16.90	22.40	22.80	21.40	6.80	8.40	5.60
1971	7.00	18.10	23.50	22.80	27.30	6.90	8.50	5.80
1972	7.80	19.60	26.30	25.10	30.10	7.70	9.80	7.10
1973	9.00	20.80	26.00	26.40	26.60	8.70	10.70	9.20
1974	8.80	27.00	28.30	28.20	27.00	9.70	12.80	11.30
1975	8.40	24.70	32.70	25.90	30.90	9.90	12.40	10.40
1976	9.40	21.00	34.60	27.30	35.70	13.90	11.70	12.10
1977	10.10	23.20	36.50	26.30	33.00	11.80	11.40	13.60
1978	10.40	22.50	34.80	27.10	31.30	10.80	11.20	13.30
1979	10.20	22.80	33.40	28.50	30.50	12.20	12.50	12.60
1980	9.50	21.50	31.50	26.00	27.30	11.40	10.20	11.20
1981	9.10	21.90	33.50	26.20	28.50	13.30	11.00	12.00
1982	8.70	20.20	35.20	24.50	28.90	14.30	8.60	10.10
1983	8.80	22.60	37.50	25.40	31.60	16.00	10.20	11.60
1984	10.20	25.80	38.50	27.00	36.60	19.90	10.80	13.90
1985	8.50	24.90	38.20	29.10	39.40	19.70	9.80	14.10
1986	9.30	26.40	43.30	30.80	41.80	22.20	11.20	16.60

Import Penetration (%), 1966-86

Year	Paper	Prim	Metr	Mach	Trans	Elec	NonM	Petr	Chem
1966	5.50	23.50	11.60	64.20	39.10	21.90	15.30	10.80	23.00
1967	5.30	23.60	12.70	64.40	50.00	22.30	15.50	11.00	22.90
1968	5.70	23.10	12.40	64.00	58.60	23.00	13.40	11.40	23.70
1969	6.00	24.50	13.30	64.80	60.50	25.90	15.20	11.40	25.30
1970	5.90	24.60	12.60	65.50	67.10	25.30	15.60	10.30	26.80
1971	6.40	23.50	12.90	66.30	65.70	27.30	14.60	9.20	25.00
1972	6.90	23.00	14.10	67.60	69.00	30.50	15.10	8.10	27.30
1973	7.20	25.10	14.50	70.50	69.30	32.20	15.40	6.20	28.20
1974	7.40	31.60	15.10	70.70	67.50	32.50	16.60	6.20	30.70
1975	10.50	23.30	15.00	71.30	69.30	30.40	15.90	4.00	28.10
1976	11.20	21.90	14.60	71.20	70.70	34.50	16.20	2.90	29.20
1977	9.80	22.20	15.70	72.90	75.80	36.80	17.30	3.30	30.90
1978	9.80	25.90	15.80	74.10	76.60	39.30	16.60	3.20	33.60
1979	10.00	34.70	15.20	74.60	73.50	40.30	18.00	3.30	34.00
1980	9.30	42.60	14.50	73.30	72.50	38.60	19.20	4.90	31.60
1981	10.60	39.80	15.40	74.00	74.30	40.10	18.50	3.70	30.20
1982	10.30	30.60	14.00	72.70	81.60	39.00	17.10	3.00	26.90
1983	10.40	31.90	15.40	77.60	82.50	45.20	17.50	4.00	30.70
1984	12.20	33.00	17.20	79.70	84.10	52.50	19.40	6.60	33.20
1985	11.80	33.30	16.00	79.60	84.00	48.50	18.90	6.40	32.60
1986	12.90	42.50	17.80	83.50	87.10	52.10	18.70	7.00	35.00

5.3 Financial Inperpenetration (%), 1966-86

Financial Inperpenetration (%), 1966-86

Year	F&B	RUB	Leath	Text	Knit	Cloth	Wood	Furn
1966	13.45	4.23	10.51	14.11	16.45	12.40	3.58	7.39
1967	13.66	4.02	11.07	12.33	17.34	6.31	6.63	7.99
1968	14.56	1.75	12.97	10.36	7.04	8.73	6.05	9.04
1969	17.44	1.80	14.24	13.50	18.45	10.88	8.13	9.62
1970	17.40	2.61	9.48	14.30	8.13	9.55	7.47	11.86
1971	17.66	2.65	14.12	14.16	8.77	7.89	9.12	9.54
1972	19.55	3.08	9.95	17.50	8.30	10.99	5.40	11.51
1973	19.35	3.90	10.16	11.65	4.61	16.07	7.27	10.26
1974	17.54	2.91	15.75	11.78	8.66	15.96	4.96	12.64
1975	18.28	0.76	10.97	11.68	6.94	18.98	4.34	19.30
1976	19.37	2.74	14.04	11.42	4.31	9.59	4.82	11.41
1977	17.99	6.03	17.34	10.80	4.45	9.11	9.62	11.76
1978	17.36	4.74	19.36	13.60	5.89	7.66	8.94	9.46
1979	16.89	0.89	20.51	11.73	3.00	7.73	10.97	11.41
1980	17.40	0.51	37.99	12.46	2.86	8.23	13.26	18.81
1981	16.47	0.34	31.48	12.51	3.62	5.67	11.61	6.84
1982	22.66	0.08	27.89	13.13	3.20	5.93	11.66	3.27
1983	22.58	0.85	36.37	20.30	0.65	3.71	9.54	9.63
1984	22.77	0.51	30.54	19.97	2.33	3.70	9.83	7.64
1985	31.94	22.99	22.78	12.26	1.78	2.17	12.05	2.68
1986	31.89	7.02	15.69	12.27	1.07	6.18	11.56	8.96

Financial Inperpenetration (%), 1966-86

Year	Paper	Prim	MetF	Mach	Trans	Elec	NonM	Petr	Chem
1966	20.33	5.13	12.36	8.18	16.94	11.86	9.54	16.11	12.96
1967	19.39	6.98	9.19	8.66	15.92	12.38	12.85	11.10	14.11
1968	20.26	6.65	10.20	7.57	13.45	11.74	16.06	10.44	13.56
1969	19.35	10.60	11.68	5.87	13.92	14.03	15.75	13.31	16.61
1970	17.91	10.02	13.93	6.46	12.61	15.85	17.80	9.02	12.99
1971	16.60	9.40	11.65	5.31	13.25	15.44	23.40	8.90	11.26
1972	16.65	12.92	13.41	5.55	15.57	14.31	21.24	9.16	9.30
1973	16.59	12.69	16.86	15.08	8.99	14.31	22.43	11.14	11.43
1974	18.79	11.34	12.77	16.88	10.34	14.51	22.20	10.50	10.17
1975	18.49	11.09	14.83	15.10	11.67	22.26	23.24	11.33	9.95
1976	19.46	10.03	14.92	8.37	12.32	15.81	24.67	15.34	8.30
1977	24.72	9.53	14.28	8.31	12.48	12.07	23.66	14.75	8.23
1978	24.20	8.10	14.60	9.25	12.31	15.34	24.18	10.05	9.57
1979	19.13	7.97	18.81	11.34	8.99	33.21	18.23	23.43	9.86
1980	16.45	7.43	19.25	13.49	5.65	42.05	17.51	22.95	11.62
1981	17.30	7.03	25.66	11.14	6.02	43.02	26.84	27.67	9.05
1982	13.75	6.98	23.88	12.13	7.11	40.57	33.42	28.03	11.85
1983	13.65	7.16	28.79	16.85	7.11	39.56	33.22	17.84	9.64
1984	13.91	7.31	28.59	10.85	7.37	34.71	25.41	16.42	9.29
1985	11.71	10.29	30.78	14.00	12.62	34.80	36.88	22.34	18.17
1986	11.20	14.79	29.15	14.03	10.90	38.32	29.12	34.20	21.33

5.4 Financial Interpenetration between Firm and Bank (%), 1966-86

Financial Interpenetration between Firm and Bank (%), 1966-86

Year	F&B	RUB	Leath	Text	Knit	Cloth	Wood	Furn
1966	4.67	2.37	3.89	2.85	4.70	4.49	13.27	6.93
1967	4.62	2.93	3.34	3.49	6.72	3.15	13.68	4.23
1968	4.53	4.25	1.70	2.97	10.24	3.96	11.86	4.95
1969	3.80	4.61	0.53	3.60	5.75	4.41	10.78	7.04
1970	5.03	3.87	1.20	4.68	8.41	4.56	13.29	6.21
1971	5.59	3.43	1.69	5.74	7.02	4.14	12.57	4.36
1972	8.67	3.45	4.21	7.15	10.14	4.98	10.64	7.80
1973	9.87	3.73	5.04	7.40	6.01	3.77	8.07	10.67
1974	9.12	3.90	5.61	8.89	14.92	2.42	8.48	8.94
1975	9.74	25.89	6.74	8.62	17.68	3.43	11.29	7.08
1976	9.50	23.99	9.57	6.97	22.50	5.04	11.56	5.37
1977	7.22	3.35	11.65	7.13	7.05	8.16	10.88	10.91
1978	10.30	2.00	17.95	6.51	16.67	9.64	12.59	13.61
1979	12.61	24.02	22.23	8.28	12.77	14.50	15.11	13.23
1980	14.51	26.97	7.96	8.64	19.94	9.12	27.51	17.45
1981	12.27	27.97	11.71	12.04	13.27	7.84	32.85	15.11
1982	21.83	24.01	13.89	19.18	7.07	11.39	37.85	11.80
1983	24.49	30.13	17.94	9.45	13.53	12.02	35.87	7.78
1984	18.75	45.24	14.40	11.86	10.63	7.73	38.95	10.05
1985	12.73	30.31	13.94	11.63	5.67	9.39	29.45	13.87
1986	8.79	24.32	10.30	11.44	11.39	9.39	24.38	8.93

Financial Interpenetration between Firm and Bank (%), 1966-86

Year	Paper	Prim	MetF	Mach	Trans	Elec	NonM	Petr	Chem
1966	1.26	2.66	4.62	9.61	6.35	5.40	11.79	1.38	2.40
1967	1.36	3.48	4.33	12.61	10.56	7.87	5.34	1.67	2.48
1968	1.26	2.92	4.25	12.90	8.05	9.49	6.73	1.00	2.42
1969	1.23	3.24	4.67	10.17	7.08	7.14	12.97	2.13	2.23
1970	1.42	3.24	5.33	10.78	8.35	5.84	14.49	2.51	2.12
1971	1.78	2.79	5.21	9.40	19.52	5.98	9.02	2.78	2.75
1972	3.29	2.57	6.00	8.34	20.51	9.74	7.58	7.72	1.61
1973	4.82	3.82	8.37	6.26	13.35	8.61	8.53	7.97	3.06
1974	2.90	2.51	10.65	6.23	12.93	15.83	11.35	5.11	9.30
1975	2.64	2.38	11.06	8.98	9.99	10.74	8.45	4.63	17.65
1976	5.16	5.69	16.74	9.08	7.94	8.38	11.59	8.35	25.34
1977	5.85	2.17	15.14	11.32	11.27	15.56	9.50	2.33	17.19
1978	4.07	3.11	15.71	13.24	8.24	12.90	8.72	0.44	3.80
1979	3.59	2.14	20.18	14.02	15.05	26.36	20.51	0.16	4.63
1980	5.25	4.86	16.96	12.64	11.65	26.95	21.51	2.90	7.10
1981	23.53	15.00	26.97	13.44	12.62	11.05	10.77	18.98	9.20
1982	30.18	5.70	22.67	10.57	15.31	11.94	27.31	9.21	12.95
1983	36.36	6.16	22.05	16.22	18.14	18.73	23.54	8.43	7.91
1984	35.25	10.66	28.48	11.24	6.11	21.61	14.10	2.94	7.51
1985	34.48	15.07	22.54	5.36	5.90	16.78	7.61	1.50	9.11
1986	26.72	12.55	16.60	7.88	7.82	12.48	7.00	11.75	11.36

Appendix B: Main Empirical Results

Main empirical results are given in the following tables.

1. Shadow Value of Capital Stock (PSK) and T-Ratio, 1967-86

Shadow Value of Capital Stock (PSK) and T-Ratio, 1967-86

Year	Food and Bev		Rub & Plastics		Leather		Textile	
1967.	-0.0749	-1.440	0.0275	0.493	0.1534	1.816	0.0330	-0.658
1968.	0.0020	0.054	0.1082	2.268	0.2395	2.905	0.0596	1.501
1969.	0.0090	0.258	0.1169	2.589	0.2481	3.081	0.0734	1.911
1970.	-0.0424	-1.017	0.0455	0.985	0.1999	2.461	0.0214	0.499
1971.	0.0044	0.111	0.0951	1.947	0.2486	2.862	0.0773	1.673
1972.	-0.0464	-1.133	0.0419	0.891	0.2060	2.368	0.0367	0.769
1973.	-0.0167	-0.483	0.0812	2.202	0.2292	2.968	0.0816	2.146
1974.	-0.0161	-0.391	0.0722	2.134	0.2179	3.111	0.0666	1.898
1975.	-0.0518	-1.348	0.0001	0.002	0.1939	2.684	0.0295	0.860
1976.	-0.0280	-0.819	0.0281	0.804	0.2103	2.841	0.0553	1.628
1977.	-0.0019	-0.055	0.0809	2.248	0.2156	2.853	0.0817	2.218
1978.	0.0289	0.738	0.1316	2.890	0.2462	2.977	0.1225	2.686
1979.	-0.0197	-0.527	0.0766	2.049	0.1995	2.747	0.0909	2.594
1980.	-0.0326	-0.883	0.0550	1.489	0.1774	2.332	0.0793	2.265
1981.	-0.0574	-1.519	0.0281	0.744	0.1562	2.130	0.0499	1.385
1982.	-0.0195	-0.498	0.0895	2.307	0.2193	2.945	0.0937	2.471
1983.	-0.0787	-1.950	0.0263	0.715	0.1503	1.997	0.0565	1.538
1984.	-0.0367	-0.933	0.0550	1.183	0.2009	2.733	0.0898	2.409
1985.	-0.0438	-1.006	0.0409	0.998	0.2182	2.909	0.1102	2.706
1986.	0.0479	0.862	0.1681	3.136	0.3161	3.811	0.2038	3.679

Shadow Value of Capital Stock (PSK) and T-Ratio, 1967-86 (cont'd)

	Knitting		Clothing		Wood		Furn and Fix.	
1967.	0.0861	1.125	0.1952	2.254	-0.0269	-0.532	0.1269	1.684
1968.	0.1963	2.598	0.2772	3.294	0.0622	1.569	0.1992	2.861
1969.	0.1971	2.679	0.2887	3.470	0.0711	1.940	0.2046	3.049
1970.	0.1553	2.105	0.2380	2.822	0.0036	0.089	0.1504	2.183
1971.	0.2089	2.664	0.3009	3.342	0.0487	1.182	0.2125	2.866
1972.	0.1638	2.097	0.2595	2.831	0.0134	0.324	0.1731	2.284
1973.	0.2097	2.994	0.2847	3.426	0.0419	1.325	0.2054	3.050
1974.	0.1822	2.966	0.2833	3.748	0.0285	0.849	0.1929	3.276
1975.	0.1630	2.524	0.2396	3.057	-0.0227	-0.732	0.1344	2.294
1976.	0.1813	2.633	0.2831	3.555	0.0088	0.300	0.1773	2.954
1977.	0.2297	3.175	0.2953	3.732	0.0248	0.780	0.1888	3.059
1978.	0.2577	3.211	0.4095	4.723	0.0596	1.509	0.2339	3.328
1979.	0.2375	3.370	0.2941	3.810	0.0086	0.276	0.1998	3.330
1980.	0.2231	3.093	0.2862	3.751	-0.0296	-0.867	0.1706	2.806
1981.	0.1971	2.800	0.2574	3.420	-0.0673	-1.847	0.1762	2.837
1982.	0.2676	3.613	0.3076	4.079	-0.0190	-0.467	0.2343	3.718
1983.	0.2142	2.971	0.2655	3.526	-0.0481	-1.284	0.1825	3.051
1984.	0.2517	3.478	0.3143	4.090	-0.0072	-0.178	0.2295	3.691
1985.	0.2620	3.459	0.3171	3.968	0.0122	0.318	0.2414	3.592
1986.	0.3513	4.084	0.4031	4.538	0.1141	2.229	0.3283	4.308

Shadow Value of Capital Stock (PSK) and T-Ratio, 1967-86 (cont'd)

	Metal Fab		Machinery		Paper&Allied		Prim Metal	
1967.	-0.0253	-0.509	0.0387	0.662	-0.2085	-3.533	-0.1614	-2.963
1968.	0.0526	1.436	0.1131	2.332	-0.1299	-2.846	-0.0718	-1.806
1969.	0.0611	1.791	0.1369	2.907	-0.1088	-2.488	-0.0669	-1.777
1970.	-0.0003	-0.007	0.0817	1.634	-0.1559	-3.183	-0.1150	-2.602
1971.	0.0519	1.306	0.1240	2.413	-0.1114	-2.404	-0.0674	-1.631
1972.	0.0086	0.212	0.0902	1.706	-0.1534	-3.325	-0.1174	-2.823
1973.	0.0388	1.181	0.1150	2.595	-0.1172	-2.698	-0.0826	-2.182
1974.	0.0474	1.353	0.1144	2.644	-0.1143	-2.220	-0.0794	-1.738
1975.	0.0014	0.043	0.0678	1.620	-0.1626	-3.306	-0.1272	-2.954
1976.	0.0146	0.479	0.0932	2.420	-0.1344	-3.024	-0.1135	-2.744
1977.	0.0389	1.202	0.1036	2.624	-0.1270	-2.687	-0.0867	-2.036
1978.	0.0772	1.945	0.1379	2.876	-0.0867	-1.780	-0.0436	-0.960
1979.	0.0284	0.817	0.1012	2.633	-0.1145	-2.430	-0.0834	-1.943
1980.	0.0196	0.594	0.0865	2.302	-0.1209	-2.646	-0.0969	-2.207
1981.	-0.0427	-1.149	0.0468	1.296	-0.1838	-3.671	-0.1424	-3.094
1982.	0.0231	0.681	0.0876	2.532	-0.1415	-2.598	-0.0787	-1.612
1983.	-0.0622	-1.863	0.0019	-0.062	-0.2342	-3.846	-0.1312	-2.811
1984.	-0.0258	-0.705	0.0589	1.822	-0.1900	-3.116	-0.0844	-1.870
1985.	-0.0168	-0.446	0.0597	1.679	-0.1786	-2.928	-0.0904	-1.965
1986.	0.0772	1.545	0.1422	2.791	-0.0790	-1.149	-0.0096	-0.162

Shadow Value of Capital Stock (PSK) and T-Ratio, 1967-86 (cont'd)

Year	Transp Equip		Elec Prod		Non-Metal Min		Petrol & Coal	
1967.	-0.0434	-0.822	-0.0004	-0.007	-0.1153	-2.415	-0.0663	-1.401
1968.	0.0551	1.368	0.0746	1.796	-0.0400	-1.181	0.0194	0.572
1969.	0.0764	1.933	0.0899	2.258	-0.0343	-1.069	0.0184	0.589
1970.	0.0165	0.375	0.0360	0.813	-0.0815	-2.129	-0.0258	-0.692
1971.	0.0529	1.161	0.0864	1.881	-0.0255	-0.642	0.0171	0.450
1972.	0.0146	0.303	0.0411	0.880	-0.0669	-1.719	-0.0310	-0.828
1973.	0.0857	2.041	0.0836	2.162	-0.0333	-1.053	-0.0018	-0.063
1974.	0.0849	1.842	0.0699	1.784	-0.0458	-1.305	0.0060	0.189
1975.	0.0509	1.135	0.0231	0.592	-0.0844	-2.631	-0.0417	-1.418
1976.	0.0834	1.961	0.0613	1.746	-0.0706	-2.284	-0.0418	-1.523
1977.	0.1093	2.453	0.0721	1.993	-0.0520	-1.529	-0.0111	-0.373
1978.	0.1472	2.880	0.1076	2.476	-0.0153	-0.398	0.0375	1.030
1979.	0.0961	2.135	0.0215	0.473	-0.0610	-1.899	-0.0264	-0.825
1980.	0.0740	1.809	-0.0070	-0.138	-0.0839	-2.632	-0.0432	-1.418
1981.	0.0258	0.623	-0.0143	-0.297	-0.1154	-3.405	-0.0997	-2.909
1982.	0.0736	1.791	0.0399	0.912	-0.1026	-2.411	-0.0317	-0.930
1983.	0.0295	0.701	-0.0297	-0.698	-0.1394	-3.561	-0.0757	-2.535
1984.	0.0983	2.259	0.0095	0.235	-0.0598	-1.780	-0.0323	-1.029
1985.	0.0977	2.106	0.0135	0.328	-0.0588	-1.460	-0.0368	-1.036
1986.	0.1759	3.002	0.0937	1.708	0.0532	1.057	-0.0022	-0.040

Shadow Value of Capital Stock (PSK) and T-Ratio, 1967-86
(cont'd)

Year	Chemical & Chemical Products	
1967.	-0.1512	-3.032
1968.	-0.0713	-2.057
1969.	-0.0637	-1.894
1970.	-0.1072	-2.701
1971.	-0.0521	-1.386
1972.	-0.0850	-2.254
1973.	-0.0485	-1.584
1974.	-0.0589	-1.556
1975.	-0.1247	-3.406
1976.	-0.1242	-3.274
1977.	-0.1059	-2.569
1978.	-0.0649	-1.446
1979.	-0.1089	-2.473
1980.	-0.1343	-3.001
1981.	-0.1593	-3.439
1982.	-0.1219	-2.440
1983.	-0.1708	-3.377
1984.	-0.1317	-2.545
1985.	-0.1428	-2.716
1986.	-0.0593	-0.946

2. Cost Elasticity of Export Orientation (exports), of Financial interpenetration between forms, of Financial interpenetration between firm and bank, and Their Significance (T-Ratio)

Cost Elasticity of Export Orientation, of Financial interpenetration between forms, of Financial interpenetration between firm and bank, and their T-Ratios

Year	Eex	T-ratio	Eff	T-ratio	Ebf	T-ratio
Food and Beverage:						
1967.	-0.0177	-0.7280	0.1080	3.4715	0.0193	1.3949
1968.	-0.0145	-0.6388	0.0510	1.7633	-0.0061	-0.6712
1969.	-0.0174	-0.7348	0.0437	1.3186	-0.0080	-1.0524
1970.	-0.0216	-0.8734	0.0905	2.3352	0.0069	0.5994
1971.	-0.0199	-0.7963	0.0448	1.2088	-0.0113	-0.8383
1972.	-0.0257	-1.0324	0.0957	2.2754	0.0133	0.6081
1973.	-0.0277	-1.0002	0.0597	1.7780	-0.0062	-0.3504
1974.	-0.0195	-0.8596	0.0580	1.6250	-0.0098	-0.5284
1975.	-0.0217	-0.9660	0.0896	2.4123	0.0106	0.6816
1976.	-0.0247	-0.9872	0.0629	1.8071	-0.0073	-0.4517
1977.	-0.0255	-0.8826	0.0318	0.9683	-0.0215	-1.6594
1978.	-0.0267	-0.8558	0.0036	0.1002	-0.0508	-2.3918
1979.	-0.0327	-1.0312	0.0418	1.5424	-0.0245	-1.2383
1980.	-0.0332	-1.0957	0.0553	1.9012	-0.0138	-0.5968
1981.	-0.0364	-1.1270	0.0685	2.3514	-0.0003	-0.0167
1982.	-0.0434	-1.2783	0.0223	0.5689	-0.0474	-1.3064
1983.	-0.0445	-1.4285	0.0923	2.3392	0.0450	1.0567
1984.	-0.0427	-1.2818	0.0342	0.8822	-0.0334	-1.1523
1985.	-0.0521	-1.5220	0.0009	0.0136	-0.0283	-1.1717
1986.	-0.0498	-1.1464	-0.1627	-2.3424	-0.0787	-3.2030
Rubber and Plastics:						
1967.	0.0203	1.7922	0.0311	3.7361	0.0147	1.8134
1968.	0.0202	2.0991	0.0067	2.0597	-0.0022	-0.2917
1969.	0.0198	2.0336	0.0058	1.7648	-0.0063	-0.8009
1970.	0.0228	2.0028	0.0153	2.9355	0.0083	1.0569
1971.	0.0212	1.9877	0.0083	1.5123	-0.0052	-0.7176
1972.	0.0225	1.8411	0.0165	2.6407	0.0042	0.5548
1973.	0.0274	1.7170	0.0125	1.9477	-0.0052	-0.9235
1974.	0.0252	1.6720	0.0097	1.7024	-0.0065	-0.9094
1975.	0.0218	1.3909	0.0057	3.5161	0.1209	3.7441
1976.	0.0297	1.3576	0.0144	3.1750	0.0565	1.6915
1977.	0.0310	1.5285	0.0101	1.0604	-0.0102	-2.3198
1978.	0.0347	1.4668	-0.0024	-0.2503	-0.0124	-3.4696
1979.	0.0274	1.1550	0.0035	2.3455	0.0013	0.0471
1980.	0.0279	1.1643	0.0024	2.8458	0.0351	1.0747
1981.	0.0308	1.1190	0.0020	3.5128	0.0798	2.1779
1982.	0.0513	1.4326	0.0001	0.9296	-0.0608	-2.0467
1983.	0.0387	1.1602	0.0041	3.0442	0.0618	1.5325
1984.	0.0297	0.7243	0.0021	2.1457	0.0948	1.1925
1985.	-0.0078	-0.2135	0.0099	0.3272	0.0341	0.6330
1986.	0.0428	0.7844	-0.0270	-2.1668	-0.1899	-3.3104

Cost Elasticity of Export Orientation, of Financial interpenetration between forms, of Financial interpenetration between firm and bank, and Their T-Ratio (cont'd)

Year	Eex	T-ratio	Eff	T-ratio	Ebf	T-ratio
Leather:						
1967.	0.0299	2.5930	0.0577	2.6387	0.0193	2.0337
1968.	0.0353	2.7695	0.0046	0.2151	-0.0002	-0.0656
1969.	0.0350	2.7018	-0.0071	-0.2993	-0.0006	-0.5431
1970.	0.0454	2.9289	0.0238	1.3574	0.0023	0.8658
1971.	0.0366	2.6840	-0.0075	-0.2678	-0.0018	-0.4742
1972.	0.0391	2.8920	0.0227	1.1232	0.0078	0.7655
1973.	0.0449	2.8851	0.0054	0.3369	-0.0015	-0.1699
1974.	0.0316	2.6013	0.0019	0.0779	0.0012	0.1099
1975.	0.0414	2.8425	0.0231	1.3313	0.0127	1.2273
1976.	0.0447	2.6370	0.0085	0.4312	0.0078	0.4919
1977.	0.0513	2.4817	-0.0130	-0.4822	0.0015	0.0843
1978.	0.0498	2.1767	-0.0450	-1.1808	-0.0197	-0.5690
1979.	0.0380	2.1049	0.0045	0.1596	0.0563	1.6031
1980.	0.0273	1.3551	-0.0871	-1.2417	0.0160	1.1120
1981.	0.0281	1.5973	-0.0034	-0.0662	0.0418	2.1674
1982.	0.0426	1.8351	-0.0937	-1.9763	-0.0126	-0.5246
1983.	0.0290	1.3462	-0.0359	-0.5400	0.0743	2.3265
1984.	0.0284	1.6510	-0.0785	-1.5643	0.0058	0.2418
1985.	0.0367	2.0545	-0.0487	-1.3483	-0.0092	-0.3573
1986.	0.0490	2.1284	-0.1014	-3.1052	-0.0812	-2.7826
Textile:						
1967.	0.0116	1.2221	0.0962	4.0281	0.0219	2.3032
1968.	0.0160	1.5108	0.0351	2.1484	0.0005	0.1003
1969.	0.0129	1.2880	0.0327	1.6737	-0.0017	-0.2885
1970.	0.0133	1.1731	0.0713	2.9317	0.0146	1.5894
1971.	0.0134	1.1535	0.0325	1.3141	-0.0025	-0.2113
1972.	0.0080	0.7734	0.0744	2.4219	0.0191	1.2085
1973.	0.0136	1.0807	0.0329	2.0850	-0.0025	-0.2333
1974.	0.0155	1.1340	0.0335	1.8143	-0.0007	-0.0459
1975.	0.0118	1.0927	0.0539	3.0034	0.0173	1.8446
1976.	0.0133	1.1463	0.0351	2.3428	-0.0013	-0.1500
1977.	0.0158	1.1794	0.0195	1.2495	-0.0135	-1.5331
1978.	0.0160	1.0330	-0.0079	-0.3289	-0.0284	-2.6154
1979.	0.0163	1.0423	0.0194	1.3587	-0.0145	-1.4719
1980.	0.0186	1.0595	0.0238	1.7224	-0.0094	-1.0011
1981.	0.0152	0.9127	0.0432	2.9826	0.0125	1.0066
1982.	0.0183	0.9792	0.0076	0.4573	-0.0359	-1.6412
1983.	0.0091	0.6013	0.0323	1.5309	0.0004	0.0346
1984.	0.0119	0.6689	-0.0033	-0.1450	-0.0237	-1.8285
1985.	0.0183	1.0073	0.0035	0.2139	-0.0358	-2.1651
1986.	0.0228	0.9079	-0.0556	-2.4695	-0.1057	-3.6653

Cost Elasticity of Export Orientation, of Financial interpenetration between forms, of Financial interpenetration between firm and bank, and Their T-Ratio (cont'd)

Year	Eex	T-ratio	Eff	T-ratio	Ebf	T-ratio
Knitting:						
1967.	0.0117	2.3269	0.1043	2.9778	0.0550	2.8473
1968.	0.0108	2.8449	0.0190	1.4895	0.0190	0.9590
1969.	0.0146	2.4047	0.0089	0.3017	0.0062	0.5612
1970.	0.0194	2.7553	0.0347	2.2833	0.0322	1.7785
1971.	0.0155	2.6797	0.0121	0.6793	-0.0002	-0.0119
1972.	0.0158	2.6464	0.0325	1.9392	0.0328	1.3735
1973.	0.0164	2.7878	0.0091	1.1400	-0.0025	-0.2541
1974.	0.0129	2.5429	0.0218	1.4732	0.0247	0.9675
1975.	0.0090	2.5164	0.0315	2.5780	0.0694	2.8359
1976.	0.0114	2.5530	0.0161	2.1454	0.0627	1.6621
1977.	0.0115	2.7705	0.0039	0.4727	-0.0125	-1.2734
1978.	0.0122	2.5134	-0.0017	-0.1346	-0.0384	-1.2682
1979.	0.0110	2.7490	0.0045	0.8379	-0.0117	-0.6338
1980.	0.0091	2.6283	0.0075	1.5252	0.0179	0.6526
1981.	0.0105	2.7242	0.0114	1.9287	0.0168	0.8597
1982.	0.0112	2.7119	-0.0034	-0.5382	-0.0317	-2.6307
1983.	0.0094	2.8432	0.0016	1.3856	-0.0010	-0.0517
1984.	0.0102	2.7135	0.0001	0.0308	-0.0325	-2.0433
1985.	0.0112	2.7590	-0.0010	-0.2681	-0.0243	-2.3893
1986.	0.0159	2.3410	-0.0050	-1.8623	-0.1111	-3.3471
Clothing:						
1967.	0.0083	1.7496	0.0346	2.4595	0.0105	1.1432
1968.	0.0117	1.9223	0.0071	0.4030	-0.0080	-1.0058
1969.	0.0163	1.8538	-0.0019	-0.0895	-0.0120	-1.3276
1970.	0.0178	1.8503	0.0242	1.1978	0.0023	0.2247
1971.	0.0208	1.9815	-0.0019	-0.1068	-0.0142	-1.4649
1972.	0.0173	1.7087	0.0185	0.7382	-0.0018	-0.1381
1973.	0.0173	1.4737	-0.0119	-0.3989	-0.0094	-1.3202
1974.	0.0169	1.5192	-0.0137	-0.4550	-0.0069	-1.3872
1975.	0.0110	1.2486	0.0131	0.3709	-0.0011	-0.1360
1976.	0.0141	1.6923	0.0023	0.1277	-0.0144	-1.5550
1977.	0.0163	1.7239	-0.0051	-0.2909	-0.0302	-2.3625
1978.	0.0233	2.2332	-0.0176	-0.9516	-0.0630	-3.1905
1979.	0.0161	1.5582	0.0017	0.1174	-0.0391	-1.7121
1980.	0.0203	1.7429	0.0003	0.0234	-0.0277	-1.9261
1981.	0.0235	1.8898	0.0077	0.7467	-0.0153	-1.1561
1982.	0.0242	1.8002	-0.0108	-0.9290	-0.0650	-3.2627
1983.	0.0207	1.8946	0.0040	0.5960	-0.0298	-1.6009
1984.	0.0273	1.9193	-0.0056	-0.7500	-0.0464	-3.6140
1985.	0.0286	1.9127	-0.0029	-0.6218	-0.0590	-3.1173
1986.	0.0324	1.4938	-0.0404	-2.5788	-0.1105	-4.0724

Cost Elasticity of Export Orientation, of Financial interpenetration between forms, of Financial interpenetration between firm and bank, and Their T-Ratio (cont'd)

Year	Eex	T-ratio	Eff	T-ratio	Ebf	T-ratio
Wood:						
1967.	0.0662	1.0621	0.0373	2.4951	0.0779	2.0108
1968.	0.0921	1.9221	0.0045	0.3931	-0.0065	-0.3112
1969.	0.0848	1.8863	-0.0003	-0.0223	-0.0147	-0.8356
1970.	0.0739	1.3716	0.0214	1.3121	0.0322	1.1861
1971.	0.0732	1.5661	-0.0003	-0.0148	-0.0142	-0.5182
1972.	0.0799	1.4981	0.0112	0.9080	0.0078	0.3123
1973.	0.0790	1.5536	-0.0015	-0.1230	-0.0162	-1.3386
1974.	0.0781	1.8000	0.0044	0.4340	-0.0162	-1.1309
1975.	0.0671	1.6103	0.0159	1.8722	0.0122	0.9703
1976.	0.0682	1.5168	0.0062	0.7235	-0.0147	-0.9925
1977.	0.0539	1.0103	-0.0122	-0.7021	-0.0312	-1.8972
1978.	0.0594	0.8741	-0.0295	-1.5147	-0.0657	-3.0351
1979.	0.0288	0.4711	-0.0129	-0.6055	-0.0287	-1.3857
1980.	-0.0123	-0.2166	0.0110	0.4545	0.0413	1.1262
1981.	-0.0167	-0.2973	0.0367	1.6214	0.1346	2.8369
1982.	0.0031	0.0406	-0.0058	-0.2451	0.0171	0.2635
1983.	-0.0146	-0.2152	0.0192	1.0375	0.1032	1.6793
1984.	-0.0260	-0.3257	-0.0013	-0.0658	0.0263	0.4116
1985.	-0.0266	-0.4036	-0.0158	-0.6932	-0.0372	-0.6827
1986.	0.0069	0.0699	-0.0757	-3.1615	-0.2038	-3.3874
Furniture and Fixture:						
1967.	0.0098	2.1666	0.0506	3.2390	0.0225	1.9130
1968.	0.0109	2.3410	0.0183	1.2378	-0.0001	-0.0077
1969.	0.0187	2.2951	0.0133	0.8790	-0.0038	-0.3114
1970.	0.0231	2.2063	0.0427	2.0994	0.0175	1.3729
1971.	0.0238	2.3226	0.0081	0.4474	-0.0061	-0.6527
1972.	0.0184	2.0547	0.0357	1.6490	0.0151	0.8399
1973.	0.0217	2.0701	0.0163	1.1119	-0.0010	-0.0647
1974.	0.0198	1.9974	0.0159	0.8442	-0.0021	-0.1373
1975.	0.0155	1.6828	0.0450	1.6766	0.0167	1.7282
1976.	0.0213	2.1081	0.0157	1.0495	-0.0034	-0.4354
1977.	0.0285	2.0987	0.0068	0.4017	-0.0108	-0.7877
1978.	0.0339	2.0579	-0.0101	-0.5636	-0.0458	-1.9860
1979.	0.0371	2.0750	0.0058	0.4117	-0.0112	-0.6828
1980.	0.0311	1.6340	0.0121	0.6128	0.0213	1.0052
1981.	0.0437	2.2563	0.0168	1.7992	0.0127	0.6442
1982.	0.0690	2.5176	-0.0041	-0.7293	-0.0529	-3.0498
1983.	0.0663	2.5110	0.0022	0.1935	-0.0110	-1.1947
1984.	0.0879	2.5665	-0.0145	-1.3142	-0.0406	-3.1325
1985.	0.1003	2.6880	-0.0040	-0.8779	-0.0587	-2.5392
1986.	0.1055	1.9231	-0.0671	-3.6117	-0.0965	-3.9442

Cost Elasticity of Export Orientation, of Financial interpenetration between forms, of Financial interpenetration between firm and bank, and Their T-Ratio (cont'd)

Year	Eex	T-ratio	Eff	T-ratio	Ebf	T-ratio
Metal Fabricating:						
1967.	0.0031	0.4058	0.0758	3.9711	0.0209	1.7098
1968.	0.0044	0.5245	0.0383	2.1441	-0.0032	-0.4231
1969.	0.0035	0.4363	0.0356	1.8198	-0.0068	-0.8169
1970.	0.0023	0.2427	0.0774	2.9158	0.0121	1.1016
1971.	0.0044	0.4302	0.0350	1.5798	-0.0078	-0.6910
1972.	0.0027	0.2257	0.0672	2.6713	0.0089	0.6523
1973.	0.0001	0.0072	0.0514	2.0311	-0.0023	-0.1740
1974.	0.0007	0.0517	0.0428	1.8785	-0.0071	-0.3763
1975.	-0.0003	-0.0250	0.0735	2.9096	0.0205	1.4764
1976.	-0.0010	-0.0772	0.0618	2.8406	0.0193	0.8132
1977.	0.0003	0.0164	0.0386	1.7599	-0.0125	-0.5811
1978.	-0.0003	-0.0155	0.0104	0.3857	-0.0516	-1.8479
1979.	-0.0080	-0.4395	0.0520	2.1505	0.0094	0.3770
1980.	-0.0073	-0.4271	0.0561	2.1900	0.0077	0.3565
1981.	-0.0158	-0.8773	0.1204	3.0599	0.1277	3.3875
1982.	-0.0082	-0.4322	0.0202	0.6058	-0.0164	-0.5426
1983.	-0.0085	-0.4158	0.0934	2.3982	0.0848	2.9979
1984.	-0.0104	-0.4662	0.0523	1.3012	0.0694	1.8371
1985.	-0.0090	-0.5157	0.0343	0.7142	0.0282	0.7372
1986.	-0.0058	-0.2070	-0.1217	-2.4160	-0.1013	-2.4325
Machinery:						
1967.	0.0547	0.9792	0.0406	2.1878	0.0628	1.7575
1968.	0.0729	1.9351	0.0062	0.4917	-0.0059	-0.2643
1969.	0.0812	2.0879	-0.0014	-0.1425	-0.0234	-1.3721
1970.	0.0736	1.6111	0.0138	1.0324	0.0119	0.5348
1971.	0.0971	2.1858	-0.0040	-0.3442	-0.0243	-1.1972
1972.	0.0833	1.8871	0.0076	0.6387	-0.0018	-0.0914
1973.	0.0488	1.0722	-0.0296	-1.2431	-0.0146	-1.4840
1974.	0.0287	0.6517	-0.0393	-1.1872	-0.0161	-1.4277
1975.	0.0226	0.4370	-0.0091	-0.2768	-0.0008	-0.0580
1976.	0.0677	1.4405	-0.0083	-0.5673	-0.0222	-1.6933
1977.	0.0715	1.2896	-0.0206	-1.3261	-0.0405	-2.3384
1978.	0.0629	0.9323	-0.0408	-2.0278	-0.0778	-3.2754
1979.	0.0138	0.2405	-0.0313	-1.4507	-0.0448	-2.2537
1980.	-0.0013	-0.0257	-0.0285	-1.2492	-0.0341	-2.1787
1981.	0.0053	0.0957	-0.0070	-0.3207	-0.0151	-0.9282
1982.	0.0535	0.8012	-0.0532	-2.3321	-0.0601	-4.0643
1983.	0.0153	0.1835	-0.0326	-0.9317	-0.0081	-0.3605
1984.	0.0568	0.6482	-0.0447	-1.9344	-0.0550	-3.6593
1985.	0.0459	0.6067	-0.0652	-2.2207	-0.0308	-3.4416
1986.	0.0581	0.4734	-0.1331	-3.8931	-0.0899	-4.1545

Cost Elasticity of Export Orientation (exports), of Financial interpenetration between forms, of Financial interpenetration between firm and bank, and Their T-Ratio (cont'd)

Year	Eex	T-ratio	Eff	T-ratio	Ebf	T-ratio
Paper and Allied:						
1967.	-0.0443	-0.5307	0.0917	1.6281	0.0073	1.8180
1968.	-0.0302	-0.5135	0.0026	0.0546	-0.0004	-0.1492
1969.	-0.0370	-0.6115	-0.0163	-0.3525	-0.0019	-0.7877
1970.	-0.0402	-0.5848	0.0354	0.7336	0.0023	0.7409
1971.	-0.0188	-0.3355	-0.0067	-0.1646	-0.0033	-0.7917
1972.	-0.0426	-0.7413	0.0343	0.8002	0.0037	0.4620
1973.	-0.0452	-0.8466	0.0048	0.1407	-0.0053	-0.6603
1974.	-0.0636	-1.0948	-0.0111	-0.2352	-0.0050	-0.8636
1975.	-0.0439	-0.6579	0.0185	0.3792	0.0016	0.3548
1976.	-0.0612	-0.9655	-0.0085	-0.1864	-0.0047	-0.5809
1977.	-0.0879	-1.2690	-0.0507	-0.8848	-0.0105	-0.9595
1978.	-0.0797	-1.0774	-0.0988	-1.6472	-0.0192	-2.4555
1979.	-0.0689	-1.0127	-0.0367	-0.8305	-0.0103	-1.6697
1980.	-0.0639	-0.9342	-0.0200	-0.5294	-0.0124	-1.5952
1981.	-0.1129	-1.5625	0.0348	0.8234	0.0707	2.2576
1982.	-0.0700	-0.9435	-0.0034	-0.1100	-0.0107	-0.2264
1983.	-0.0484	-0.6958	0.0529	1.5008	0.1903	2.5927
1984.	-0.0463	-0.5999	0.0188	0.5281	0.0813	1.2513
1985.	-0.0319	-0.4268	0.0162	0.5481	0.0596	0.7721
1986.	0.0035	0.0326	-0.0465	-1.6027	-0.1583	-2.2632
Primary Metal:						
1967.	0.0140	0.1830	0.0401	2.1446	0.0146	1.4339
1968.	0.0288	0.5358	0.0072	0.4866	-0.0054	-0.9594
1969.	0.0133	0.2887	0.0078	0.3734	-0.0066	-1.1527
1970.	-0.0026	-0.0372	0.0230	0.8839	0.0025	0.3643
1971.	0.0152	0.3165	0.0044	0.2109	-0.0072	-1.1620
1972.	-0.0124	-0.2559	0.0341	1.1498	0.0015	0.2445
1973.	-0.0144	-0.3040	0.0081	0.3495	-0.0068	-1.1170
1974.	-0.0078	-0.1647	0.0069	0.2692	-0.0060	-1.2361
1975.	-0.0003	-0.0074	0.0321	1.3441	0.0001	0.0176
1976.	0.0025	0.0513	0.0134	0.6538	-0.0080	-0.9854
1977.	0.0138	0.2751	-0.0012	-0.0646	-0.0081	-2.1987
1978.	0.0143	0.2387	-0.0177	-0.9878	-0.0200	-3.4848
1979.	0.0104	0.2069	0.0009	0.0571	-0.0082	-2.3452
1980.	0.0045	0.0590	-0.0059	-0.3280	-0.0163	-2.1782
1981.	-0.0188	-0.3041	0.0156	0.9464	0.0060	0.3330
1982.	0.0405	0.6470	-0.0119	-0.7693	-0.0319	-3.5789
1983.	0.0255	0.4875	0.0075	0.4878	-0.0127	-1.4565
1984.	0.0085	0.1444	-0.0068	-0.4449	-0.0441	-3.1340
1985.	-0.0139	-0.2632	-0.0011	-0.0615	-0.0444	-1.9235
1986.	-0.0245	-0.2203	-0.1037	-2.9143	-0.1189	-3.6276

Cost Elasticity of Export Orientation, of Financial interpenetration between forms, of Financial interpenetration between firm and bank, and Their T-Ratio (cont'd)

Year	Eex	T-ratio	Eff	T-ratio	Ebf	T-ratio
Transportation Equipment:						
1967.	-0.0880	-1.1719	0.0617	1.6121	0.0449	1.4768
1968.	-0.0888	-1.3106	-0.0231	-0.7406	-0.0227	-1.4432
1969.	-0.1099	-1.4146	-0.0419	-1.2511	-0.0300	-2.1314
1970.	-0.1273	-1.0080	-0.0113	-0.2994	-0.0073	-0.3732
1971.	-0.1649	-1.6408	-0.0309	-0.8719	-0.0458	-0.9053
1972.	-0.2261	-1.8037	-0.0103	-0.2144	0.0102	0.1717
1973.	-0.1671	-1.5392	-0.0243	-1.1088	-0.0570	-2.1596
1974.	-0.1688	-1.8519	-0.0263	-0.9517	-0.0566	-2.1203
1975.	-0.1891	-1.8341	-0.0178	-0.5503	-0.0288	-1.5470
1976.	-0.2108	-1.8487	-0.0463	-1.3517	-0.0431	-2.6891
1977.	-0.2511	-1.8204	-0.0668	-1.8738	-0.0763	-3.0095
1978.	-0.2408	-1.6630	-0.0938	-2.4072	-0.0814	-4.1169
1979.	-0.2255	-1.9156	-0.0346	-1.4691	-0.0893	-3.0975
1980.	-0.1669	-1.4503	-0.0178	-1.2363	-0.0687	-3.3790
1981.	-0.1916	-1.4846	-0.0111	-0.6611	-0.0509	-2.3883
1982.	-0.2219	-1.1770	-0.0460	-2.1602	-0.1287	-4.1899
1983.	-0.2834	-1.4786	-0.0256	-1.2102	-0.0867	-2.3924
1984.	-0.2824	-1.4279	-0.0529	-2.2534	-0.0621	-4.9790
1985.	-0.3374	-1.7563	-0.0977	-2.3534	-0.0589	-4.2834
1986.	-0.3040	-1.3413	-0.1328	-3.5650	-0.1228	-5.0152
Electrical Products:						
1967.	0.0100	0.4470	0.0878	3.7577	0.0430	1.9915
1968.	0.0167	0.6754	0.0315	1.7895	-0.0003	-0.0222
1969.	0.0134	0.5337	0.0214	1.0593	-0.0093	-0.7958
1970.	0.0091	0.3213	0.0575	2.0355	0.0108	0.9341
1971.	0.0109	0.4219	0.0186	0.6956	-0.0098	-0.7802
1972.	0.0046	0.1869	0.0556	2.1406	0.0158	0.7154
1973.	0.0043	0.1628	0.0248	1.2962	-0.0105	-0.8140
1974.	-0.0012	-0.0447	0.0337	1.4527	-0.0002	-0.0093
1975.	-0.0101	-0.3842	0.0645	1.7863	0.0206	1.4809
1976.	0.0023	0.0833	0.0271	1.3104	-0.0088	-0.7794
1977.	0.0074	0.2585	0.0194	1.1780	-0.0223	-1.0753
1978.	0.0056	0.1624	-0.0183	-0.7053	-0.0548	-2.5589
1979.	-0.0524	-1.3478	0.0130	0.2530	0.0677	1.7878
1980.	-0.0770	-1.7352	0.0027	0.0308	0.1098	2.3666
1981.	-0.0778	-1.6626	-0.0249	-0.2472	0.0271	1.7070
1982.	-0.0614	-1.2320	-0.1557	-1.8504	-0.0248	-1.3597
1983.	-0.0806	-1.6227	-0.0233	-0.2982	0.0488	1.7833
1984.	-0.0980	-1.7679	-0.0929	-1.4537	-0.0056	-0.2023
1985.	-0.0919	-1.6997	-0.1036	-1.5505	-0.0227	-0.8094
1986.	-0.0899	-1.1471	-0.3203	-3.7521	-0.0972	-2.9045

Cost Elasticity of Export Orientation, of Financial interpenetration between forms, of Financial interpenetration between firm and bank, and Their T-Ratio (cont'd)

Year	Eex	T-ratio	Eff	T-ratio	Ebf	T-ratio
Non-metallic Mineral Products:						
1967.	0.0155	1.1531	0.1139	4.0467	0.0405	2.6973
1968.	0.0155	1.1567	0.0692	2.5331	0.0164	1.3519
1969.	0.0165	1.0900	0.0661	2.5844	0.0345	1.6543
1970.	0.0176	1.0394	0.1202	3.4345	0.0938	3.1383
1971.	0.0129	0.8176	0.0700	1.5472	0.0198	0.9853
1972.	0.0122	0.6951	0.1056	2.6003	0.0325	1.9043
1973.	0.0117	0.5977	0.0671	2.0706	0.0173	1.3563
1974.	0.0093	0.5203	0.0735	1.9314	0.0271	1.4013
1975.	0.0079	0.5050	0.1094	2.7169	0.0347	3.0842
1976.	0.0076	0.4525	0.0863	2.3488	0.0357	2.2430
1977.	0.0127	0.6102	0.0492	1.3247	0.0102	0.7251
1978.	0.0147	0.5581	-0.0039	-0.0906	-0.0146	-0.9770
1979.	0.0142	0.5412	0.0630	2.5327	0.0522	2.1379
1980.	0.0144	0.6108	0.0766	2.9652	0.0755	2.9101
1981.	0.0077	0.3291	0.1004	2.3860	0.0424	3.4198
1982.	0.0029	0.1040	0.0453	0.7178	0.0987	2.2964
1983.	0.0011	0.0422	0.1176	1.9578	0.1441	3.9682
1984.	0.0172	0.5575	0.0203	0.5446	0.0081	0.4467
1985.	0.0020	0.0640	-0.0366	-0.5374	0.0009	0.0691
1986.	0.0167	0.4473	-0.1500	-2.8422	-0.0484	-2.5920
Petroleum and Coal Products:						
1967.	0.0028	0.9066	0.0950	4.1270	0.0098	2.1085
1968.	0.0045	1.0964	0.0429	2.3738	0.0000	-0.0267
1969.	0.0048	0.9883	0.0449	2.0844	-0.0007	-0.2014
1970.	0.0074	1.0607	0.0569	3.2229	0.0064	1.2341
1971.	0.0096	1.1083	0.0326	1.8326	-0.0026	-0.4300
1972.	0.0126	0.8865	0.0555	3.1520	0.0198	1.1585
1973.	0.0127	0.7675	0.0445	2.6281	0.0023	0.1990
1974.	0.0106	0.6211	0.0372	1.9511	-0.0046	-0.4893
1975.	0.0074	0.5338	0.0608	3.0249	0.0061	1.0291
1976.	0.0027	0.3347	0.0673	2.8956	0.0069	0.5970
1977.	0.0028	0.4261	0.0391	1.5742	-0.0048	-1.3151
1978.	0.0099	0.6079	0.0056	0.2738	-0.0025	-2.8813
1979.	-0.0007	-0.0279	0.0222	0.7102	-0.0003	-1.2101
1980.	-0.0001	-0.0053	0.0393	1.3184	-0.0021	-0.5454
1981.	-0.0110	-0.5437	0.1216	3.0387	0.0843	3.9626
1982.	-0.0020	-0.1138	0.0019	0.0438	-0.0167	-1.3049
1983.	0.0039	0.2026	0.0634	2.5993	0.0039	0.3694
1984.	0.0098	0.4360	0.0189	0.7508	-0.0094	-2.0835
1985.	0.0052	0.2164	0.0068	0.1970	-0.0046	-1.8665
1986.	-0.0008	-0.0361	-0.1314	-1.9467	-0.0612	-1.9492

Cost Elasticity of Export Orientation, of Financial interpenetration between forms, of Financial interpenetration between firm and bank, and Their T-Ratio (cont'd)

Year	Eex	T-ratio	Eff	T-ratio	Ebf	T-ratio
Chemical and Chemical Products:						
1967.	0.0129	0.4057	0.1142	3.7490	0.0154	2.1961
1968.	0.0177	0.6096	0.0520	2.2153	0.0011	0.2522
1969.	0.0122	0.3941	0.0465	1.7287	-0.0007	-0.1704
1970.	0.0146	0.4462	0.0717	2.7620	0.0053	1.2226
1971.	0.0191	0.5983	0.0345	1.5836	-0.0031	-0.5088
1972.	0.0182	0.5750	0.0485	2.6184	0.0018	0.4873
1973.	0.0122	0.3802	0.0368	2.0769	-0.0031	-0.6360
1974.	0.0102	0.3137	0.0384	2.0011	-0.0014	-0.0848
1975.	0.0046	0.1464	0.0653	3.3454	0.0669	3.1271
1976.	0.0027	0.0734	0.0500	3.3900	0.0838	2.2047
1977.	0.0080	0.1972	0.0323	2.2193	0.0017	0.0654
1978.	0.0169	0.3455	0.0019	0.1011	-0.0190	-2.6835
1979.	0.0020	0.0434	0.0207	1.1875	-0.0112	-1.5408
1980.	-0.0067	-0.1459	0.0314	1.5663	-0.0079	-0.8106
1981.	-0.0054	-0.1181	0.0398	2.3687	0.0051	0.4560
1982.	-0.0046	-0.0950	0.0177	0.8535	-0.0361	-1.9863
1983.	-0.0049	-0.1058	0.0377	2.1144	-0.0048	-0.4084
1984.	-0.0024	-0.0463	0.0161	0.9211	-0.0252	-2.1599
1985.	-0.0320	-0.6251	0.0164	0.5292	-0.0222	-1.4925
1986.	-0.0324	-0.4711	-0.0834	-2.1033	-0.0874	-3.0019

3. **Different Components of Technical Change Rate and TFP Growth Rate**

- R-pure: Pure technical change
- R-scale: Change due to scale factor
- R-Bias: Change due to biased technology
- R-Tech: Rate of Technical Change
- R-TFP: Rate of TFP growth

Different Components of Technical Change Rate and TFP Growth Rate

Year	R-pure	R-Scale	R-bias	R-Tech	R-TFP
Food&Beverage:					
1968.	0.1790	-0.3668	0.1773	-0.0105	-0.0235
1969.	0.0284	-0.0585	0.0289	-0.0012	0.0035
1970.	-0.1035	0.2140	-0.1052	0.0053	0.0103
1971.	0.1120	-0.2317	0.1142	-0.0055	-0.0068
1972.	-0.0874	0.1812	-0.0994	-0.0055	0.0184
1973.	0.0751	-0.1540	0.0783	-0.0006	0.0449
1974.	0.0079	-0.0164	0.0077	-0.0008	0.0227
1975.	-0.0621	0.1288	-0.0659	0.0009	0.0033
1976.	0.0581	-0.1215	0.0607	-0.0027	-0.0193
1977.	0.0491	-0.1021	0.0451	-0.0079	-0.0056
1978.	0.0758	-0.1601	0.0830	-0.0013	0.0228
1979.	-0.0831	0.1744	-0.0901	0.0012	0.0250
1980.	-0.0163	0.0341	-0.0182	-0.0005	0.0084
1981.	-0.0470	0.0991	-0.0457	0.0064	0.0115
1982.	0.1503	-0.3107	0.2253	0.0643	0.0645
1983.	-0.1079	0.2243	-0.1302	-0.0138	-0.0379
1984.	0.0787	-0.1649	0.0750	-0.0112	-0.0049
1985.	0.0053	-0.0112	0.0061	0.0002	0.0010
1986.	0.1378	-0.3916	0.1850	-0.0133	-0.0224
Rubber&Plastics:					
1968.	0.2481	-0.4404	0.1966	0.0043	-0.0027
1969.	0.0394	-0.0716	0.0322	0.0000	-0.0008
1970.	-0.1435	0.2510	-0.1190	-0.0115	-0.0429
1971.	0.1552	-0.2824	0.1271	0.0000	-0.0048
1972.	-0.1211	0.2254	-0.1043	-0.0001	0.0056
1973.	0.1041	-0.1997	0.0887	-0.0069	0.0066
1974.	0.0110	-0.0205	0.0093	-0.0002	0.0127
1975.	-0.0861	0.1537	-0.1127	-0.0451	-0.0855
1976.	0.0805	-0.1519	0.0745	0.0031	0.0088
1977.	0.0681	-0.1274	0.0349	-0.0245	-0.0216
1978.	0.1051	-0.2033	0.0822	-0.0160	-0.0127
1979.	-0.1152	0.2229	-0.1451	-0.0374	-0.0196
1980.	-0.0226	0.0416	-0.0224	-0.0034	-0.0097
1981.	-0.0652	0.1231	-0.0625	-0.0046	0.0085
1982.	0.2084	-0.3776	0.1791	0.0099	-0.0065
1983.	-0.1496	0.2858	-0.1638	-0.0276	-0.0270
1984.	0.1092	-0.2134	0.1407	0.0365	0.0737
1985.	0.0074	-0.0142	0.0080	0.0011	0.0143
1986.	0.2604	-0.5007	0.1626	-0.0777	-0.0803

Different Components of Technical Change Rate and TFP Growth Rate (cont'd)

Year	R-pure	R-Scale	R-bias	R-Tech	R-TFP
Leather:					
1968.	0.1502	-0.2564	0.1058	-0.0005	-0.0029
1969.	0.0238	-0.0398	0.0171	0.0011	-0.0027
1970.	-0.0868	0.1394	-0.0522	0.0004	-0.0022
1971.	0.0940	-0.1577	0.0792	0.0155	0.0138
1972.	-0.0733	0.1181	-0.0502	-0.0054	-0.0057
1973.	0.0630	-0.1052	0.0495	0.0073	0.0032
1974.	0.0067	-0.0111	0.0061	0.0017	0.0025
1975.	-0.0521	0.0865	-0.0347	-0.0003	-0.0015
1976.	0.0488	-0.0831	0.0463	0.0120	0.0091
1977.	0.0412	-0.0652	0.0383	0.0143	0.0173
1978.	0.0636	-0.1125	0.0688	0.0199	0.0047
1979.	-0.0698	0.1164	-0.0705	-0.0239	-0.0261
1980.	-0.0137	0.0230	-0.0113	-0.0019	-0.0009
1981.	-0.0394	0.0676	-0.0321	-0.0039	-0.0056
1982.	0.1261	-0.1951	0.1015	0.0326	0.0432
1983.	-0.0905	0.1502	-0.1104	-0.0508	-0.0504
1984.	0.0661	-0.1126	0.0403	-0.0063	-0.0113
1985.	0.0045	-0.0074	0.0027	-0.0003	0.0002
1986.	0.1576	-0.2552	0.0779	-0.0197	-0.0111
Textile:					
1968.	0.0781	-0.1506	0.0563	-0.0163	-0.0221
1969.	0.0124	-0.0246	0.0132	0.0009	0.0071
1970.	-0.0451	0.0808	-0.0452	-0.0095	-0.0316
1971.	0.0488	-0.0989	0.0469	-0.0032	0.0005
1972.	-0.0381	0.0797	-0.0445	-0.0029	0.0120
1973.	0.0327	-0.0630	0.0195	-0.0108	-0.0107
1974.	0.0035	-0.0060	0.0035	0.0010	-0.0025
1975.	-0.0271	0.0484	-0.0246	-0.0033	-0.0270
1976.	0.0253	-0.0480	0.0206	-0.0021	-0.0046
1977.	0.0214	-0.0409	0.0183	-0.0012	-0.0001
1978.	0.0331	-0.0658	0.0313	-0.0014	0.0020
1979.	-0.0363	0.0711	-0.0316	0.0032	0.0158
1980.	-0.0071	0.0128	-0.0066	-0.0009	-0.0042
1981.	-0.0205	0.0396	-0.0235	-0.0044	0.0018
1982.	0.0655	-0.1018	0.0954	0.0592	0.0497
1983.	-0.0470	0.1011	-0.0297	0.0244	0.0477
1984.	0.0343	-0.0622	0.0366	0.0087	0.0067
1985.	0.0023	-0.0045	0.0011	-0.0010	-0.0011
1986.	0.0819	-0.1650	0.0727	-0.0103	-0.0152

Different Components of Technical Change Rate and TFP Growth Rate (cont'd)

Year	R-pure	R-Scale	R-bias	R-Tech	R-TFP
Knitting:					
1968.	0.0788	-0.1478	0.0334	-0.0356	-0.0377
1969.	0.0125	-0.0222	0.0137	0.0040	-0.0003
1970.	-0.0456	0.0790	-0.0215	0.0119	0.0053
1971.	0.0493	-0.0904	0.0369	-0.0042	-0.0086
1972.	-0.0385	0.0677	-0.0377	-0.0085	-0.0121
1973.	0.0331	-0.0601	0.0101	-0.0169	-0.0213
1974.	0.0035	-0.0057	0.0058	0.0036	0.0007
1975.	-0.0273	0.0474	-0.0251	-0.0050	-0.0083
1976.	0.0256	-0.0411	0.0243	0.0088	0.0106
1977.	0.0216	-0.0343	-0.0074	-0.0201	-0.0120
1978.	0.0334	-0.0583	0.0489	0.0239	0.0210
1979.	-0.0366	0.0656	-0.0107	0.0184	0.0148
1980.	-0.0072	0.0126	-0.0089	-0.0035	-0.0036
1981.	-0.0207	0.0343	-0.0083	0.0053	0.0014
1982.	0.0662	-0.0963	0.0174	-0.0127	0.0074
1983.	-0.0475	0.0785	-0.0484	-0.0174	-0.0161
1984.	0.0347	-0.0617	0.0226	-0.0044	-0.0086
1985.	0.0023	-0.0040	0.0008	-0.0008	-0.0036
1986.	0.0827	-0.1506	0.0915	0.0236	0.0030
Clothing:					
1968.	0.0584	-0.1093	0.0571	0.0062	0.0057
1969.	0.0093	-0.0173	0.0087	0.0006	0.0001
1970.	-0.0338	0.0593	-0.0230	0.0025	0.0005
1971.	0.0365	-0.0706	0.0206	-0.0134	-0.0143
1972.	-0.0285	0.0576	-0.0303	-0.0012	0.0011
1973.	0.0245	-0.0478	0.0267	0.0035	0.0024
1974.	0.0026	-0.0046	0.0019	-0.0001	-0.0008
1975.	-0.0203	0.0374	-0.0231	-0.0059	-0.0069
1976.	0.0190	-0.0365	0.0050	-0.0125	-0.0129
1977.	0.0160	-0.0272	0.0170	0.0059	0.0075
1978.	0.0247	-0.0512	0.0477	0.0213	0.0233
1979.	-0.0271	0.0538	-0.0054	0.0213	0.0201
1980.	-0.0053	0.0088	-0.0017	0.0017	0.0021
1981.	-0.0153	0.0273	-0.0078	0.0041	0.0019
1982.	0.0490	-0.0790	0.0566	0.0267	0.0309
1983.	-0.0352	0.0668	-0.0216	0.0100	0.0105
1984.	0.0257	-0.0505	0.0083	-0.0165	-0.0175
1985.	0.0017	-0.0033	0.0015	-0.0001	-0.0014
1986.	0.0613	-0.1229	0.0621	0.0004	-0.0134

Different Components of Technical Change Rate and TFP Growth Rate (cont'd)

Year	R-pure	R-Scale	R-bias	R-Tech	R-TFP
Wood:					
1968.	0.4459	-0.8303	0.3762	-0.0082	0.0065
1969.	0.0707	-0.1315	0.0620	0.0012	0.0176
1970.	-0.2578	0.4800	-0.2364	-0.0142	-0.0743
1971.	0.2790	-0.5255	0.2548	0.0083	0.0325
1972.	-0.2177	0.4120	-0.1850	0.0093	0.0899
1973.	0.1871	-0.3550	0.1650	-0.0029	0.0582
1974.	0.0198	-0.0374	0.0178	0.0002	-0.0347
1975.	-0.1546	0.2881	-0.1457	-0.0123	-0.0846
1976.	0.1447	-0.2797	0.1332	-0.0018	0.0627
1977.	0.1223	-0.2344	0.1167	0.0046	0.0251
1978.	0.1888	-0.3628	0.1781	0.0041	0.0460
1979.	-0.2071	0.3970	-0.2057	-0.0157	0.0237
1980.	-0.0406	0.0780	-0.0468	-0.0094	-0.0640
1981.	-0.1171	0.2244	-0.1280	-0.0207	-0.1047
1982.	0.3744	-0.6995	0.4177	0.0927	0.0456
1983.	-0.2688	0.5255	-0.2761	-0.0193	0.0835
1984.	0.1962	-0.3820	0.2144	0.0286	0.0597
1985.	0.0132	-0.0259	0.0128	0.0001	0.0255
1986.	0.4679	-0.9134	0.4503	0.0049	0.0130
Furniture:					
1968.	0.4459	-0.7684	0.3402	0.0177	0.0145
1969.	0.0707	-0.1232	0.0555	0.0031	-0.0001
1970.	-0.2578	0.4425	-0.1983	-0.0136	-0.0191
1971.	0.2790	-0.4862	0.2010	-0.0062	-0.0082
1972.	-0.2177	0.3878	-0.1769	-0.0067	0.0023
1973.	0.1871	-0.3312	0.1499	0.0053	0.0059
1974.	0.0198	-0.0346	0.0159	0.0010	-0.0007
1975.	-0.1546	0.2676	-0.1315	-0.0135	-0.0296
1976.	0.1447	-0.2530	0.1039	-0.0044	-0.0049
1977.	0.1223	-0.2107	0.1037	0.0153	0.0167
1978.	0.1888	-0.3342	0.1531	0.0077	0.0025
1979.	-0.2071	0.3667	-0.1682	-0.0086	-0.0077
1980.	-0.0406	0.0715	-0.0381	-0.0072	-0.0080
1981.	-0.1171	0.2091	-0.0833	0.0088	0.0142
1982.	0.3744	-0.6362	0.2731	0.0113	0.0137
1983.	-0.2688	0.4736	-0.2116	-0.0068	-0.0063
1984.	0.1962	-0.3486	0.1532	0.0008	-0.0005
1985.	0.0132	-0.0237	0.0103	-0.0002	-0.0021
1986.	0.4679	-0.8488	0.3674	-0.0135	-0.0374

Different Components of Technical Change Rate and TFP Growth Rate (cont'd)

Year	R-pure	R-Scale	R-bias	R-Tech	R-TFP
Metal Fabricating:					
1968.	0.3179	-0.6148	0.2841	-0.0128	-0.0165
1969.	0.0504	-0.0979	0.0462	-0.0013	0.0022
1970.	-0.1838	0.3527	-0.1734	-0.0045	-0.0098
1971.	0.1989	-0.3845	0.1752	-0.0105	-0.0160
1972.	-0.1552	0.3020	-0.1455	0.0014	0.0073
1973.	0.1334	-0.2646	0.1337	0.0024	0.0219
1974.	0.0141	-0.0281	0.0131	-0.0009	0.0231
1975.	-0.1102	0.2114	-0.1081	-0.0068	-0.0246
1976.	0.1032	-0.2019	0.1089	0.0102	0.0152
1977.	0.0872	-0.1704	0.0820	-0.0012	-0.0032
1978.	0.1346	-0.2683	0.1319	-0.0018	0.0106
1979.	-0.1476	0.2954	-0.1636	-0.0158	0.0130
1980.	-0.0290	0.0572	-0.0279	0.0003	0.0029
1981.	-0.0835	0.1632	-0.1067	-0.0269	-0.0661
1982.	0.2669	-0.5091	0.2606	0.0184	-0.0049
1983.	-0.1916	0.3386	-0.2099	-0.0629	-0.1077
1984.	0.1399	-0.2695	0.1624	0.0327	0.0527
1985.	0.0094	-0.0134	0.0096	0.0006	0.0211
1986.	0.3336	-0.6471	0.3183	0.0047	0.0003
Machinery:					
1968.	0.2445	-0.4493	0.2097	0.0049	-0.0123
1969.	0.0388	-0.0743	0.0295	-0.0060	0.0114
1970.	-0.1413	0.2638	-0.1223	0.0002	-0.0173
1971.	0.1529	-0.2787	0.1234	-0.0024	-0.0067
1972.	-0.1193	0.2277	-0.0957	0.0127	0.0484
1973.	0.1026	-0.1971	0.0972	0.0027	0.0234
1974.	0.0109	-0.0212	0.0098	-0.0006	0.0237
1975.	-0.0848	0.1592	-0.0790	-0.0046	0.0153
1976.	0.0794	-0.1488	0.0614	-0.0081	-0.0267
1977.	0.0671	-0.1265	0.0623	0.0029	0.0001
1978.	0.1035	-0.2029	0.0962	-0.0031	0.0130
1979.	-0.1135	0.2239	-0.1088	0.0066	0.0667
1980.	-0.0223	0.0438	-0.0206	0.0009	0.0151
1981.	-0.0642	0.1229	-0.0589	-0.0003	-0.0065
1982.	0.2053	-0.3656	0.1836	0.0233	-0.0174
1983.	-0.1474	0.2666	-0.1666	-0.0474	-0.1361
1984.	0.1076	-0.2115	0.0795	-0.0245	0.0054
1985.	0.0072	-0.0139	0.0061	-0.0005	0.0130
1986.	0.2565	-0.4978	0.2472	0.0059	0.0085

Different Components of Technical Change Rate and TFP Growth Rate (cont'd)

Year	R-pure	R-Scale	R-bias	R-Tech	R-TFP
Paper&allied:					
1968.	0.0399	-0.0842	0.0466	0.0022	-0.0022
1969.	0.0063	-0.0143	0.0059	-0.0021	0.0248
1970.	-0.0231	0.0450	-0.0199	0.0020	-0.0142
1971.	0.0250	-0.0497	0.0266	0.0019	-0.0147
1972.	-0.0195	0.0448	-0.0259	-0.0005	0.0191
1973.	0.0168	-0.0373	0.0204	-0.0002	0.0253
1974.	0.0018	-0.0039	0.0017	-0.0005	0.0890
1975.	-0.0138	0.0152	-0.0134	-0.0120	-0.1167
1976.	0.0130	-0.0307	0.0194	0.0017	0.0696
1977.	0.0110	-0.0218	0.0194	0.0085	-0.0080
1978.	0.0169	-0.0380	0.0130	-0.0080	0.0067
1979.	-0.0185	0.0383	-0.0066	0.0132	0.0592
1980.	-0.0036	0.0075	-0.0035	0.0004	0.0397
1981.	-0.0105	0.0198	-0.0402	-0.0309	-0.0721
1982.	0.0335	-0.0543	0.0643	0.0435	-0.0062
1983.	-0.0241	0.0163	-0.0518	-0.0595	-0.1310
1984.	0.0176	-0.0359	0.0166	-0.0018	0.0384
1985.	0.0012	-0.0024	0.0010	-0.0002	0.0115
1986.	0.0419	-0.0913	0.0041	-0.0452	-0.0583
Primary Metal:					
1968.	0.5757	-1.1216	0.5243	-0.0216	-0.0073
1969.	0.0913	-0.1769	0.0870	0.0014	0.0057
1970.	-0.3329	0.6463	-0.3078	0.0056	0.0390
1971.	0.3602	-0.7025	0.3377	-0.0046	-0.0345
1972.	-0.2810	0.5492	-0.2718	-0.0037	-0.0101
1973.	0.2416	-0.4749	0.2322	-0.0011	0.0476
1974.	0.0256	-0.0502	0.0239	-0.0008	0.0844
1975.	-0.1996	0.3868	-0.1918	-0.0046	-0.0733
1976.	0.1869	-0.3640	0.1837	0.0066	-0.0211
1977.	0.1580	-0.3092	0.1474	-0.0039	0.0127
1978.	0.2438	-0.4840	0.2318	-0.0084	0.0325
1979.	-0.2674	0.5244	-0.2515	0.0055	0.0823
1980.	-0.0525	0.1022	-0.0503	-0.0005	0.0022
1981.	-0.1512	0.2965	-0.1607	-0.0153	-0.0861
1982.	0.4835	-0.9291	0.4493	0.0036	-0.0857
1983.	-0.3470	0.6742	-0.3392	-0.0120	-0.0680
1984.	0.2533	-0.5020	0.2565	0.0078	0.0864
1985.	0.0171	-0.0337	0.0182	0.0015	-0.0033
1986.	0.6041	-1.1858	0.6220	0.0404	0.0334

Different Components of Technical Change Rate and TFP Growth Rate (cont'd)

Year	R-pure	R-Scale	R-bias	R-Tech	R-TFP
Transportation Equipment:					
1968.	0.2225	-0.4660	0.1844	-0.0590	-0.0191
1969.	0.0353	-0.0738	0.0316	-0.0068	0.0299
1970.	-0.1287	0.2510	-0.1180	0.0043	-0.0707
1971.	0.1392	-0.2980	0.1737	0.0150	0.1190
1972.	-0.1086	0.2290	-0.1127	0.0076	0.0771
1973.	0.0934	-0.2017	0.0627	-0.0456	-0.0063
1974.	0.0099	-0.0209	0.0095	-0.0015	-0.0040
1975.	-0.0772	0.1613	-0.0696	0.0145	0.0488
1976.	0.0722	-0.1553	0.0644	-0.0186	0.0187
1977.	0.0611	-0.1319	0.0611	-0.0098	0.0637
1978.	0.0942	-0.2018	0.0821	-0.0254	-0.0042
1979.	-0.1034	0.2183	-0.1093	0.0057	0.0149
1980.	-0.0203	0.0404	-0.0168	0.0034	-0.0839
1981.	-0.0584	0.1225	-0.0596	0.0045	-0.0025
1982.	0.1869	-0.3866	0.1963	-0.0034	-0.0440
1983.	-0.1341	0.2951	-0.1396	0.0214	0.1648
1984.	0.0979	-0.2222	0.0670	-0.0572	0.0815
1985.	0.0066	-0.0145	0.0068	-0.0011	0.0801
1986.	0.2335	-0.5011	0.2283	-0.0392	-0.0458
Electrical Products:					
1968.	0.2113	-0.4068	0.1954	-0.0002	-0.0064
1969.	0.0335	-0.0654	0.0293	-0.0027	0.0087
1970.	-0.1222	0.2335	-0.1097	0.0016	-0.0110
1971.	0.1322	-0.2569	0.1192	-0.0054	-0.0094
1972.	-0.1031	0.2041	-0.1011	-0.0002	0.0074
1973.	0.0886	-0.1775	0.0774	-0.0114	-0.0032
1974.	0.0094	-0.0184	0.0104	0.0014	0.0192
1975.	-0.0733	0.1405	-0.0721	-0.0049	-0.0340
1976.	0.0686	-0.1333	0.0520	-0.0127	-0.0226
1977.	0.0580	-0.1104	0.0603	0.0079	-0.0106
1978.	0.0895	-0.1758	0.0826	-0.0037	0.0009
1979.	-0.0981	0.1966	-0.1635	-0.0650	-0.0487
1980.	-0.0193	0.0378	-0.0244	-0.0059	-0.0029
1981.	-0.0555	0.1106	-0.0398	0.0153	0.0235
1982.	0.1774	-0.3360	0.1845	0.0260	-0.0022
1983.	-0.1273	0.2447	-0.1548	-0.0374	-0.0663
1984.	0.0930	-0.1877	0.0984	0.0036	0.0370
1985.	0.0063	-0.0127	0.0061	-0.0003	0.0155
1986.	0.2217	-0.4431	0.2307	0.0093	0.0069

Different Components of Technical Change Rate and TFP Growth Rate (cont'd)

Year	R-pure	R-Scale	R-bias	R-Tech	R-TFP
Non-Metallic Mineral:					
1968.	0.0391	-0.0810	0.0623	0.0204	0.0219
1969.	0.0062	-0.0118	0.0114	0.0059	0.0048
1970.	-0.0226	0.0374	-0.0415	-0.0267	-0.0639
1971.	0.0245	-0.0585	0.0241	-0.0099	0.0010
1972.	-0.0191	0.0403	-0.0025	0.0187	0.0448
1973.	0.0164	-0.0362	0.0210	0.0013	0.0105
1974.	0.0017	-0.0035	0.0026	0.0009	0.0050
1975.	-0.0136	0.0225	-0.0108	-0.0018	-0.0107
1976.	0.0127	-0.0230	0.0213	0.0110	0.0123
1977.	0.0107	-0.0185	0.0073	-0.0005	-0.0056
1978.	0.0166	-0.0369	0.0165	-0.0039	0.0053
1979.	-0.0182	0.0371	-0.0372	-0.0183	-0.0088
1980.	-0.0036	0.0055	-0.0043	-0.0024	-0.0270
1981.	-0.0103	0.0179	-0.0059	0.0017	-0.0035
1982.	0.0329	-0.0324	0.1375	0.1379	0.1261
1983.	-0.0236	0.0461	-0.0108	0.0117	0.0243
1984.	0.0172	-0.0378	-0.0221	-0.0427	-0.0293
1985.	0.0012	-0.0025	0.0015	0.0002	0.0155
1986.	0.0411	-0.0873	0.0013	-0.0449	-0.0440
Petroleum and Coal Products:					
1968.	0.0562	-0.1121	0.0463	-0.0096	-0.0085
1969.	0.0089	-0.0165	0.0118	0.0042	-0.0048
1970.	-0.0325	0.0619	-0.0210	0.0085	0.0051
1971.	0.0351	-0.0689	0.0372	0.0035	0.0102
1972.	-0.0274	0.0596	-0.0410	-0.0088	0.0126
1973.	0.0236	-0.0502	0.0278	0.0012	0.0396
1974.	0.0025	-0.0061	0.0019	-0.0018	0.0992
1975.	-0.0195	0.0369	-0.0226	-0.0052	0.0056
1976.	0.0182	-0.0354	0.0323	0.0151	0.0315
1977.	0.0154	-0.0323	0.0057	-0.0112	0.0209
1978.	0.0238	-0.0516	0.0089	-0.0189	-0.0019
1979.	-0.0261	0.0515	-0.0498	-0.0244	-0.0075
1980.	-0.0051	0.0090	-0.0061	-0.0022	0.0184
1981.	-0.0148	0.0298	-0.0441	-0.0291	0.0712
1982.	0.0472	-0.0791	0.0131	-0.0188	-0.0330
1983.	-0.0339	0.0664	-0.0108	0.0217	0.0189
1984.	0.0247	-0.0459	0.0095	-0.0117	-0.0127
1985.	0.0017	-0.0032	0.0021	0.0006	-0.0020
1986.	0.0590	-0.0787	0.1725	0.1527	0.1459

Different Components of Technical Change Rate and TFP Growth Rate (cont'd)

Year	R-pure	R-Scale	R-bias	R-Tech	R-TFP
Chemicals and Chemical Products:					
1968.	0.3458	-0.6605	0.3231	0.0084	0.0073
1969.	0.0549	-0.1058	0.0536	0.0027	0.0067
1970.	-0.1999	0.3817	-0.1790	0.0027	-0.0052
1971.	0.2163	-0.4165	0.2003	0.0002	-0.0014
1972.	-0.1688	0.3261	-0.1495	0.0078	0.0102
1973.	0.1451	-0.2857	0.1404	-0.0003	0.0285
1974.	0.0154	-0.0297	0.0157	0.0013	0.0501
1975.	-0.1199	0.2287	-0.1345	-0.0257	-0.0470
1976.	0.1122	-0.2188	0.1286	0.0221	0.0215
1977.	0.0949	-0.1865	0.0900	-0.0016	0.0073
1978.	0.1464	-0.2903	0.1231	-0.0208	-0.0180
1979.	-0.1606	0.3221	-0.1608	0.0006	0.0551
1980.	-0.0315	0.0618	-0.0333	-0.0029	0.0049
1981.	-0.0908	0.1792	-0.0917	-0.0033	0.0270
1982.	0.2904	-0.5702	0.3319	0.0521	0.0369
1983.	-0.2084	0.4161	-0.1998	0.0079	0.0023
1984.	0.1521	-0.3040	0.1546	0.0027	0.0276
1985.	0.0102	-0.0205	0.0118	0.0016	0.0021
1986.	0.3629	-0.7225	0.4101	0.0505	0.0534

4. Index of Technical Change and TFP:

Index of Technical Change and TFP

Year	Tech	TFP	Tech	TFP	Tech	TFP
	Food & Bev		Rub & Plast		Leather	
1968.	0.9895	0.9765	1.0043	0.9973	0.9995	0.9971
1969.	0.9883	0.9800	1.0043	0.9965	1.0007	0.9943
1970.	0.9935	0.9901	0.9928	0.9538	1.0010	0.9921
1971.	0.9881	0.9834	0.9927	0.9492	1.0166	1.0058
1972.	0.9826	1.0015	0.9927	0.9544	1.0111	1.0000
1973.	0.9821	1.0464	0.9859	0.9607	1.0185	1.0032
1974.	0.9813	1.0702	0.9857	0.9730	1.0202	1.0058
1975.	0.9822	1.0737	0.9412	0.8897	1.0199	1.0042
1976.	0.9795	1.0529	0.9442	0.8976	1.0321	1.0133
1977.	0.9717	1.0470	0.9211	0.8783	1.0468	1.0309
1978.	0.9705	1.0709	0.9063	0.8671	1.0677	1.0357
1979.	0.9716	1.0977	0.8724	0.8501	1.0422	1.0087
1980.	0.9711	1.1069	0.8694	0.8419	1.0402	1.0078
1981.	0.9773	1.1197	0.8654	0.8491	1.0361	1.0022
1982.	1.0406	1.1919	0.8740	0.8435	1.0699	1.0455
1983.	1.0262	1.1468	0.8499	0.8208	1.0156	0.9928
1984.	1.0148	1.1411	0.8810	0.8813	1.0092	0.9816
1985.	1.0149	1.1423	0.8820	0.8938	1.0089	0.9818
1986.	0.9958	1.1168	0.8135	0.8220	0.9891	0.9709

Index of Technical Change and TFP

Year	Tech	TFP	Tech	TFP	Tech	TFP
	Textile		Knitting		Clothing	
1968.	0.9837	0.9779	0.9644	0.9623	1.0062	1.0057
1969.	0.9846	0.9849	0.9682	0.9620	1.0068	1.0058
1970.	0.9752	0.9537	0.9797	0.9671	1.0093	1.0063
1971.	0.9721	0.9542	0.9757	0.9588	0.9958	0.9919
1972.	0.9693	0.9657	0.9674	0.9472	0.9946	0.9931
1973.	0.9588	0.9554	0.9510	0.9270	0.9980	0.9954
1974.	0.9598	0.9530	0.9544	0.9277	0.9979	0.9946
1975.	0.9567	0.9273	0.9496	0.9199	0.9920	0.9878
1976.	0.9546	0.9230	0.9580	0.9297	0.9796	0.9751
1977.	0.9535	0.9229	0.9387	0.9185	0.9853	0.9824
1978.	0.9521	0.9248	0.9612	0.9378	1.0063	1.0053
1979.	0.9552	0.9394	0.9788	0.9517	1.0277	1.0255
1980.	0.9543	0.9354	0.9754	0.9482	1.0295	1.0277
1981.	0.9501	0.9370	0.9806	0.9496	1.0337	1.0296
1982.	1.0063	0.9836	0.9682	0.9566	1.0613	1.0614
1983.	1.0309	1.0305	0.9514	0.9413	1.0719	1.0725
1984.	1.0399	1.0375	0.9472	0.9331	1.0542	1.0538
1985.	1.0388	1.0363	0.9464	0.9297	1.0541	1.0523
1986.	1.0281	1.0206	0.9687	0.9326	1.0546	1.0332

Index of Technical Change and TFP

Year	Tech	TFP	Tech	TFP	Tech	TFP
	Wood		Furniture		Metal Fab	
1968.	0.9918	1.0065	1.0177	1.0145	0.9872	0.9835
1969.	0.9930	1.0242	1.0208	1.0145	0.9859	0.9857
1970.	0.9789	0.9481	1.0069	0.9951	0.9814	0.9760
1971.	0.9870	0.9790	1.0006	0.9869	0.9712	0.9605
1972.	0.9962	1.0670	0.9939	0.9892	0.9725	0.9674
1973.	0.9934	1.1291	0.9997	0.9950	0.9749	0.9886
1974.	0.9936	1.0900	1.0007	0.9943	0.9739	1.0115
1975.	0.9813	0.9978	0.9822	0.9649	0.9673	0.9866
1976.	0.9796	1.0604	0.9779	0.9602	0.9772	1.0016
1977.	0.9841	1.0870	0.9929	0.9762	0.9760	0.9984
1978.	0.9882	1.1370	1.0006	0.9787	0.9743	1.0090
1979.	0.9727	1.1639	0.9920	0.9712	0.9588	1.0222
1980.	0.9635	1.0895	0.9848	0.9634	0.9591	1.0251
1981.	0.9436	0.9754	0.9934	0.9771	0.9333	0.9574
1982.	1.0310	1.0199	1.0047	0.9954	0.9506	0.9527
1983.	1.0111	1.1051	0.9979	0.9891	0.8908	0.8501
1984.	1.0400	1.1711	0.9988	0.9885	0.9199	0.8949
1985.	1.0402	1.2009	0.9986	0.9864	0.9205	0.9138
1986.	1.0452	1.2166	0.9851	0.9495	0.9249	0.9141

Index of Technical Change and TFP

Year	Tech	TFP	Tech	TFP	Tech	TFP
	Machinery		Paper & allied		Primy metal	
1968.	1.0049	0.9877	1.0022	0.9978	0.9784	0.9927
1969.	0.9989	0.9989	1.0001	1.0226	0.9798	0.9983
1970.	0.9991	0.9816	1.0022	1.0080	0.9853	1.0372
1971.	0.9966	0.9750	1.0041	0.9932	0.9807	1.0014
1972.	1.0093	1.0222	1.0036	1.0121	0.9771	0.9913
1973.	1.0120	1.0461	1.0034	1.0377	0.9760	1.0384
1974.	1.0115	1.0709	1.0029	1.1300	0.9753	1.1261
1975.	1.0068	1.0873	0.9909	0.9982	0.9708	1.0429
1976.	0.9986	1.0583	0.9925	1.0676	0.9772	1.0210
1977.	1.0015	1.0584	1.0009	1.0590	0.9734	1.0339
1978.	0.9983	1.0722	0.9929	1.0661	0.9652	1.0675
1979.	1.0049	1.1436	1.0060	1.1293	0.9706	1.1558
1980.	1.0058	1.1610	1.0064	1.1741	0.9701	1.1584
1981.	1.0056	1.1534	0.9753	1.0895	0.9553	1.0587
1982.	1.0290	1.1333	1.0177	1.0828	0.9587	0.9679
1983.	0.9802	0.9791	0.9572	0.9409	0.9472	0.9021
1984.	0.9562	0.9844	0.9554	0.9770	0.9546	0.9801
1985.	0.9557	0.9972	0.9552	0.9883	0.9561	0.9768
1986.	0.9614	1.0056	0.9120	0.9307	0.9947	1.0094

Index of Technical Change and TFP

Year	Tech	TFP	Tech	TFP	Tech	TFP
	Transp Equip		Elec Prod		Non-metal	
1968.	0.9410	0.9809	0.9998	0.9936	1.0204	1.0219
1969.	0.9346	1.0102	0.9972	1.0023	1.0263	1.0268
1970.	0.9387	0.9388	0.9988	0.9912	0.9989	0.9612
1971.	0.9527	1.0505	0.9933	0.9819	0.9891	0.9621
1972.	0.9600	1.1315	0.9932	0.9891	1.0076	1.0052
1973.	0.9162	1.1244	0.9818	0.9860	1.0089	1.0158
1974.	0.9148	1.1198	0.9832	1.0049	1.0098	1.0209
1975.	0.9281	1.1745	0.9784	0.9707	1.0080	1.0100
1976.	0.9108	1.1965	0.9660	0.9488	1.0191	1.0225
1977.	0.9019	1.2727	0.9735	0.9387	1.0186	1.0167
1978.	0.8790	1.2674	0.9699	0.9396	1.0146	1.0221
1979.	0.8839	1.2864	0.9068	0.8938	0.9961	1.0131
1980.	0.8869	1.1785	0.9015	0.8912	0.9937	0.9858
1981.	0.8909	1.1755	0.9153	0.9166	0.9954	0.9823
1982.	0.8878	1.1238	0.9390	0.9146	1.1327	1.1062
1983.	0.9068	1.3091	0.9039	0.8540	1.1460	1.1331
1984.	0.8549	1.4158	0.9072	0.8856	1.0971	1.0999
1985.	0.8540	1.5291	0.9069	0.8994	1.0974	1.1169
1986.	0.8205	1.4591	0.9154	0.9056	1.0481	1.0677

Index of Technical Change and TFP

Year	Tech	TFP	Tech	TFP
	Petr & coal:		Chem & Chem prod	
1968.	0.9904	0.9915	1.0084	1.0073
1969.	0.9946	0.9867	1.0111	1.0140
1970.	1.0030	0.9913	1.0139	1.0088
1971.	1.0065	1.0019	1.0141	1.0073
1972.	0.9976	1.0145	1.0220	1.0175
1973.	0.9988	1.0547	1.0217	1.0465
1974.	0.9970	1.1593	1.0231	1.0989
1975.	0.9919	1.1658	0.9967	1.0473
1976.	1.0069	1.2026	1.0188	1.0698
1977.	0.9956	1.2277	1.0171	1.0776
1978.	0.9768	1.2254	0.9960	1.0582
1979.	0.9530	1.2162	0.9966	1.1165
1980.	0.9509	1.2386	0.9937	1.1220
1981.	0.9232	1.3268	0.9904	1.1523
1982.	0.9058	1.2830	1.0420	1.1948
1983.	0.9255	1.3073	1.0501	1.1976
1984.	0.9147	1.2906	1.0530	1.2306
1985.	0.9152	1.2881	1.0547	1.2331
1986.	1.0550	1.4760	1.1079	1.2990