Essays in the Economics of Innovation

The Knowledge Production Function

Evidence from New Micro Data

HANS LÖÖF

STOCKHOLM 2002

DEPARTMENT OF INDUSTRIAL ECONOMICS AND MANAGEMENT
ROYAL INSTITUTE OF TECHNOLOGY
Essays in the Economics of Innovation
ABSTRACT


This doctoral thesis consists of five self-contained essays. Common themes that unify the essays are the conditions for innovative engagements and the effort to endogenize innovations into the explanation of profitability, productivity and growth in manufacturing and service production. The purpose is to explore the importance of innovation in explaining heterogeneity in the performance of firms. The traditional analysis of the relationship between research and development and productivity is extended and developed by using, on the one hand, firm-level data not previously available and, on the other, a modern state-of-the-art econometric framework.

Essay I. Methods and results are reviewed and stylized facts presented regarding the return on innovation. The limitations of the data and methods used in mainstream literature are discussed. A set of firm-level observations recently made available and a multiple knowledge production function analysis have been used to clarify the role of innovation in explaining performance heterogeneity among manufacturing firms in Sweden.

Essay II. The relationships between innovation and productivity among manufacturing firms in Finland, Norway and Sweden are studied. The main purpose is to investigate the contributions of firm-level innovation in creating the large observed differences in aggregated productivity growth between Norway on the one hand and Finland and Sweden on the other.

Essay III. The focus of this essay is threefold. One, since innovation has been found to be a major contributor to productivity growth in manufacturing, we seek to find whether there is any evidence for the notion that service industries have a lower propensity to be innovative or that they are less efficient in deriving benefits from innovations. Second, we consider what real productivity growth does, and what the measurement methods do to produce the reported weak growth rates in services. Third, given that intermediate services have been found to be one of the fastest growing input factors in manufacturing, largely reflecting the replacement of internally provided activities by externally produced outputs, we examine what the
impact of outsourcing is on productivity growth in manufacturing. The essay brings a comparative perspective to these issues by analyzing the firm-level data on innovative activities and economic performance in knowledge-intensive manufacturing and service firms in Sweden.

Essay IV. This essay investigates the sensitivity of estimated relationships between innovation and firm performance. The essay compares the sensitivity of results with regards to different types of models, estimation methods, measures of firm performance, classification of firms, type of innovations and data sources. The analyses are performed on both the level and growth rate of firm performance, and the influence of outliers is explored.

Essay V. The role of capital structure and external financing in innovation and production is studied. Results from different model specifications are explored. A preferred dynamic model with flexible adjustment is used for an inter-country and an intra-country comparison of the determinants of the optimal mix between debt and equity as well as the rate of change towards an optimal capital structure.

**Keywords:** Knowledge capital, performance heterogeneity, innovation, manufacturing, services, Community Innovation Survey, cross-country comparisons, outsourcing, capital structure, dynamic adjustment, optimal leverage, panel data.

**JEL Classification Numbers:** C23, C24, C31, C51, D24, G32, L60, O31, O32
ACKNOWLEDGEMENTS

During the course of writing this thesis, I have benefited from discussions and collaboration with a great number of people. First of all, I would like to thank the members of my doctoral committee Professor Gunnar Eliasson and Professor Staffan Laestadius, The Royal Institute of Technology, and Professor Almas Heshmati, Stockholm School of Economics – and The United Nations University (UNU/WIDER) – for their support, encouragement and comments on numerous earlier versions of different parts of this thesis which were given in a very constructive and helpful manner. I would like to thank Professor Heshmati in particular for his continuous guidance not least in co-authoring three of the five essays. I deeply appreciate his extraordinary efficiency, carefulness, patience and kindness. He has been my mentor and teacher and the best of friends. I have had the luck and great honor to benefit from the brilliance and intellectual creativity of Professor Eliasson. He has not only been my untiring supervisor but also a most inspiring research colleague. The collaboration with him has been most inspiring. The challenging discussions with Professor Laestadius on the costs and benefits of quantitative analysis of innovativeness have been appreciated.

Professor Jacques Mairesse at the University of Paris was kind to invite me to the CREST/INTENSEE, Paris for a short visit. This gave me the opportunity to learn more about his and his colleagues’ research on the relationship between innovation and productivity. I thank them for their hospitality and fruitful discussions. I extend special gratitude to Emmanuel Duguet.

Special thanks go to Rita Asplund, Lars Bager-Sjögren, Roger Svensson, and Susan Long. The initial collaboration with Asplund, who is co-author of essay II, was decisive in writing this thesis. Bager-Sjögren’s deep understanding of econometrics was equally decisive in using the knowledge production function approach in the analysis. Roger Svensson has kindly read the entire manuscript in a most thorough manner and contributed to improving every chapter. Deep appreciation goes to Susan Long for her professional and patient work in checking, correcting and improving the language in essay I and essay III-V. I am grateful to Peter Collopy for correcting the language in essay II. I would also like to thank Svein-Olav Nås for interesting discussions and for his contribution as co-author of essay II.
Ulf Johansson is responsible, at least partly, for encouraging me to leave the Ministry of Industry and going back to academia.

I am also very indebted to Anders Sundström at Statistics Sweden, who has not only served as a highly competent provider of the micro-data set that has been used in the econometric analysis, but who has also had constructive suggestions on how to improve the purely Swedish innovation survey used in essay III and IV. Bo Hansson graciously shared his data on firms listed on Stockholm Stock Exchange.

I am grateful to my colleagues at the Department of Industrial Economics and Management. In particular I would like to thank Sven Antvik, David Bauner, Monica Bertilsdotter, Terrence Brown, Pontus Cerin, Peter Dobers, Bengt Domej, Ann-Charlott Fridh, Dan Johansson, Andreas Jonason, Birger Ljung, Sven Modell, Pavel Pelikan, Christopher Palmberg, Sofia Sandgren, Maria Söderberg, Sten Wikander and Kristin Örnulf. I also would like to thank Björn Bergström, Christina Carlsson, Sébastien Gustin, Christer Lindholm, Jessica Matz, Caroline Pettersson and Jan-Erik Tibblin for their kind support in dealing with all the administrative problems and obstacles during my work on this thesis.

Financial support from NUTEK/VINNOVA is gratefully acknowledged. I owe a great deal to Ulf Eklund and Göran Marklund at VINNOVA.

Lastly, I would like to thank my wife, Maritha, and both my sons, Petter and Jonatan, for their invaluable support and encouragement.

Stockholm, January 2002

Hans Lööf
CONTENTS

1. Introduction........................................................................................................... 13
   1.1 The Purpose of the study................................................................. 13
   1.2 Methodological framework: The Knowledge production function........ 14
   1.3 The data...................................................................................................... 17
   1.4 Theoretical, methodological and statistical issues............................. 18
   1.5 Conclusions............................................................................................... 18

2. Outline of the thesis............................................................................................ 21

3. Essay I to V........................................................................................................ 31

Essay I to V


1 Hans Lööf is the main author of the co-authored essays I, II and IV.
1. INTRODUCTION

1.1 The purpose of the study

The ambition to endogenize innovations into an explanation of profitability, productivity and growth in manufacturing and service production provides the common theme for the five essays. The purpose is to explore the role of innovation in explaining the heterogeneity of firm performance. Attempts are made to extend and develop the traditional analysis of the relationship between research and development and productivity by using, on the one hand, firm-level data not previously available and, on the other, a state-of-the-art econometric framework.

This thesis started as a separate Nordic project that was part of a European research project concerned with classifying and measuring the return on intangibles. The main purpose of the separate Nordic project was to analyze the innovative capacity of firms. The particular research issue was specifically to measure the relationship between various intangibles and the innovativeness of firms, and then the relationship between innovativeness and firm performance in terms of productivity, employment and growth.

Some of the main measurement problems with intangibles are associated with factors such as: research, development, patents, licenses, design, training, human resources, tacit and codified knowledge, entrepreneurship, management, organizational routines, organizational concepts, critical mass, software, marketing, advertising, distribution and logistics, image, brand name, reputation, the degree of connectivity of the related network, etc. Most of these variables and other intangibles are by definition hard or impossible to measure. Moreover, no consensus has been reached on the classification or categorization of intangibles.

An issue closely related to the particular characteristics of intangibles concerns the two “styles” of research on the contribution of R&D, human capital and other intangible capital to economic growth: case studies and econometric estimates of production functions.

The American economist Zvi Griliches [1], whose extensive work on various aspects of the relationship between R&D and productivity has inspired the present dissertation, argues that case studies are very expensive in terms of data and time, and are always subject to attack as not being representative. Thus, it is never quite clear
what general conclusions one can draw on the basis of such studies. The econometric production function approach is more general than the case study approach. It abandons the interesting details of specific events and concentrates instead on “the average firm” and tries to control for differences in firm size, human capital, physical capital, industry classifications and so on.

The ambition to better understand the role of intangibles in productivity and growth is one of the strong motivating forces for research in the economics of innovation. One important step in this direction was recently taken by the OECD, Eurostat and other national and international organizations, through their effort to develop and standardize the methodology and information used in innovation surveys. Consensus on this prolonged work was reported in the Oslo Manual [2], and serves today as a theoretical foundation for the Community Innovation Survey (CIS) data collected in the European OECD countries and in additional industrialized countries. In this new set of innovation data, R&D is one of several sources of innovation.

Although the CIS data set is a crude proxy of the extremely complicated and mainly tacit process that transforms tangible and intangible innovation input into commercially valuable goods, services and processes, it has been found to be useful in several recent studies. This new set of innovation data provides an important complement to other statistics on firm-level innovation such as R&D, patents and licensing. There are at least three unique aspects of the Community Innovation Survey data. First, it provides information on total expenditures on innovative activities. Second, it contains information on the output of these activities, reported as sales income from new or significantly improved products and services. Third, the range of observations is extensive and includes responses from firms conducting formal R&D as well as responses from small and medium-sized manufacturing and service firms that normally do not report their innovative activities in other statistical surveys.

1.2 Methodological framework: The knowledge production function

The prime objective of this study is to capture, measure and better understand the economic process that leads to the development or significant improvement in services, products and processes. The CIS data, complemented with register data, provides opportunities to measure both the inputs and the outputs of such a process,
and to study the correlation between innovation input, innovation output and various definitions of firm performance.

Pakes and Griliches [3] introduced the knowledge production function concept describing the causal correlation between resources invested in inventive activity, additions to economically valuable knowledge, or “inventive output”, and indicators of expected or realized benefits from invention such as growth, profitability, productivity, or the stock market value of the firm or industry.

In the underlying theory of the knowledge production function, the success of a particular research project depends stochastically on the level of current and past R&D investments. The R&D expenditures are assumed to be exogenous. This means that there is no feedback from profitability to innovation investment. Hence, in the model the disturbance terms are assumed to be mutually uncorrelated.

One particular feature of the original Pakes-Griliches production function is that “inventive output” is assumed to be intrinsically unobservable. However, they assume that patents can serve as a proxy for the process of transforming R&D into a higher degree of economically valuable knowledge.

In an attempt to endogenize the R&D investment in the knowledge production function, Crépon, Duguet and Mairesse [4] proposed a four-equation recursive model where the disturbances are assumed to be jointly correlated. This means that the factors that are supposed to have an influence on the estimated probability of being engaged in R&D also influence the estimated elasticity of productivity, and vice versa. The endogenizing of the R&D variable by this specification of the knowledge production function is underpinned both by innovation theory and empirical studies on R&D and productivity in recent decades.

Unfortunately the cross-sectional nature of the CIS observations does not allow a recursive equation system. Therefore the modified model used by Lööf and Heshmati [5] is an econometric specification that is an intermediate one between the Pakes-Griliches exogenous knowledge production function and the endogenous model by Crépon, Duguet and Mairesse. In specifying the knowledge production function model used in essays I-IV, the two first equations – the probability of engaging in innovative activities and the size of innovative activities – are estimated jointly, and the two last equations – innovation output and productivity – are estimated
simultaneously. In our model the predicted value of the innovation input estimate is used as an endogenously determined explanatory variable in the innovation output equation.

More specifically, the econometric framework in essay I-IV is based on the following knowledge production model:

\[
\begin{align*}
    g^* &= \beta_0^0 + \sum_n \beta_n^0 x_n^0 + \epsilon^0 \\
    k^* &= \beta_0^1 + \sum_m \beta_m^1 x_m^1 + \epsilon^1 \\
    t &= \beta_0^2 + \beta_q q + \beta_k k + \sum_l \beta_l^2 x_l^2 + \epsilon^2 \\
    q &= \beta_0^3 + \beta_t t + \sum_k \beta_k^3 x_k^3 + \epsilon^3
\end{align*}
\]

where the first two equations are estimated separately as a generalized tobit model where observations on both innovative firms and non-innovative firms are included. The last two equations are estimated as a two-stage least square (2SLS) or a three-stage least square (3SLS) simultaneous equation system where the endogenous innovation input variable is limited only to strictly positive values in the last two steps. \( g^* \) is a latent (unobserved) innovation decision variable, \( k^* \) represents latent innovation input, \( t \) is innovation output, \( q \) is productivity, \( x \) are explanatory variables including employment, physical capital and human capital and various indicator variables. We assume that the random terms in the first part of the model (\( \epsilon^0 \) and \( \epsilon^1 \)) are not correlated with the two error terms in the second part of the model (\( \epsilon^2 \) and \( \epsilon^3 \)). This is not obvious when \( k \) in equation (2) is predicted from equation (1). However, in examining the performance of a two-stage evaluation methodology based on a selection problem similar to ours, Heckman, Ichimura and Todd [6] suggest that selection bias, rigorously defined, is a relatively small part of bias as conventionally measured given the fact that observables drawn from the total sample [as in our equation (2)] have the same distributions of attributes as the observables in the common sample [as in our equation (1)].

The completely endogenous model, such as the one suggested by Crépon, Duget and Mairesse, is preferable to our semi-endogenous model, and will be used when more CIS surveys are available to provide longitudinal panel data.
Since innovative activity is studied in this dissertation, a natural question to ask would be about the entrepreneurial activity that brings together economic (business) concerns, financial concerns and innovation. However, due to the lack of financial data in the CIS surveys, this important aspect of the knowledge production function cannot be incorporated in the specification of our model. The relationship between financing and innovation, therefore, is discussed separately in essay V, which is based on panel data methodology and a dynamic adjustment model. An important issue is whether or not particular financial institutions or a lack of them matter in terms of levels and changes in profitability and productivity.

1.3 The data

The data used in essay I-IV is based on the methodology proposed by the Oslo Manual. The observations analyzed in essay I and II are collected under the framework of the second Community Innovation Survey. The data used in essay III and IV was collected as an experimental enlargement of the CIS II conducted by Statistics Sweden in collaboration with the present research project. It should be noted that the experimental enlargement was a purely Swedish initiative outside the regular CIS program. With this particular survey, we were able analyze the appropriateness of using an identical questionnaire for innovation for both manufacturing and service firms.

The survey data has been further enhanced with register data including firm-level information on sales, profit before and after taxes, value added, physical capital, total assets, ordinary employment, temporary labor, and the level and kind of education of employees.

The key variables in the CIS survey are innovation input, measured as sales income from new or significantly improved products, innovation investments and dummy variables describing sources of knowledge for the innovation process, strategy and collaboration on innovation, obstacles to innovation and process organization.

Essay I uses a sample of 619 Swedish manufacturing firms with 20 or more employees observed between 1994 and 1996. Because of improvements to the data set, we succeeded in increasing the number of observations somewhat, and in essay II
these observations were compared with 1,315 manufacturing firms in Norway observed between 1995 and 1997 and 1,062 manufacturing firms in Finland observed between 1994 and 1996. Using a Swedish survey answered by nearly 50% of all manufacturing and services firms with 20 or more employees that existed between 1996 and 1998, we were able to conduct work on two additional research topics. First we compared the innovativeness of 1,227 knowledge-intensive manufacturing and service firms, and then we used the entirely cross-sectional sample of 3,190 firms to analyze the sensitivity of the estimated relationship between innovation and firm performance.

The observations used in essay V relate to firms listed on the Stockholm Stock Exchange during the period 1991-1998. The data is obtained from Six’s research database. The number of annual observations varies between 117 and 221.

1.4 Theoretical, methodological and statistical issues

All key variables in this dissertation are afflicted by more or less severe measurement problems: human capital, R&D, innovation output, knowledge spillovers between various actors in the economy, the service production, quality improvements and the deflating of nominal growth rates to real growth rates.

The serious difficulties in our econometric inference are due to the fact that most of the variables of interest tend to move together over time and space, making it hard to untangle their separate effects. Moreover, it is not easy to establish causality. Innovations are themselves affected by the level of output and by past profits and productivity. To address these problems, we have been forced to formulate simultaneous equation models and to turn towards more complex estimation techniques.

The complexity of the economic mechanisms studied in this dissertation in fact poses a major research problem in itself. To what extent do the simplified model specifications that we have had to use bias the interpretations of the real underlying mechanisms, and to what extent do the results reported reflect a biased view of the real world? These difficult specification problems have to be kept in mind in the interpretation of our empirical results.
A related problem is the lack of well-established theoretical underpinnings on the innovating firm that could guide us in specifying the various equations in the simultaneity equation model used.

There is also a semantic issue involved, regarding the question of what we mean by the contribution of innovation input and innovation output to productivity or to other alternative measures of firm performance used in this study. Most of the growth literature has interpreted this question in the partial sense, and we have followed this tradition. By partial we mean the derivative of various measures of firm performance with respect to innovation output.

Finally, one can of course question the accuracy and meaning of self-reporting firm data on innovativeness. It can be argued that firms tend to exaggerate because of the positive value judgments regarding the word “innovation”. However, only the firms themselves know the answer, and since innovations have been a survival factor for a growing share of firms, it can be assumed that this type of information is as important for managers as it is for economic researchers.

1.5 Conclusions

In this dissertation, data on the knowledge production function from extensive samples of manufacturing firms in Sweden, Norway and Finland and from an extensive sample of service firms in Sweden has been analyzed. The objective was to investigate the role of innovation in explaining the heterogeneity of firm performance. The entrepreneurial activity that brings economic and financing considerations to bear on innovation has been discussed separately outside the framework of knowledge production. The general conclusions from the dissertation are as follows.

First, the Community Innovation Survey firm-level data supplemented with register data from annual reports, and data on human capital analyzed under the framework of a Cobb-Douglas knowledge production function has greatly advanced the possibilities to study and to understand the relationships between R&D and productivity.

Second, the ambition in the economics of innovation to obtain measurable and reliable output on innovative activity is achieved in a satisfactory way by the CIS definition of innovation sales for manufacturing as well as for service firms.
Third, a multi-equation model of the knowledge production function produces estimates of firm performance with respect to innovation output that are statistically significant and of plausible magnitude for manufacturing. For the service firms there are few studies to refer to. A comparison with manufacturing firms, however, shows striking similarities.

Fourth, this dissertation contributes to an increased understanding of the relationship between innovation and firm performance in several respects. Essay I represents the first attempt to employ the newly available CIS data supplemented with extensive register data under a knowledge production framework. Essay II is the first large-scale comparison of firm-level innovation data among the Nordic countries using an up-to-date econometric framework. Essay III is a unique comparison of innovativeness and its economic results in knowledge-intensive manufacturing and services based on detailed firm-level information. The uniqueness of essay IV is that it considers the sensitivity of the relationship between innovation input, innovation output and firm performance in a variety of dimensions including different measures of firm performance, different types of innovations, different sectors of the economy and different types of models and estimation methods. The scientific justification for essay V is that the presence of market imperfections makes the debt-equity structure a critical concern in the firm’s financing decision, and hence, by implication, also in its decision to innovate. By using a panel data set of firms and a dynamic adjustment model we are able to shed new light on the determinants of optimal capital structure among firms relying on different financial markets.
2. OUTLINE OF THE THESIS

The main objective of this dissertation is to explore the relationship between innovation and performance. In order to do this, we compare firms with respect to size, intensity of human capital, physical capital and industry classification. We compare firms across countries, we compare service firms with manufacturing firms, we compare different measures of firm performance, we compare the level dimension and the growth rate dimension and we compare different data sets and different model specifications.

2.1 Essay I
Knowledge Capital and Performance Heterogeneity: A Firm-Level Innovation Study

First, the essay summarizes the methods and results of previous studies on the return on innovative investments for firms. Some stylized facts are presented. It also highlights some criticism of the methods and data used in mainstream econometric studies considering the relationship between innovation and productivity growth. New methods are discussed with a view to dealing with the serious problems of selectivity and simultaneity biases in innovation studies. Finally, a version of these new econometric methods is applied to a new type of data sets, created under the framework of the Oslo Manual for the international harmonizing of firm-level innovation surveys.

The purpose of the study is to explain the role of innovation in the observed heterogeneity in firm productivity. Following the tradition of Knight, mainstream economists typically view heterogeneity as related to conduct and performance [at least in the same industry] and as a temporary phenomenon. The general prediction is that firm-level growth rates will eventually converge, as better practices and technologies become diffused and are imitated. However, this proposition of non-persistent heterogeneity has been challenged from a theoretical as well as an empirical point of view.

The empirical data in the study shows first that knowledge capital, defined as the ratio of innovation sales to total sales, is found to be a significant factor contributing to the performance heterogeneity among firms. This relationship holds even when
controlling for human capital, type of output, firm size, and the entry, merger, partial closure or exit of firms. Second, knowledge capital increases with innovation input, internal knowledge within the firm and co-operation on innovation with domestic universities. Third, when controlling for differences in innovation investments and human capital, knowledge-intensive manufacturing firms are not more innovative than labor- or capital-intensive manufacturing firms. Fourth, organizational rigidities in innovation projects and a lack of appropriate investment sources for innovative activities were found to have a negative impact on productivity. Finally, an outspoken offensive or aggressive innovation strategy, competent customers and sources within the firm as the most important sources of information for innovation are positively related to the size of innovation investment.

2.2 Essay II

Innovation and Performance in Manufacturing Industries: A Comparison of the Nordic Countries

This study investigates the relationship between innovation and productivity in manufacturing industries at the firm level in Finland, Norway and Sweden. The study has two main objectives. The first is to investigate the presence of differences in aggregated productivity growth among countries, despite their sharing a high degree of political, social and cultural similarity. The aim is to see whether one can explain these differences by information contained in the internationally harmonized firm-level innovation survey, known in Europe as the Community Innovation Survey [CIS] data. The second objective is to investigate whether a recently introduced econometric model has general characteristics appropriate for handling CIS data collected in different countries.

When aggregated labor productivity growth in manufacturing is considered, Finland and Sweden show the highest growth rates among OECD countries in recent years, while Norway has a very low growth rate. At the same time Finland and Sweden are highly ranked internationally as R&D investors and have a high ratio of residential patent applications/population while Norway is ranked very low in both aspects. This suggests that R&D and innovation performance might be key factors causing the differences in productivity growth among the three countries.
However, analyzing firm-level data reveals that the proportion of innovative firms, the amount of innovation investment or innovation output is not small in Norway. Looking then at the relationship between innovation and productivity, we find that the estimated elasticity of productivity with respect to innovation output is higher in Norway than in its two neighboring countries. Furthermore, surprisingly, we do not find any significant relationship between innovation and productivity for the average manufacturing firm in Finland, a country with a highly productive economy.

We cannot tell whether the regression results for the three countries are the result of data errors, model specifications or unobserved country effects. A number of factors might individually or jointly contribute to the explanation of the existing productivity patterns. Representativeness of the respondent firms might partly explain deviations between aggregated and disaggregated figures when productivity and innovativeness are considered. While all Norwegian firms in the relevant size groups are included in the sample, the Finnish sample, given the truncation of small firms, is strongly biased towards large firms.

A second explanation for the differences can be that the paper considers the level of productivity while the weak Norwegian productivity relates to growth. For the firm, however, it is generally necessary to be competitive in both level and growth rate performance. This has been well documented in the literature. The findings indicate that highly productive firms are likely to be highly productive firms tomorrow as well.

A third set of causes of the somewhat unexpected results might be found in the quality of the CIS data, in the appropriateness of the econometric model used, and in the method of estimation. A single model specification has been estimated at the individual country level without pooling the data. When the data is estimated in separate regressions, the specifications ideally should be country-specific. In the absence of confidentiality problems, the use of firm-level CIS data in a pooled country regression could be a preferred research method. Of course this is meaningful only on account of complementary information on firm-specific and country-specific effects. Despite the limitations and problems discussed previously and given that the data quality and our research methods are found to be acceptable, our tentative conclusions in this study is that sources of the strong productivity performance in Finland and the weak performance in Norway should be found more in the countries’
national innovation systems [R&D policy, education, taxes, competitiveness, financial system, international integration] rather than at the firm level. For Sweden, however, there seems to be a correspondence between micro and aggregated figures.

It is obvious that the conclusions are strongly affected by the quality of the CIS data and the appropriateness of the econometric model, and by estimating the model without pooling the country data. We have listed a number of possible factors explaining the differences in innovation behavior among the three countries. One is the effect of firm size on the innovation behavior of firms. A second factor is the type of industrial structure and thus the difference in the innovation behavior of firms independent of their country of location. These industries are different in export intensity, which affects their innovation behavior and performance. A common factor is the positive association between past and current R&D behavior. The countries differ in the factors that could hamper innovation. Innovation is affected by a lack of appropriate sources of finance and qualified personnel in Sweden, organizational rigidities in Norway and a lack of information on technology in Finland. This can be interpreted as meaning that an increase in the supply of skilled personnel in Sweden, organizational innovations in Norway and more efficient diffusion of technology in Finland could be expected to stimulate innovation activities. Finally, the countries differ in their view of external co-operation on innovation.

2.3 Essay III
A Comparative Perspective on Innovation, Outsourcing and Productivity in Knowledge Intensive Firms

This paper compares innovation and productivity in “measurable” and “non-measurable” sectors by exploring micro data. Because of worries about the ability to increase productivity in the service sector, concern has been raised about the growing share of services in the economy. My interest in this issue is threefold. (1) Since innovation has been found to be a major contributor to productivity growth in manufacturing, is there any evidence for the notion that service industries have a lower propensity to be innovative or that they are less efficient in deriving benefits from innovations? (2) What does real productivity growth do, and what do the measurement methods do, to produce the reported weak growth rates in services? (3)
Intermediate services have been found to be one of the fastest growing input factors in manufacturing, largely reflecting the replacement of internally provided activities by externally produced outputs. What is the impact of outsourcing on productivity growth in manufacturing?

The papers brings a comparative perspective to the first and the third question by analyzing the relationship between productivity, innovation, human capital, physical capital and temporary labor for 649 knowledge-intensive manufacturing firms and 580 mainly knowledge-intensive business services firms in Sweden. It finds that innovation contributes significantly to productivity in both the level and growth dimension for knowledge-intensive manufacturing as well as business services.

A striking feature of the study is the temporary labor estimate. The estimate, used as a proxy for outsourcing, is very large and significant for knowledge-intensive manufacturing firms in the level as well as in the growth rate dimension.

The overall results indicate that the reported weak aggregated productivity growth in business services is not a real economic problem. On the contrary, the results support the hypothesis that our measurement tools are becoming increasingly inadequate in the context of an economy characterized by continuously ongoing innovation processes.

2.4 Essay IV
On The Relationship between Innovation and Performance:

A Sensitivity Analysis

This essay is aimed at investigating the sensitivity of the estimated relationship between innovativeness and firm performance. It compares the sensitivity of results with regard to different types of models, estimation methods, measures of firm performance, classification of firms, types of innovations and data sources. The analyses are performed in both the level and growth dimensions of innovation, and the influence of outliers is explored.

The data set used contains extensive information on various key characteristics of firms. This includes information related to R&D, various innovation inputs and innovation indicators, human capital and other economic data variables at the individual firm level which is augmented with information from a large innovation
survey with firm-level data from register data. The combined data is comprehensive and covers about 40% of all service and manufacturing firms in Sweden in 1998 with 20 or more employees.

To our knowledge, this study is one of the first attempts to estimate the causal effect of innovation investment on innovation output and the causal effect of innovation output on firm performance for service firms. Furthermore, it compares the relationship between innovation and firm performance for manufacturing and service firms by using the same econometric framework but accounting for the heterogeneity of the two industries by relying on an extensive data set.

The essay finds that the simple OLS model gives a downward bias in elasticities given selectivity and simultaneity problems and is inappropriate for analyzing the relationship between innovation and productivity. The basic model produces highly significant estimates in both the log level and growth rate dimensions. The size of the estimate is within the range of what has been found in previous literature, although we use a broader definition of innovation output compared to the traditional definition, which is focused on technology. An alternative model that takes the simultaneity bias into account but ignores the selectivity bias produces larger standard errors in the growth rate dimension compared to the basic model. In a comparison of manufacturing firms and service firms, there is striking homogeneity regarding the estimated relationship between innovation input and innovation output and between innovation output and the level of productivity that is not well documented in previous studies. One reason is that innovation output data from service firms is still rare. Our conclusion supports the view that services and goods are not much different, and productivity or performance analysis raises similar difficulties for both sectors.

A consideration of different performance measures shows that sales is a less appropriate approximation of value added when the relationship between innovation and performance is analyzed; it is also clear that innovations are more profitable for manufacturing firms than for service firms. Finally, employment increases with innovation output only for services while no correlation can be established between innovation intensity and profit growth for either or both categories of firms.

The study finds a closer relationship between innovation output and (a) the level of value added per employee, (b) the level of sales per employee and (c) the sales
margin for innovations new to the firm compared to innovations new to the market. In contrast, the growth rate of productivity increases only with innovations new to the market. The significant relationship between innovation and employment growth for service firms is independent of the degree of novelty of the innovations.

Using different sources of data on the same model specification we find that register data on profit, sales and employment is preferable to survey data if both are available. The survey data is particularly unreliable in growth regressions which require information from previous time periods.

2.4 Essay V
Technological Change and the Determinants of Dynamic Optimal Capital Structure

The interdependence of finance and technological change plays a strategic role in modern economies, especially when it comes to high technology and serviced-based small and medium-sized firms. For an increasing number of firms, innovation has become the critical survival factor. Moreover, the development of the financial system, which to an increasing extent is characterized by early access to various types of risk capital, has stimulated innovation and accelerated the pace of innovation growth, which in turn has speeded up the evolution of the financial system, leading to a “virtuous circle”. The capital markets give the innovative firm opportunities to invest in projects whose returns are to be realized in the future. The innovative firm is then assumed to create value if the expected return exceeds the return required by the financial market for the risk involved. Hence, on the one hand, the financial markets promote the firm’s exploitation of new technological opportunities, and on the other hand they increase the competitive pressure on the firm to do so successfully.

An important issue is whether or not particular financial institutions or a lack of them matter in terms of levels and changes in profitability and productivity. In this paper we compare the determinants of optimal capital structure, the difference between observed and optimal capital structure and the rate of change in the adjustment process towards optimal capital structure in two polar cases, the public market-oriented system in the U.K. and the U.S. and the bank-oriented system in
Sweden. We also carry out some comparison for listed and non-listed firms in Sweden.

Large differences are observed between the Anglo-American financial system and the bank-oriented Swedish system, and between firms in Sweden that depend on the possibility of raising funds from the stock market. However, extensive differences are also identified between firms in the U.K. and the U.S.

The U.S. firms deviate less from the optimal level than firms in both Sweden and the U.K. do. The speed of adjustment towards targeted capital structures is much faster in the two Anglo-American countries than it is in Sweden. A comparison of measures of leverage indicates that Swedish managers pay more attention to the market valuation of their firm than the book valuation.

The essay demonstrates that a dynamic model in which transaction costs are incurred when a firm adjusts to the optimal capital structure outperforms a corresponding static model which assumes that the firm always reaches its optimal debt-equity ratio.
REFERENCES


