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INNOVATION AND ECONOMIC PERFORMANCE AT THE ENTERPRISE LEVEL

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Preface

This report presents the results from the core component of a major research project entitled ”Profitability and growth as a result of R&D and innovation”, financed by the Research Council of Norway under the programme “Industry, finance and market” (“Næring, finans og marked”). We are grateful for this support that enabled us to work with what we think are important and interesting topics for both analysing and policymaking within the fields of innovation and research policy. We are also grateful to Statistics Norway for giving access to micro level innovation and accounting data, without which this kind of research would not have been possible.

Tore Sandven at STEP has carried out research on the present module. Other modules of the project include a special focus on innovative successes, an analysis of innovation activities in large corporations, econometric modelling of the relationships between innovation inputs, innovation outputs and productivity in Nordic countries, and a study of restructuring activities as part of the innovation process. Results from the overall project are synthesized in a final report drawing upon all the modules of the project.

Svein Olav Nås
Project leader

Abstract

This study is an empirical investigation of the relationship between innovation and economic performance at the level of individual business units, or more precisely the enterprise level. It uses the data from the Norwegian innovation survey 1992 merged with accounting data for the period 1991-1997. At the same time the study has a methodological purpose, to check to see whether the indicators from the innovation survey seem to function well when confronted with empirical accounting data. The answer to this question is positive. We do find a number of clear and statistically highly significant associations between innovation variables and economic performance variables. Moreover, these associations mostly make good sense. This indicates that at least some of the innovation variables to a significant extent actually do measure what we want them to measure. The performance measures used in the study are growth in sales and total assets, as well as two different measures of profit ratio. For the two growth measures we find very clear and consistent positive associations with innovation variables throughout the whole period, from 1991 to 1997. The variables which make the most significant contribution here are especially innovation expenditures, but also the proportion of sales in 1992 accounted for by product innovations. For the two profit ratio measures, we find a very clear association with innovation variables for 1992, then some association for 1993, but no significant association after 1993. Here innovation expenditures make almost no significant contribution, but the proportion of sales in 1992 accounted for by product innovations does.

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Chapter 1. Introduction

It is a commonplace that innovation is essential to economic performance. Such claims are often simply asserted, and are often also quite general and vague. Often one gets the impression that the claim refers indistinguishably to economic growth generally, to the competitiveness of national economies, to the competitiveness, profitability, survival and growth of individual enterprises, and so on. Clearly, there is need for more precise empirical information which help us make distinctions as to how, when, in what sense, to what extent, etc. innovation is important. In this paper we will try to make a small contribution to this task by going more closely into the relationship between innovation and economic results at the enterprise level, basing our analysis on data on both innovation and economic results for a panel of 640 Norwegian manufacturing enterprises.[1]

The report is organized as follows. Chapter 2 gives a short description of the data. Chapter 3 addresses some basic theoretical and methodological issues in relation to the present study, discussing what kinds of results we should expect. In Chapter 4 we present a preliminary empirical investigation, analysing the probability of dropping out of the sample after 1994. Chapter 5 presents the main empirical results of the study, analysing the relationships between the innovation variables and four different measures of economic performance: operating profit ratio, return on investment, asset growth, and sales growth. Chapter 6 shortly presents the results of an analysis of the relationship between innovation and the variation in the performance measures. Chapter 7 sums up the main results and discusses some implications for further research.

[1] The paper builds on and attempts to carry further work already done on this data set by Svein Olav Nås and Ari Leppälahti. See Svein Olav Nås and Ari Leppälahti, 'Innovation, firm profitability and growth,' *STEP report* 1/97, Oslo, May 1997. Since this report appeared, accounting data for the years 1995 – 1997 have been added to the data set.

Chapter 2. The data

Our data set merges data from the Norwegian innovation survey 1992 with accounting data.[2] The innovation data are the Norwegian component of the Community Innovation Survey (CIS) 1992.[3] Here a representative sample of enterprises has been asked a number of questions relating to innovation. A couple of introductory questions allow us to distinguish between enterprises with and without innovations. The definition refers to the three year period 1990-1992, and the questions are whether the enterprise during this period has developed or introduced any technologically changed *products*, and whether the enterprise during this period has developed or introduced any technologically changed *processes*. The enterprises who answer in the affirmative to one or both of these questions may thus be defined as innovative, those who answer no to both questions as not innovative. Roughly, a little less than half of the enterprises in the sample are innovative according to this definition (in the sample we will use here, the proportion is 43.1 per cent, see below). We are thus able to compare innovative and non innovative enterprises in terms of economic performance.

The enterprises who are defined as innovative have then been asked a number of questions regarding their innovative activities and the results of this activity. These include expenditures on innovation activities, including R&D expenditures. In this connection, they were also asked if they had participated in R&D cooperation with different kinds of enterprises and institutions. As a measure of the results of the innovation activities, the enterprises were also asked to estimate the proportion of sales accounted for by product innovations. In addition, there are a number of other questions, including questions on different ways of acquiring new technology, on the relative importance of different objectives of innovation activities and on the relative importance of different sources of information for innovation activities. A set of questions on factors hampering innovation activity is asked to innovative and non innovative enterprises alike. All these questions refer either to the three year period 1990-1992, or to the year 1992.

In addition, for all enterprises, both innovative and non innovative, there is some background information regarding such data as industry classification, number of persons employed, sales, exports and investments, and whether or not the enterprise is an independent enterprise or part of an enterprise group. All these data refer to the year 1992.

The data from the innovation survey have then been merged with ordinary accounting data, reported by the enterprises in accordance with legal regulations to Norwegian public authorities, who use these data first and foremost for purposes of taxation. We have these accounting data for the seven years from 1991 through to 1997.

[2] For a more detailed description and discussion of the data set, the basic concepts underlying the data and the construction of the panel, see Nås and Leppälahti (1997), pp. 5-16.

[3] In Norway, the survey was carried out by Statistics Norway, and was financed by the Research Council of Norway (NFR) and the Norwegian employers' association (NHO).

The number of enterprises in our sample is 640. Basically, these are all the enterprises in the innovation survey sample (originally 908) which one could find in the accounting data base every year in the period 1991-1994, i.e. which had not ceased to exist as separate statistical units in the course of this period. For all the 640 enterprises we thus have accounting data for the whole period 1991-1994. However, when accounting data also for 1995, 1996 and 1997 later were added to the data base, some of these 640 enterprises had also ceased to exist as separate statistical units (whether because they had ceased to exist altogether, through bankruptcy, or whether they had continued to exist in a different form, for instance through being bought up, merger, etc.). Thus, some of the enterprises have missing values on the accounting data variables for 1995, and the proportion increases for 1996 and then again for 1997.

It should be noted that the sample we have here is not a simple random sample, but a disproportionate stratified sample, i.e. where the units are sampled from different strata and where the probability of selection varies across the strata.[4] To take this deviation from a simple random sample into account would have complicated the analysis of the data substantially, and we have chosen not to do so, as we have reason to believe that this would not have altered the results of the analysis in any significant way. The strata are defined by the cross classification of enterprise size groups, measured by number of employees, and industry (classified originally in ISIC categories, then reclassified in NACE categories). Generally, the larger the enterprise, the higher the probability of selection; in addition, this probability varies across industries.

It would have been important to take this variation in the probability of selection into account if the effect of other independent variables (notably, the innovation variables) on the economic performance variables varied significantly with enterprise size and/or industry. This would mean that there were significant interaction effects between the other independent variables and enterprise size and/or industry on economic performance. However, we find virtually no evidence in our data that any such interaction effects should be significant. Consequently, we have reason to believe that analysing the sample as if it were a simple random sample will not significantly distort the results.

[4] See, for instance, Eun Sul Lee, Ronald N. Forthofer and Ronald J. Lorimer, *Analyzing Complex Survey Data*, Sage University Paper series on Quantitative Applications in the Social Sciences, 07-071, Newbury Park: Sage Publications, 1989, pp. 9-16.

Chapter 3. Theoretical and methodological issues. What kinds of relationships would we expect? Problems of interpretation

In this section we will discuss what kind of results we would expect to get from an empirical study of the relationship between innovation and economic performance at the enterprise level. From a straightforward idea of innovation as essential to economic performance, we might simply expect to find that innovative enterprises performed better than non innovative ones, and the better the more intensive the innovation activity, as measured by quantitative innovation indicators.

However, there are several reasons why we should not expect the results of an empirical investigation like the present one to be that straightforward. Part of these reasons has to do with measurement problems, both when it comes to measures of economic performance and measures of innovation, including the timing of measurements. This, among other things, influences to what extent we can be justified in considering variation in innovation variables as causes of variation in performance variables in cases where we find significant association between these variables. We will come back to these issues further below.

But even in the event that we did have indicators not affected by measurement problems, it is not altogether certain that we should simply expect innovative enterprises unambiguously to perform better than non innovative enterprises. One argument to support this claim we can get by applying William Lazonick's distinction between *innovative* and *adaptive* investment strategies. Innovative strategies are strategies for value creation and capacities for future growth; they 'entail a developmental period before they generate returns.' Adaptive strategies are strategies for value extraction; they 'reap the returns on past investments,' while gradually undermining the capacities for generating value in the future.[5] This would suggest that it is an open question whether innovative enterprises are more profitable than non innovative enterprises in the short run. In the long run it suggests that innovative enterprises should experience higher growth rates than non innovative one, perhaps with larger variation in results, due to the riskiness of innovative strategies. Then, of course, comes the question of whether the seven years (1991-1997) which our data cover constitute a long enough period to register these relationships. This whole issue further suggests that contrasting the performance of individual innovative and non innovative enterprises is not that interesting in itself, but that this should perhaps be seen in relation to a question of whether a given economy has a reasonable *mix* of enterprises following an innovative strategy and enterprises following an adaptive strategy. This would involve looking at processes of birth, growth, transformation and death of enterprises, and would crucially have to confront the question of structural change. In any case, this distinction between innovative and adaptive strategies suggests that we have to distinguish among

[5] See William Lazonick, 'Creating and extracting value: corporate investment behavior and American economic performance,' in Michael A. Bernstein and David E. Adler (eds.), *Understanding American Economic Decline*, Cambridge: Cambridge University Press, 1994, pp. 79-113. Quotes from p. 80.

performance variables, and that we might expect innovative enterprises to perform better than non innovative ones on some variables, but not necessarily on others. For instance, while we might not expect any differences on profit ratios in the short run, we might expect innovative enterprises to perform better in terms of growth of assets.

That it is crucial to distinguish among performance measures is also strongly suggested by what Marshall W. Meyer refers to as the 'paradox of performance,' namely the fact that 'while performance measures and measurement activity have proliferated over time, performance measures tend to be very weakly correlated with one another.'[6] It is interesting to note that when Meyer chooses one particular measure to use as a criterion measure to test an hypothesis that 'more successful organizations will exhibit greater variance across performance measures than less successful ones,'[7] he chooses growth in an organization's assets. Although he acknowledges that this choice is somewhat arbitrary, he also claims that 'it may be justified on several grounds.' He claims that 'growth in an organization's assets – not simply in its sales – is one of the few performance measures for which there is strong theoretical justification in the literature.'[8] Furthermore, 'most constituencies surrounding a firm favor asset growth,' while 'measures to increase productivity and returns may, by contrast, provoke severe opposition.' Concerning theoretical justification in the literature, he also comments that 'agency theory *asserts* the primacy of shareholder returns, but this is assumed rather than derived from other first premises.'[9] We may add that the assertion of the primacy of shareholder returns rests on an idea of the shareholders as 'residual claimants,' coupled with a fundamental conviction that if investment decisions are made in accordance with the interests of 'residual claimants,' the outcome will be optimal.[10] This latter conviction is not part of the theoretical perspective of the present paper. Correspondingly, from the perspective of the present paper, a preoccupation with an ideal 'true' measure of economic performance and with evaluating the validity of different empirical indicators by the extent to which they reflect this single, true measure, does not appear as a fruitful approach.[11] Rather, we will regard economic performance as in essence a multi-dimensional phenomenon.

Another consideration which may help us get a perspective on our expectations of what results to get from our investigation and on the interpretation of these results is the low explained variance (for instance, in terms of R^2) generally obtained when economic performance is the dependent variable. J. Bradford Jensen and Robert H. McGuckin, arguing against the practice of basing studies of competition and economic growth on industry-level observations (and other types of aggregates),

[6] Marshall W. Meyer with Kenneth C. O'Shaughnessy, 'Organizational Design and the Performance Paradox,' in Richard Swedberg (ed.), *Explorations in Economic Sociology*, New York: Russell Sage Foundation, 1993, pp. 249-278. Quote from p. 249.

[7] Meyer (1993), p. 265.

[8] P. 266.

[9] P. 266.

[10] For a discussion and critique of the ideology of maximizing shareholder returns, see William Lazonick and Mary O'Sullivan, 'Maximizing shareholder value: a new ideology for corporate governance,' *Economy and Society*, Volume 29, Number 1, February 2000, pp. 13-35.

[11] See for instance the discussion in Robert Jacobson, 'The Validity of ROI as a Measure of Business Performance,' *The American Economic Review*, Vol. 77, No. 3, June 1987, pp. 470-478.

claim that 'most of the observed variation in the data is within industries.' Indeed, 'the vast majority of this variation is not associated with traditional observables such as location, industry, size, age or capital; rather, it is associated with unobserved firm- or business unit-specific factors, many of which appear to be long-lived attributes of the business unit.'[12] We may assume that part of this residual variation may be accounted for by different innovation variables, but knowing the small share of total variation normally accounted for by the more traditional common factors, we should perhaps not expect too much from the innovation variables in this respect.

At the same time, the importance of unobserved, firm-specific factors make the causal interpretation of any association we should find between innovation variables and economic performance problematic. This kind of relationship may well express the workings of unobserved third variables. Jensen and McGuckin note that it is well documented that adoption of advanced technology is positively related to performance, but then ask: 'does this positive association reflect the impact of the technology on the efficiency (competitiveness) of the adopting firm, or is it primarily a manifestation of well-managed efficient firms being more likely to adopt advanced technologies?'[13]

The importance of taking account of 'unobservable factors' has been heavily stressed by Robert Jacobson.[14] Among these he mentions corporate culture, access to scarce resources, management skill, luck, a particular technology, accumulated consumer information, brand name and reputation.[15] He claims that unobservable factors 'can be postulated to be principal determinants of business success,' and that 'failure to control for unobservable factors influencing profitability both biases and exaggerates the effect of strategic factors.'[16] Jacobson argues in favour of using lagged measurements of the dependent variable to control for such firm-specific unobservable factors. This means that when explaining some economic performance variable in a given year, the same variable for an earlier year should be entered as an explanatory variable along with the other explanatory variables in the model. The point is that if these unobservable factors are thought of as 'long-lived attributes of the business unit,' which precisely seems to be the rationale for considering them important, then they will influence economic performance both in this particular year and in the earlier year. Consequently, when explaining economic performance this year, economic performance in the earlier year may serve as a proxy for these unobserved factors. If, for instance, the association between adopting advanced technology and economic performance simply reflects the circumstance that well-managed efficient firms are more likely to adopt advanced technology, the effect of adopting new technology on economic performance will become insignificant when we control for economic performance in the earlier year (which must then be thought

[12] J. Bradford Jensen and Robert H. McGuckin, 'Firm Performance and Evolution: Empirical Regularities in the US Microdata,' *Industry and Corporate Change*, Volume 6, Number 1, 1997, pp. 25-47. Quote from pp. 27-28.

[13] Jensen and McGuckin (1997), p. 44.

[14] See Robert Jacobson, 'Unobservable Effects and Business Performance,' *Marketing Science*, Vol. 9, No. 1, Winter 1990, pp. 74-95 (including commentaries by Robert D. Buzzell and William Boulding, as well as a reply by Jacobson).

[15] Jacobson (1990), p. 74.

[16] P. 74.

of as referring to a period in time prior to the period to which the adoption of the advanced technology variable refers). On the other hand, if the association reflects a real effect of adoption of new technology on economic performance, the effect should remain significant (and substantial) even when we control for economic performance prior to the adoption of the advanced technology.

Clearly, these are complicated questions. The economic performance variable at the earlier date will not simply reflect unobservable factors related to the business unit, but may also to a significant extent express the effects of 'strategic factors' at a still earlier time. Or more generally, these unobservable factors cannot simply be attributed to the business unit as immutable essences, but evolve over time, and may do so partly in response to strategic factors. Ideally, we should thus control not only for economic performance at an earlier date (as a proxy for unobservable factors), but also for the other explanatory variables at a still earlier date (so as not to make the error of ignoring the possibility that economic performance at the earlier date itself may reflect the effects of strategic factors). This would imply quite complex models, giving rise to difficult questions regarding the interpretation of different kinds of coefficients.[17]

The conclusion to draw from this for our purposes here is that we should reflect carefully on the temporal relationships between the variables in our data. It is clear that our possibilities for using economic performance at an earlier date as a control variable when explaining economic performance are strictly limited. The only candidate for which there may be some justification seems to be economic performance in 1991, since many of the innovation variables and the other background variables refer to 1992 and the rest of the innovation variables to the period 1990-1992. Below we will briefly see if anything comes out of this. When it comes to using innovation variables at an earlier date as control variables, this is not possible at all with our data.

We should also think through the relationships among the different innovation variables. For instance, we would be inclined to look at the relationship between innovation expenditures (including R&D expenditures) and product and process innovations predominantly as one where expenditures influence (cause) innovations, with the reverse causal direction being of secondary importance. However, in our data the temporal relationship between these variables does not match this assumption. The measures of expenditures refer to the year 1992, while the definitions of product and process innovations refer to the period 1990-1992. The latter should rather predominantly reflect expenditures made earlier than 1992, partly perhaps considerably earlier. This raises, among other things, the issue of to what extent we may be justified here in treating variables measured at one date as proxies for the same variables measured at an earlier date.
A related question in this connection is to what extent the different innovation variables themselves may be said to reflect 'strategic' factors and to what extent they simply reflect permanent attributes of the enterprise. For instance, does having introduced product or process innovations primarily reflect choices or capabilities? When an enterprise has not introduced product or process innovations, will this typically be because this in an 'objective' sense is not profitable in the situation in

[17] Cf. the discussion in Jacobson (1990).

question, or should it rather typically be characterized as a failure to introduce otherwise profitable innovations due to lack of competence? These are complicated questions, both conceptually and empirically. How we analyse them will depend on what we take as given and permanent, what we think of as changing through processes of doing and learning, and what we think can be changed through strategic action. A decision not to innovate may from one point of view have been a rational one, but precisely because the present lack of competence of the organization has been entered as a given premise. However, to a certain extent the competence of the organization may be upgraded through strategic action. The whole issue is complicated by the fact that there are different kinds of competence, at different levels: for instance, there is not only question of the competence necessary to develop a certain new product or process, but also of the competence of discerning the opportunity and the need for the innovation in the first place.[18] The question of whether to innovate or not may not even have been asked, because one may simply not have been aware of the opportunity. Another important point is that the upgrading of competence only to a limited extent can be brought about through straightforward instrumental action in the sense of manipulating instruments which then cause the desired results to happen. Rather, a crucial component of the upgrading of competence will be processes which to a large extent have to run on their own. The strategic action here may first and foremost be to get going and try to channel self reinforcing processes, and to create conditions favourable to learning. We will not go further into the discussion of these issues here.

In our data, we get correlations between economic performance variables and innovation variables. Primarily, our perspective will be to look at the former as dependent variables, the latter as independent. However, we have limited possibility in our data to check whether this direction of causation is the most appropriate way to interpret the associations we find.[19] The associations may also express the effects of third variables not available in our data. Also, the associations may partly reflect a causal relationship in the other direction, from economic performance to innovation activity. To the extent that this latter influence is reflected in our data, opposite forces might be at work. On the one hand, good economic results may lead to more innovation, for instance through making available the economic resources needed for the effort. On the other hand, bad economic results may lead to innovation, because this may trigger an effort to make changes to improve one’s performance.

To these uncertainties regarding the correspondence between the temporal structure of our data and the kinds of causal relationships we are searching for we must add the uncertainties concerning to what extent the variables in our data actually reflect the phenomena which we are interested in. Regarding the performance variables,

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18 Cf., for instance, Bo Carlsson and Gunnar Eliasson, ‘The Nature and Importance of Economic Competence,’ *Industrial and Corporate Change*, Volume 3, Number 3, 1994, pp. 687-711, especially pp. 694-700.

19 See the discussion in Thomas D. Cook and Donald T. Campbell, *Quasi-Experimentation: Design & Analysis Issues for Field Settings*, Boston: Houghton Mifflin Company, 1979, more precisely the section entitled ‘The Causal Analysis of Concomitancies in Time Series,’ pp. 321-339, written by Melvin M. Mark. Although this section is concerned with statistical methods for making causal inferences about two variables measured as time series, i.e., it refers to a somewhat different type of data from the ones that we use here, many of the issues addressed are relevant to the problems which we discuss in the present paper.

there has been much discussion of the validity of accounting data as measures of economic performance.[20] When it comes to the innovation indicators used in the innovation studies, they have quite recently been developed, precisely for the purpose of the Community Innovation Survey of which our data constitute the Norwegian component. They are in need of being tested and refined and developed further. Indeed, one objective of the present study is to contribute to the evaluation and further development of these innovation indicator. We will discuss in more detail some of the innovation variables further below.

Given the above considerations, we cannot expect too much in the way of hypothesis testing from the present study, i.e. of testing specific, well-founded hypotheses against data which we may be reasonably confident represent reality. Rather, the present study will be predominantly *exploratory* in character. We will analyse the data in an exploratory way to see what kinds of relationships emerge, and we will focus on the interpretation of the results. Can we make sense of these relationships? This will not simply be an investigation of what the world looks like, of whether, for instance, innovative enterprises perform better than enterprises without innovations. It will also, reciprocally, be a test of the indicators which we have. To the extant that we do find relationships which we can make sense of, this will not simply tell us about how the world is, but will also strengthen our confidence that there is some validity in the indicators which we use and that we may go along and develop these further. However, should we on the contrary find little evidence of relationships which we can make sense of, this should not simply lead us to conclude, for instance, that there is no relationship between innovation and economic performance. This might be the case, of course, but this should also make us suspicious of the validity of our indicators. Is there too much measurement error, so that associations are diluted? One possible conclusion would thus be that we should concentrate more on improving indicators. Again, the main problem here might not be the indicators in themselves, but the temporal structure of the measurements. The most reasonable assumption here seems to be that there will be a substantial amount of measurement error in the data, but not so much as to completely invalidate the indicators. This should be kept in mind when one interprets the size of associations as measured by correlation coefficients or regression parameters and the like.

Given that the analysis here is exploratory, meaning that we search the data to see if any interesting relationships emerge, there is a particular danger that we capitalize on random variations here. This makes it particularly desirable to be able to replicate the investigation, to test the robustness of the results. We hope to be able to do this by performing the same type of analysis on the data from the Norwegian innovation survey of 1997, merged with the accounting data paralleling those we here have for the 1992 innovation survey, which should mean yearly accounting data for the period from 1996 and onwards. For the enterprises participating in both innovation surveys, we should also be able to merge both innovation studies with the accounting data for the whole period from 1991 and onwards. In addition to testing if we got roughly the same results for the 1997 survey as for the 1992 survey, we should be able to investigate substantially further into the temporal and causal dimension, since we would then have innovation data at two points in time as well as performance data

[20] Cf. again the discussion in Jacobson (1987). Cf. also Franklin M. Fisher, 'Accounting Data and the Economic Performance of Firms,' *Journal of Accounting and Public Policy*, 7, 1988, pp. 253-260.

for a longer time series, notably also for a considerable period before the second set of innovation data, in addition to after these data.

The question we first and foremost will explore is if innovation is associated with economic performance in our data. We will here look at performance both in terms of rates of profit, and in terms of growth of assets and sales. We will both compare enterprises with and without innovations, and we will use a number of other variables describing the innovation activity and its products more closely, including quantitative variables measuring such things as the intensity of the innovation effort. We will use both simple bivariate analyses and more complex multivariate analyses, where we also will control for such background variables as enterprise size and industry.

We will also look at the relationship between innovation and the *variation* in economic performance. An hypothesis might here be that there will be more variation in economic performance among innovative enterprises than non innovative enterprises. The reason would be an idea that innovation is risky. If one succeeds, one has a chance of performing particularly well, but there is also a risk that one fails, and then one is likely to perform particularly badly. Therefore, we would expect larger proportions both of enterprises who perform particularly well and of enterprises who perform particularly badly among innovators than among non innovators, which means that the variation in performance should be larger among the former than among the latter.

As we briefly pointed out above, the question of the performance of enterprises involves not only questions of profitability and growth, but of the very survival of the enterprises. Ideally, the question of performance should be addressed through an investigation of processes of birth, growth, transformation and death of enterprises. Even if we are not able to investigate the question of survival in a comprehensive way as part of such processes here, we may address the question of survival in a more limited way. In our data, enterprises start to drop out of the sample after 1994. By 1997, almost 10 per cent of the original enterprises have dropped out of the sample, because they no longer exist as separate statistical units. Thus, we may examine the relationship between innovation and the probability of survival in the sense of still existing as separate statistical units in 1997. It is not clear what we should expect to find here, however. Given a conviction that innovation is essential to survival and growth, the naïve hypothesis would seem to be that the probability of survival would be higher among innovating than non innovating enterprises. However, we may doubt that the time span here is long enough to detect this relationship. Furthermore, should the hypothesis of a larger variation in performance among innovators than among non innovators, innovators might have a lower probability of surviving until 1997 than non innovators even if innovators *on average* should perform better than non innovators. In short, the outcome here is uncertain.

However, there is an additional complication to consider in this connection. The continuation or discontinuation of the enterprise as a statistical unit or legal entity may not be the relevant distinction for understanding the economic processes involved. This question has been discussed by Sidney G. Winter in connection with the problem of defining the boundaries of an organization.[21] Distinguishing between survival and death depends on 'an underlying assumption identifying the "individual" whose survival is at issue.'[22] There is frequently 'ambiguity about what the individual is, and the ambiguity carries over to the definition of survival.'[23] Among the most easily handled cases is perhaps that of 'a small organization that disappears through liquidation, its members and physical assets going their various separate ways.' Even in that case, however, we may not necessarily be dealing with a business failure, an entity which has not performed well enough to survive: 'it should be recognized that liquidation may represent the voluntary termination of a successful but time-bound enterprise; the inference of a negative verdict by the environment may not be warranted.'[24] The disappearance of an enterprise through acquisition by another enterprise poses more difficult problems. Acquisition may in effect be not much different from liquidation. 'It may represent, from the acquirer's viewpoint, a cheap alternative to construction of new facilities.' On the other hand, 'it may reflect the success and maturation of an entrepreneurial start-up that reaches a point where full exploitation of its profit opportunities requires a major infusion of capital or more specific assets that the acquirer is able to provide. The acquired firm in this case may or may not survive as an identifiable entity within the acquiring organization. And if it does so survive, its operations may or may not be substantially affected by the fact that it is now part of a larger organization.' Thus, 'when the events under examination are mergers, acquisitions and divestitures of large or medium-sized firms by other large and medium-sized firms, it becomes quite problematic to discern in these events the survival, demise, or perhaps resurrection of productive organizations. All of the ambiguities noted in the case of small organizations are present in greater degree.'[25]

The implication of this is that we cannot take for granted that the enterprises who drop out of the sample because they cease to exist as separate, statistical entities are business failures, i.e. have performed so badly that they have not been able to survive. There is a wide range of other possibilities. This points to the need to investigate in more detail the enterprises who have dropped out of the sample, to actually track them down to see what happened to them.[26] However, an analysis of the data which we already have here may give us some indication as to the economic performance of the enterprises who drop out of the sample. We simply propose to compare enterprises who survive until 1997 to enterprises who have dropped out of the sample after 1994 in terms of economic performance up till 1994. Should it, for instance, turn out that enterprises who no longer exist as separate entities in 1997 generally perform substantially worse up till 1994 than those who still survive in 1997, this would seem to be consistent with an assumption that the enterprises who drop out predominantly are failures, i.e. low performers.

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[21] See Sidney G. Winter, 'Survival, Selection, and Inheritance in Evolutionary Theories of Organization,' in Jitendra V. Singh (ed.), *Organizational Evolution: New Directions*, Newbury Park: Sage Publications, 1990, pp. 269-297, especially pp. 278-281.

[22] Winter (1990), p. 278.

[23] P. 279.

[24] P. 279.

[25] P. 280.

[26] There are, in fact, plans to do just this in the course of the wider project which the present paper is a part of.

In comparing those who still survive in 1997 to those who have dropped out of the sample, there are thus two different types of issue. One is to compare them in terms of economic performance up till 1994, to get an indication as to whether an assumption that the drop-outs predominantly are business failures seems reasonable. The second is to investigate whether there is any relationship between innovation and the probability of being among the drop-outs. The interpretation of the results of the latter analysis will then depend on the results of the former.

In the following we will start by comparing the drop-outs to the survivors on these two dimensions, as a preliminary investigation to the analysis of the relationship between innovation and economic performance.

Chapter 4. Preliminary investigation: comparing enterprises who have dropped out of the sample by 1997 to those who still remain

In the original sample, there were 640 enterprises. For all these we have data from the 1993 innovation survey as well as accounting data for the period from 1991 to 1994. When later accounting data for the period 1995 to 1997 were to be added to the data set, enterprises gradually dropped out of the sample because they no longer existed as separate statistical units. For 1995, accounting data could be found for only 604 of the 640 units in the original sample, for 1996 this had been reduced to 592 units, and for 1997 to 579 units. In other words, of the 640 enterprises still existing as such in 1994, 61 or 9.5 per cent had ceased to exist in 1997.

Essential to an assessment of economic performance are not only measures of profitability and growth of enterprises, but ultimately the very survival or death of economic units. The enterprises who drop out of the sample do so because they cease to exist as separate statistical units. It might be tempting, and perhaps natural, to treat these as economic units who have failed to survive because they have not performed well enough. They should thus be the worst performers of all the enterprises. As an important component of an analysis of the relationship between innovation and economic performance it would then be interesting to examine the relationship being innovative and the probability of dropping out of the sample by 1997.

However, as we have seen above, the assumption that enterprises who cease to exist as separate statistical units are simply business failures is not necessarily true. The economic units and the activities and routines which they comprise may continue under other arrangements, maybe as highly successful economic units. Not knowing quite how to characterize in terms of economic performance the units who drop out of the sample, we would not quite know what to make of a relationship between innovation and the probability of dropping out of the sample, either.

Thus, prior to examining this latter relationship, we will try to get some indication on how to characterize the economic performance of the enterprises who drop out of the sample. We will do this simply by comparing the enterprises who drop out and the enterprises who remain in the sample in terms of their economic performance in the years before the former dropped out of the sample. More precisely, we will proceed as follows. By 1997, 597 of the original 640 enterprises still existed as separate statistical units, 61 enterprises or 9.5 per cent had ceased to exist as such. We can thus classify the original 640 units by a dichotomous variable saying whether the enterprise still existed or had ceased to exist by 1997. Let us refer to them as survivors and drop-outs, respectively. We can then correlate this dichotomous variable with different performance variables for the period 1991-94, when we still have accounting data for all the units. The dichotomous variable is coded “1” for the drop-outs (those who no longer existed in 1997), “0” for the survivors (those who still did). That is to say, we look at the probability of dropping out of the sample, rather than on the reciprocal probability of surviving in the sample.

Because the performance variables contain a small number of extreme outlier values, we have chosen to use the ordinal *Kendall's tau-b* correlation coefficient as our measure here, rather than the more familiar, parametric *Pearson's r*.

To measure economic performance, we will first use two profit rate measures. The first is *operating profit ratio* (OPR), defined as the difference between total sales and operating costs in a given year, divided by total sales. The second is *return on investment* (ROI). This is meant to measure net income against the total capital invested, and is defined as net income this year divided by total assets last year.[27] Unlike the OPR measure, the net income concept here includes financial income and costs (but excludes 'extraordinary' incomes and costs). Table 1, below, shows the correlation between the dichotomous drop-out variable and these two profit rates measures for the period 1991-1994. Note that we have no data for ROI in 1991, as this would require data on total assets for 1990.

Table 1 Correlation (tau-b) of the dichotomous drop-out variable with operating profit ratio (OPR) for 1991-1994 and return on investment (ROI) for 1992-1994. P-values in parentheses. N=640.

	OPR	ROI
1991	-0.07 (0.0364)*	
1992	-0.10 (0.0022)**	-0.06 (0.0690)
1993	-0.11 (0.0008)**	-0.05 (0.1228)
1994	-0.17 (<0.0001)**	-0.13 (<0.0001)**

We see that all coefficients are negative, which means that the higher the profit ratios, the lower the chance of having ceased to exist by 1997. For both profit measures, the association is quite clear and the coefficient highly significant for the year 1994. For the operating profit ratio variable, the coefficients are significant for all the years, increasing in absolute value every year.

We have also looked at how the drop-out variable correlates with *sales growth* and *asset growth* up to 1994. Sales growth from one year to another is simply measured as total sales in the latter year divided by total sales in the former year. Asset growth is measured in the same way, as total assets in the later year divided by total assets in the earlier year. We have looked at growth in sales and assets between all possible pairs of years in the period 1991-1994. The coefficients are reported in Table 2, below.

[27] Cf. again Jacobson (1987), p. 470.

Table 2 Correlation (tau-b) of the dichotomous drop-out variable with asset growth and sales growth between all pairs of years in the period 1991-1994. P-values in parentheses. N=640.

	Asset growth	Sales growth
1991-92	0.04 (0.2674)	0.02 (0.5135)
1991-93	0.02 (0.5130)	0.03 (0.3615)
1991-94	-0.04 (0.2361)	-0.03 (0.3389)
1992-93	-0.00 (0.9463)	0.00 (0.9718)
1992-94	-0.06 (0.0631)	-0.07 (0.0433)*
1993-94	-0.08 (0.0123)*	-0.08 (0.0112)*

Most of these coefficients are not significant at all. However, growth in sales and assets in the latter part of the period tend to be negatively correlated with the dichotomous drop-out variable. This especially applies to growth between 1993 and 1994, but also to a slightly lesser extent to growth between 1992 and 1994. This means that the higher the growth in sales and assets from 1993 (and 1992) to 1994, the lower the probability of ceasing to exist by 1997. In other words, the better the performance on these indicators, the lower the probability of dropping out.

Thus, the general impression here is that economic performance up till 1994 is related to the probability of dropping out of the sample afterwards, and in the sense that the better the economic performance, the smaller the probability of dropping out. The tendency is clearer the closer we come to 1994, the last year before enterprises start to drop out of our sample. Also, the tendency is clearer for the profit rate measures than for the sales and asset growth measures, and of the former it is clearer for the operating profit ratio measure than for the return on investment measure.

The measure which is strongest correlated of all with the dichotomous drop-out variable is thus operating profit for 1994, where *tau* is –0.17, with a p-value of less than 0.0001. Let us look more closely at this relationship.

We will here use a logistic regression model for predicting probability of dropping out of the sample at each value of operating profit ratio in 1994. However, since the distribution on the operating profit ratio variable shows the presence of a small number of extreme outlier values, some of these have been excluded from the present model, as they otherwise would have had a too high influence on the model parameters. The model thus uses only 630 observations, which means that 10 observations have been excluded (the five lowest and the five highest ranked on the operating profit ratio variable). The results are shown in Table 3 (which is a reprint of parts of the SAS output).

Table 3 Logistic regression model with the dichotomous drop-out variable (fail97) as dependent variable and operating profit ratio 1994 (copr94, where the five lowest and the five highest ranked observations have been set to missing) as independent variable. N=630.

The LOGISTIC Procedure

Response Variable FAIL97
Number of Response Levels 2
Number of Observations 630

Testing Global Null Hypothesis: BETA=0

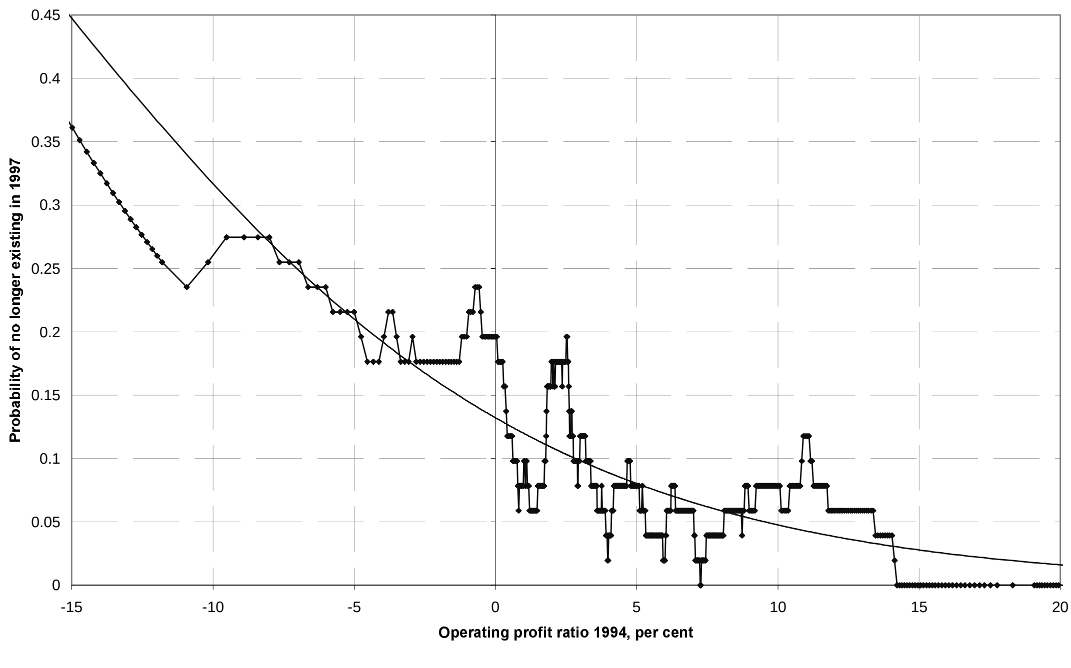
Test	Chi-Square	DF	Pr > ChiSq
Likelihood Ratio	28	1	<.0001
Score	30	1	<.0001
Wald	27	1	<.0001

Analysis of Maximum Likelihood Estimates

Parameter	DF	Estimate	Standard Error	Chi-Square	Pr > ChiSq
Intercept	1	-2	0	164	<.0001
COPR94	1	0	0	27	<.0001

We see that the coefficient for the operating profit ratio 1994 variable is negative and highly significant, which means that the higher the operating profit ratio in 1994, the lower the probability of dropping out of the sample by 1997. However, to help get a better grasp of the relationship implied here, Figure 1, below, shows graphically the probability of dropping out for each value of operating profit ratio 1994.

Figure 1 Probability of dropping out of the sample by operating profit ratio 1994, as estimated by above logistic regression model (smooth curve). Proportion of enterprises who have dropped out of the sample and mean operating profit ratio 1994 among overlapping sets of 51 observations ranked by operating profit ratio 1994 (irregular curve).

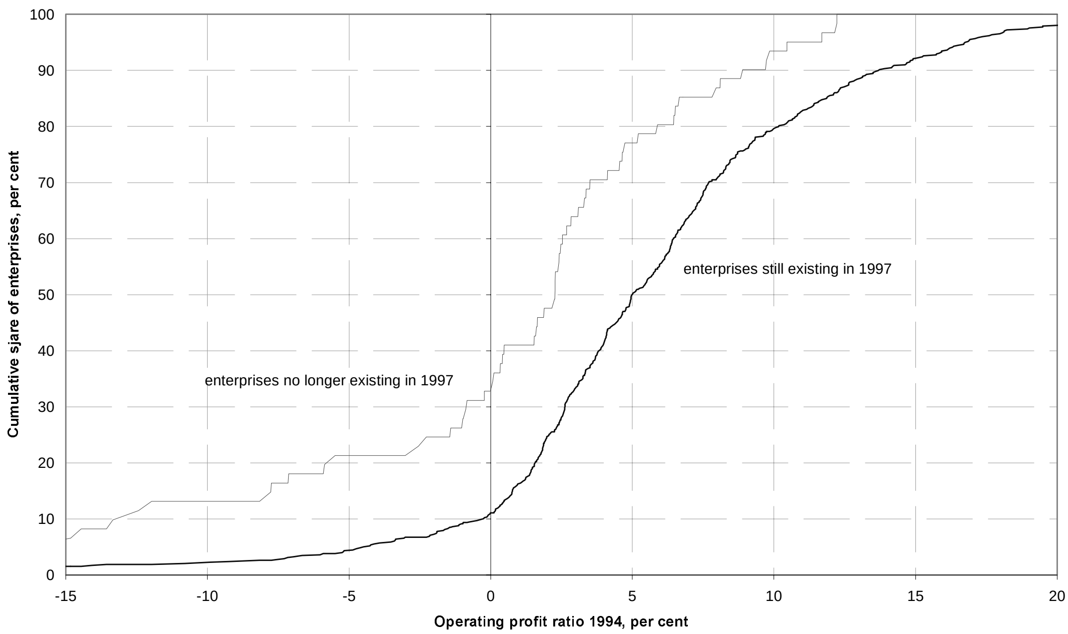


Along with the curve representing the predicted probabilities from the logistic regression model (the smooth curve), there is a second, irregular, curve which is in need of explanation. The units have been ranked according to operating profit ratio in 1994. For each unit we have then constructed a group which consists of 51 units: the unit itself, the 25 units ranked immediately above it in the classification and the 25 units ranked immediately below it in the classification. The groups are thus overlapping. For the units with less than 25 units below them in the classification, the groups consist of less than 51 units: the unit itself, the 25 units ranked immediately above it in the classification and all the units ranked below it in the classification, and vice versa for the units with less than 25 units *above* them in the classification. For each of the groups we have then calculated the mean operating profit in 1994, marked along the x-axis, and the proportion of enterprises who have dropped out of the sample, marked along the y-axis. We see that the regression line quite closely traces this more ‘empirically’ constructed curve, which should indicate that the logistic regression model represents the relationship quite well.

The above figure gives the impression of a quite clear relationship between the operating profit ratio in 1994 and the probability of dropping out of the sample by 1997. For all enterprises as a whole, the probability of dropping out is 9.5 per cent. However, for enterprises with an operating profit ratio in 1994 of –5 per cent the probability is more than 20 per cent, while for an operating profit of 10 per cent it is 5 per cent.

To fill out this picture, it may be of interest to see how the observations are distributed on the operating profit ratio variable. This is shown separately for enterprises who have dropped out and enterprises who are still in the sample by 1997 in Figure 2, below.

Figure 2 Cumulative proportion of enterprises (per cent) by operating profit ratio 1994, enterprises no longer existing in 1997 and enterprises still existing in 1997 separately.



We see that rather few of the enterprises have operating profit ratios which imply a relatively high probability of dropping out of the sample. For an operating profit ratio of –5 per cent we saw that this probability was more than 20 per cent. Figure 2 shows that only about 21 per cent of the drop-outs had an operating profit ratio in 1994 of –5 per cent or less. However, among the survivors the proportion was only about 4 per cent. Only about 11 per cent of the survivors had negative operating profit ratio in 1994, while among the drop-outs the proportion is almost one third (32.8 per cent).

There thus seems to be some justification for the assumption that the enterprises who drop out of the sample are business failures, i.e. that they do not perform well enough to be able to survive in the market. At least, for several of our performance measures, the probability of dropping out of the sample by 1997 decreases with rising economic performance. This especially applies to the two profit rates measures in 1994, but also to the operating profit ratio for 1991, 1992 and 1993, and to sales growth and asset growth from 1993 to 1994, and, to some extent, from 1992 to 1994. For none of the measures we find a statistically significant relationship in the other direction.

Having received some indication on how to characterize the enterprises who drop out of the sample in terms of economic performance, we do not, however, find any relationship between innovation and the probability of dropping out of the sample. This applies whether we use the simple dichotomy contrasting innovative and non innovative enterprises or whether we use any of the other innovation variables.

It is uncertain how we should interpret this result. The naïve conclusion is that we do not find any relationship between innovation and survival. However, the time span is probably too short for the testing of this kind of relationship. In addition, it may be that at this short time span, a better average performance among innovative enterprises than among non innovative enterprises is counterbalanced by a larger *variation* in performance among the former to produce no association between innovation and survival. Also, more complex interpretations are possible. For instance, non innovative enterprises who drop out of the sample may predominantly be economic failures who simply cease to exist, while innovative enterprises who drop out of the sample may predominantly have been acquired by other enterprises because promising ventures even though experiencing temporary financial difficulties. We have no way of investigating hypotheses of this kind here. In short, the outcome of this preliminary investigation is largely inconclusive

Chapter 5. Empirical investigation: innovation and economic performance

We will now look at the relationship between innovation and economic performance in our data. As measures of economic performance, we will use the four variables introduced above: operating profit ratio, return on investment, sales growth and asset growth.

The basic innovation variable is the dichotomy between innovative and non innovative enterprises, as defined above. Furthermore, for the innovative enterprises there are a number of variables characterizing the innovations (for instance, product or process innovations), innovation efforts (for instance, different kinds of innovation costs), innovation output (for instance, the share of sales accounted for by product innovations), etc.

We will comment on the different variables as we go along. However, we may already here note an important point. An issue which is often raised in relation to the question of whether it is rational for the individual enterprises to innovate, is the problem of the appropriability of innovation results and the possibility of free riding. The enterprise who develops an innovation may incur huge costs, but even if developing a highly successful innovation may not be able to reap the economic returns from it because it gets outperformed by other enterprises who simply imitates the innovation without having to incur costs of the same dimension as the original innovator. A fundamental distinction here consequently is a distinction between innovators and imitators. However, in our data we can only to a limited extent make a distinction between innovators and imitators, since the basic definition of innovation relates to products and processes which are new or changed from the perspective of the enterprise in question, regardless of whether they also are new to the whole market in which the enterprise operates or not. Only in some cases can we make the distinction between innovators and imitators. The most important relates to the question of the proportion of sales accounted for by product innovations. The main question here asks about the proportion of sales in 1992 accounted for by product which were new or changed in the period 1990-1992, where new or changed is defined relative to the enterprise in question. However, an additional question asks about the proportion of sales accounted for by products which were new or changed not only from the point of view of the enterprise, but also for the whole market in which the enterprise operates. We will make us of the distinction between original innovators and imitators where the data makes this possible.

As a first step in the investigation of the relationship between innovation and economic performance, we will in the following simply use the dichotomous distinction between innovative and non innovative enterprises and see if there are differences on our economic performance variables between these two groups. To find out about this, we will look at the correlation between the dichotomous innovation variable and the different performance measures. Because of a number of extreme outlier values on the performance variables, we use the ordinal *Kendall tau* *b* correlation coefficient (and not the more familiar *Pearson's r* product moment correlation coefficient).

However, we should here at the same time draw attention to a background variable in the innovation data set, namely *gross investment* (in machinery, equipment, buildings, etc.) in 1992. This variable does not specifically refer to innovation, but is likely to be correlated with innovation activity, and is certainly a candidate for explaining economic performance. It may therefore be of interest to look at the correlation not only between the dichotomous innovation variable and the different performance measures, but also between investments and performance. For the investment variable to be meaningful, investments must be related to the size of the enterprise or the activities carried out by it. We have used three different versions of the investment variable: investments (in 1992) have been expressed as a proportion of sales (in 1992), per employee (in 1992), and as a proportion of total assets (in 1992).

We first look at the correlation of the innovation variable and the three versions of the investment variable with the *operating profit ratio* (OPR), defined as total sales minus operating costs, divided by total sales, in a given year.

Table 4 Correlation (tau-b) of dichotomous innovation variable and three indicators of investments in 1992 with operating profit ratio (OPR) for the years 1991-1997.

Kendall Tau b Correlation Coefficients
Prob > |r| under H0: Rho=0
Number of Observations

	OPR91	OPR92	OPR93	OPR94	OPR95	OPR96	OPR97
INNO01	0.04058	0.08074	0.02128	0.02721	0.05323	0.03367	0.01098
	0.2094	0.0125	0.5103	0.3999	0.1097	0.3170	0.7477
	640	640	640	640	604	591	574
INVINT	0.11937	0.13045	0.08467	0.08021	0.11463	0.12181	0.06146
	<.0001	<.0001	0.0019	0.0032	<.0001	<.0001	0.0327
	637	637	637	637	601	588	571
INVEMP	0.10272	0.11981	0.06512	0.06987	0.10797	0.09330	0.04366
	0.0002	<.0001	0.0168	0.0103	0.0001	0.0010	0.1293
	637	637	637	637	601	588	571
INVCAP	0.06914	0.07626	0.03181	0.02878	0.06145	0.07122	0.01212
	0.0111	0.0051	0.2425	0.2904	0.0285	0.0120	0.6735
	637	637	637	637	601	588	571

We see that only for the year 1992 do we find any statistically significant relationship between the dichotomous innovation variable and the operating profit ratio. The relationship is a positive one: innovative enterprises tend to have higher OPR in 1992 than non-innovative enterprises. The relationship is quite weak, however.

By contrast, the investment variables show a much clearer relationship with operating profit ratio, and for most of the period for which we have data. This especially applies to the investments as a proportion of sales version. The association is almost as clear for the investment per employee version. The investment as a proportion of total assets version seems more weakly associated with OPR.

Let us concentrate on the investment as a proportion of sales version. Here the association is significant at the 5 per cent level for all the years from 1991 to 1997, and at the 1 per cent level for all the years but the last. Investments as a proportion of sales in 1992 is correlated in a highly significant way with OPR as late as in 1996.

We should note the time period to which the variables refer. The investment variable refers to investments made in 1992. The innovation variable refers to innovations (new products or processes) introduced during the three year period 1990-1992. In many cases some of the investments and activities behind these innovations will have occurred before this period. Even though the two variables are similar in that they refer to the year 1992 in the one case, the period 1990-92 in the other, they are different in other respects.

Questions of causality are complex here and it is limited what can be concluded from these correlations. We note that investments in 1992 correlate positively with the profit rate both the year before, in the same year and in the following years. We may speculate that what we see here is part of a pattern where high investments lead to high profit rates which in turn lead to high investments, etc. No such pattern is indicated for the relationship between innovation and profits. Here there only is a significantly positive relationship with the operating profit ratio in 1992, the last of the three years to which the innovation definition refers.

There might here be random year to year variation in the operating profit ratio which masks a more stable relationship between the innovation and investment variables, on the one hand, and the operating profit ratio, on the other. To get an indication of this, we have also averaged the operating profit ratio over several years in various ways and correlated these average profit ratio variables with the dichotomous innovation variable and the investment variables. The results give no indication that averaging OPR over several years make appear any relationships masked by year to year random variation.

We now turn to our second measure of profitability, *return on investment* (ROI), defined as net income this year divided by total assets last year. Consequently, here we have only data from 1992 to 1997, since *return on investment* for 1991 would require data on total assets in 1990. The correlation coefficients are shown in Table 5, below.

Table 5 Correlation (tau-b) of dichotomous innovation variable and three indicators of investments in 1992 with return on investment (ROI) for the years 1992-1997.

Kendall Tau b Correlation Coefficients
Prob > |r| under H0: Rho=0
Number of Observations

	ROI92	ROI93	ROI94	ROI95	ROI96	ROI97
INNO01	0.08127	0.00815	0.00721	0.04891	0.01447	-0.02070
	0.0119	0.8010	0.8234	0.1416	0.6677	0.5426
	640	640	640	604	589	579
INVINT	0.09622	0.02227	0.01373	0.05454	0.05328	-0.01380
	0.0004	0.4133	0.6142	0.0519	0.0607	0.6301
	637	637	637	601	586	576
INVEMP	0.10744	0.02279	0.01655	0.06322	0.02754	-0.01946
	<.0001	0.4027	0.5435	0.0243	0.3324	0.4972
	637	637	637	601	586	576
INVCAP	0.10539	0.03504	0.01796	0.05130	0.04462	-0.02125
	0.0001	0.1980	0.5094	0.0674	0.1161	0.4582
	637	637	637	601	586	576

We see that both the innovation variable and the three investment variables correlate positively with ROI in 1992, with coefficients similar to the ones we found for OPR above. However for none of the other years do we find any significant correlations between these variables. Averaging ROI over several years in different ways does not appear to change this picture.

ROI thus appears to be less associated with innovation and investment than OPR. A reason may be that ROI includes financial income and costs in the net income concept of the numerator. This may bring in too much random variation in relation to the results of productive efforts.

We now turn to *growth in sales* as a performance indicator. We here simply use sales in one year divided by sales in a previous year. In the table below 1991 is the base year: Sales in all the following years have been divided by sales in 1991. We have used nominal values and not corrected for changes in the general price level. Taking account of inflation would not have affected the ranking of the enterprises. Table 6, below, shows the tau correlation coefficients between the innovation and investment variables and sales growth. *SGR92* means growth in sales from 1991 to 1992, *SGR93* means growth in sales from 1991 to 1993, etc.

Table 6 Correlation (tau-b) of dichotomous innovation variable and three indicators of investments in 1992 with sales growth (SGR) from 1991 to each of the years 1992-1997.

Kendall Tau b Correlation Coefficients
Prob > |r| under H0: Rho=0
Number of Observations

	SGR92	SGR93	SGR94	SGR95	SGR96	SGR97
INNO01	0.02625	0.05234	0.06378	0.11276	0.07978	0.04905
	0.4168	0.1054	0.0485	0.0007	0.0177	0.1508
	640	640	640	604	591	574
INVINT	0.06498	0.07063	0.09254	0.06031	0.04650	0.03922
	0.0170	0.0095	0.0007	0.0316	0.1012	0.1729
	637	637	637	601	588	571
INVEMP	0.06782	0.06010	0.08172	0.06728	0.04766	0.03012
	0.0128	0.0273	0.0027	0.0165	0.0930	0.2954
	637	637	637	601	588	571
INVCAP	0.09231	0.08501	0.09504	0.06103	0.04803	0.03323
	0.0007	0.0018	0.0005	0.0296	0.0903	0.2481
	637	637	637	601	588	571

We see that the investment variables correlate significantly with sales growth from 1991 up to 1995, but not beyond this. We see a different, and potentially interesting, pattern for the correlation between the innovation variable and sales growth from 1991 variable. For sales growth to 1992 and 1993 we find no significant correlation with the innovation variable, and neither for sales growth to 1997. However, we do find significant coefficients for sales growth to 1994, 1995 and 1996, and in the case of 1995 the coefficient is highly significant. This may mean that we here see an effect on sales growth of introducing new products and processes which appears first after a few years and then wears off.

Lastly we turn to our fourth performance indicator, growth in total assets. Again, we have simply used total assets in one year divided by total assets in an earlier year (in nominal values). In the Table 7, below, 1991 is again used as base year, and asset growth is asset growth from 1991 to the year in question (for instance, *AG95* means asset growth from 1991 to 1995, that is, total assets in 1995 divided by total assets in 1991).

Table 7 Correlation (tau-b) of dichotomous innovation variable and three indicators of investments in 1992 with asset growth (AG) from 1991 to each of the years 1992-1997.

Kendall Tau b Correlation Coefficients
Prob > |r| under H0: Rho=0
Number of Observations

	AG92	AG93	AG94	AG95	AG96	AG97
INNO01	0.08381	0.08783	0.07566	0.09667	0.07950	0.07719
	0.0095	0.0066	0.0193	0.0037	0.0180	0.0232
	640	640	640	603	592	579
INVINT	0.18802	0.12717	0.10378	0.08377	0.08414	0.06153
	<.0001	<.0001	0.0001	0.0029	0.0030	0.0318
	637	637	637	600	589	576
INVEMP	0.17409	0.11952	0.09178	0.08896	0.08168	0.05913
	<.0001	<.0001	0.0008	0.0015	0.0040	0.0391
	637	637	637	600	589	576
INVCAP	0.17340	0.14247	0.12667	0.10696	0.10427	0.08615
	<.0001	<.0001	<.0001	0.0001	0.0002	0.0026
	637	637	637	600	589	576

All coefficients in this table are significant at the 5 per cent level. There does not seem to be much difference between the three investment measures when it comes to correlation with asset growth. For asset growth from 1991 to 1992, 1993 and 1994, correlation is higher with investment (in 1992) than with the dichotomous innovation variable (referring to the period 1990-92). In particular, the correlation between investment in 1992 and asset growth from 1991 to 1992 is higher than other correlations we have seen so far. This is not surprising, since asset growth also is a type of measure of investment. The coefficient is not particularly high, though. For asset growth from 1991 to 1995, 1996 and 1997, the correlation with the innovation variable is as high as with the investments variable.

It thus seems that we here have a consistent difference between innovative and non-innovative enterprises in performance. Using 1991 as our base year, innovative enterprises have had a higher growth of total assets than non-innovative enterprises from 1991 to every later year for which we have data, i.e. to 1992 through to 1997.

Also for the sales growth and asset growth variables we have averaged values over more than one year in various ways to see if this should bring anything new into the analysis. For instance, growth from an average of 1991 and 1992 to an average of 1996 and 1997 has been calculated and correlated with innovation and investment. Neither in this case does averaging bring anything new into the picture.

To conclude this very simple bivariate analysis, we find some, but not much, evidence that innovative enterprises perform better than non-innovative enterprises. First, concerning the two profit rate measures, we only find a significant difference between innovative and non-innovative enterprises for the year 1992, i.e. the last year of the three year period to which the definition of being innovative applies. For sales growth and asset growth we find differences in performance between innovative and non-innovative enterprises several years after the period defining the innovation variable. In the case of sales growth, we the innovative enterprises have had a higher growth rate from 1991 to both 1994, 1995 and 1996, the difference in sales growth from 1991 to 1995 in particular being highly significant. In the case of asset growth, the innovative enterprises tend to have higher growth rates from 1991 to all later years in the period for which we have data, that is through to 1997.

Multivariate analysis

We will now go on to a more detailed, multivariate analysis. For instance, a question which immediately arises when we look at the correlations above is what happens to the association between the innovation variable and the economic performance variables when we control for investment. The correlations between the dichotomous innovation variable and the three different versions of the investment variable are shown in the correlation matrix in Table 8, below.

Table 8 Correlations (tau-b) between the dichotomous innovation variable and the three indicators of investments in 1992.

Kendall Tau b Correlation Coefficients
Prob > |r| under H0: Rho=0
Number of Observations

	INNO01	INVINT	INVEMP	INVCAP
INNO01	1.00000 640	0.33179 <.0001 637	0.38226 <.0001 637	0.30321 <.0001 637
INVINT	0.33179 <.0001 637	1.00000 637	0.80670 <.0001 637	0.81311 <.0001 637
INVEMP	0.38226 <.0001 637	0.80670 <.0001 637	1.00000 637	0.75113 <.0001 637
INVCAP	0.30321 <.0001 637	0.81311 <.0001 637	0.75113 <.0001 637	1.00000 637

We see that the innovation variable is clearly correlated with the investment variables. Innovative enterprises tend quite clearly to have higher investments relative to both turnover, number of employees and total assets than non innovative enterprise, as one would expect. The three investment variables are of course strongly correlated with each other.

That investments are positively correlated with both innovation and some of the performance variables means that there is a possibility that the association we found between innovation and some of the performance variables will disappear or be weakened when we control for investment. However, as pointed out above, the question of causality is a difficult one here, so that even if we should find that the effect of innovation on economic performance disappears when we control for investment, what this means would still be an open question. One could, for instance, not automatically conclude that this indicates that innovation, as measured here, has no effect on the performance variables. One should remember here the time periods to which the variables refer. The investments variable is investments in 1992, while the dichotomous innovation variables refers to innovations introduced during the three year period 1990-1992, and they may thus be the results of activities and investments made both in this period and prior to this period.

Methodology

The analyses to follow will be made by means of ordinal logistic regression analysis with cumulative probabilities, supplemented by ordinary least squares (OLS) regression analysis to check the results. The reason for the choice of logistic regression analysis is that the economic performance variables, the dependent variables in our analysis, deviate substantially from being normally distributed. The profit ratio variables are not particularly skewed, and neither are the sales growth and assets growth variables when we use the log of their values. However, all are heavily marked by a small number of extreme outlier values which may to an unreasonable extent influence the results of analyses which are based on prediction of the mean. This is also why we used the Kendall *tau-b* correlation coefficient above instead of the more familiar parametric Pearson *r* correlation coefficient. Therefore, also, when we supplement the logistic regression analyses with ordinary least squares regression analysis to get a check on the results, the ordinary least squares regression analysis will be made with the most extreme observations on the dependent variable in question deleted.

In the following we have transformed all the dependent variables by dividing them into deciles. On each variable the observations have been ranked, and then the 10 per cent highest ranked have received the value 10, the next 10 per cent the value 9, and so on down to the value 1 for the 10 per cent lowest ranked. With the dependent variable divided into 10 values, we get 9 different dichotomies of high against low values. The ordinal logistic regression model with cumulative probabilities predicts the probability that a given observation is among the 10 per cent highest ranked (i.e. has the value 10), that it is among the 20 per cent highest ranked (i.e. has the value 9 or 10), and so on down to the probability that it is among the 90 per cent highest ranked (has a value of 2 or higher), given the assumption that the odds ratio connected with a unit increase in each independent variable is the same for all the 9 collapsings of the dependent variable into binary responses.[28] We can here also test the appropriateness of the proportional odds assumption. If the predicted values given the proportional odds assumption deviate significantly from the values predicted by a model which does not impose this assumption and thus uses more degrees of freedom, this would mean that the set of independent variables is better at predicting some dichotomized versions of the dependent variable than others. For instance, this might mean that the model predicts better the probability of being among the 20 per cent highest ranked observations than of being among the 50 per cent highest ranked observations, and perhaps not at all the probability of being among the 80 per cent highest ranked observations. This may in itself be of interest.

Also some of the independent variables we will use deviate strongly from being normally distributed. In addition to being characterized by some very extreme outlier values, they are also heavily skewed. This especially applies to the innovation cost variables, as well as to the investment variables. Therefore, we have also here divided the variables into 10 values, with roughly the same number of observation in each category. However, these variables are also marked by a large number of observations with the value 0. Consequently, these have been given the value 0 also on the new variable, and the observations with a positive value have been ranked and

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[28] Cf. Alan Agresti, *An Introduction to Categorical Data Analysis,* New York: Wiley, 1996, pp. 211-216.

divided into 10 categories. These variables thus have 11 categories, from 0 to 10. In the analyses they are treated as quantitative.

Also the employment variable is heavily skewed, of course, but here a simple log transformation seems to function well.

5.1 Operating profit ratio (OPR)

We will start by considering the operating profit ratio as the dependent economic performance variable. We saw that the dichotomous innovation variable correlated significantly with this variable only for the year 1992. We will in the following add two types of variables to the analysis. Firstly, we will see what happens to the relationship between innovation and performance when we control for other variables, i.e. variables not referring to innovation. The variables we have here are first and foremost the familiar background variables enterprise size (which we will measure by number of employees) and industry, as well as investments in 1992. We may also introduce other variables, for instance the share of turnover in 1992 accounted for by exports.

Secondly, we will introduce additional variables referring to innovation, defining for instance the intensity of the innovation effort (innovation costs, R&D expenditures, etc.), results of the innovation effort (product or process innovations, the share of sales accounted for by product innovations, etc.), R&D cooperation, objectives of the innovation efforts, sources of information, etc.

<u>Operating profit ratio 1992</u>

Let us start looking at the operating profit ratio for 1992. We saw that we here had a statistically significant positive correlation with the dichotomous innovation variable, although a weak one. This is confirmed by both the ordinal logistic regression analysis and the least squares regression analysis.

However, we saw that the investment variables also were correlated, and more strongly, with operating profit for 1992, and that there moreover was a fairly high correlation between the investment variables and innovation. Our suspicion that the effect of innovation might thus disappear or be substantially weakened when we control for investment turns indeed out to be confirmed. With both innovation and investment entered in the model, the coefficient of the parameter is reduced and is no longer statistically significant (with logistic regression, and with investments as a proportion of sales, divided into 11 values, as the investment variable, the p-value for the innovation variable becomes 0.43).

There is the question, then, of what this means. There is a clear association between investments in the year 1992 and operating profits ratio in the same year. Partly we may assume that investments in 1992 serve as a proxy for investments in earlier years, partly it is not inconceivable that investments made in one year have effects on profits already in the same year. This would support seeing high investments as a cause of higher profits. In this light one might say that the enterprises which have high investments also tend to be innovative, but given the level of investments, it does not matter for operating profits whether one is innovative or not. However, it might also be that innovative enterprises tend to have higher investments precisely because they pursue a strategy of innovation. If so, one might claim that innovation lies behind investments in the causal chain, and that the effect of innovation is mediated through higher investments. However, we also speculated above that the correlation table between investments in 1992 and operating profits in the years 1991-1997 indicated that we here had a pattern where high investments lead to high profit rates which in turn lead to high investments, etc., and it then becomes a question of how the innovation variable will fit in here. It is interesting to note here that the innovation variable correlates significantly with operating profit ratio *only* for the year 1992, while this is not the case for the investment variable. We shall not speculate more on this here, and a more thorough analysis would require time series also for the innovation data. However, we will try to go a little bit further into this below.

Enterprise size and industry

We have also introduced enterprise size and industry as control variables here to see if this brings any interesting changes to the picture. We use number of employees as our measure of enterprise size, and more specifically we find that the *log* of this variable functions better than the original variable. It also generally functions better than dividing this variable into classes. For the industry variable we have two versions, one where the enterprises are classified into 13 industries, the other into 5 industries. In the regression analyses these classifications are represented by 12 an 4 dummy variables, respectively.

We have here made two kinds of tests. We have simply controlled for these background variables in an 'ordinary' way, and we have tested for interaction effects.

Let us take the simple control first, and use the employment variable as an example. We find no significant association between employment and operating profit in 1992, and neither, when we control for investments, do we find any significant association between innovation and OPR 92. However, there is a very clear positive correlation between number of employees and the innovation variable: the larger the enterprise, the higher the probability that it is innovative. It might thus be the case that both innovation and number of employees have an effect on the operating profit ratio, but that these effects cancel each other out when we look at the two bivariate associations separately. Thus, when we hold innovation constant, we might find that profits decrease with number of employees, and when we hold number of employees constant, we might find that innovative enterprises have higher profits than non innovative enterprises. Similar effects might be found when we control for industry.

However, we in fact find no such effects neither when we control for number of employees nor when we control for industry. Indeed, neither the addition of the number of employees variable nor of either of the sets of industry dummy variables gives any significant increase in the predictive power of the model.

The second type of control for number of employees and for industry is a test of interaction effects. We have seen that adding the innovation variable to the investments variable gives no significant increase in the predictive power of the model, and neither does it when we control for industry or enterprise size. However, the lack of effect of innovation here might express a cancelling out of substantial, but different effects of innovation for different types of firms. For instance, the effect of innovation on profits might be substantially positive for large enterprises and substantially negative for small enterprises. Or the effect of innovation might be substantially positive in some industries, virtually zero in other industries, and negative in still other industries. The way to test these speculations is to add interaction variables to the model. Essentially, these are made by multiplying the independent variables in question. When controlling for number of employees, we multiply the innovation variable with the number of employees variable (of which we use the log transformation). When controlling for industry, we multiply the innovation variable with each of the industry dummy variables. Let us take as an example testing for interaction effects with the enterprises classified into 13 industries. The question is if adding to the investment variable the innovation variable plus the 12 industry dummy variables plus the 12 industry multiplied by innovation interaction variables results in a significant increase in predictive power of the model. If this is the case, we can say that innovation matters to the operating profit ratio *when we allow the effect of innovation to vary by industry*, even if we found no effect when we assumed that the effect was equal in all industries (which is the implicit assumption of running the model without industry – innovation interaction variables).

However, we in fact find no significant contribution from these interaction variables, neither for the interaction between employment and innovation nor in the case of any of the two versions of the industry classification. Thus, to sum up, we find no significant effect of the dichotomous innovation variable on operating profit ratio 1992 when we control for investments. Neither controlling for enterprise size or industry, nor including the interaction between innovation and enterprise size or innovation and industry makes any significant difference here.

Additional innovation variables

We will now introduce other innovation variables than the simple dichotomy innovative versus not innovative as independent variables to see if they can contribute to explaining the variation in operating profit ratio in 1992.

The most simple of these variables are two dichotomous variables saying whether the enterprise has had *product* innovations in the period 1990-1992 and whether it has had *process* innovations during this period. Combining these two variables we get enterprises without innovations as one category, and then among the innovative enterprises we can distinguish between those who have only product innovations, those who have only process innovations, and those who have both.

Then we have innovation cost variables, where all figures apply to 1992. These can be divided into R&D expenditures (the most familiar kind of these expenditures), expenditures on machinery and equipment in connection with product or process innovations, and also a number of other kinds of expenditures (on industrial design, training connected with the introduction of innovations, etc.). These can be expressed as a proportion of turnover, as a proportion of total assets, or per employee. Unfortunately, we do not have data on value added. We should here note both the similarity and difference between the variable expenditures on machinery and equipment in connection with product or process innovations and the investments variable we have already used. They differ in that the former is a subcategory of the latter: the former are investments in machinery and equipment etc. made in connection with innovations, while the latter *all* investments in machinery and equipment etc., irrespective or whether they refer to innovations or not.

A third type of innovation variables tries to capture the results of innovation efforts. This is the proportion of turnover in 1992 which is accounted for by product innovations, that is to say products which were introduced or changed during the period 1990-1992. There is no corresponding quantitative result measure for process innovation.

We should note here that the definition of innovation refers to products or processes which are new or changed from the point of view of the enterprise in question. It is not required that they are innovations from the point of view of the market in which the enterprise operates. The definition thus includes imitators along with the original innovators. However, in the case of product innovations we also have data which allow us to distinguish the original innovators from imitators, since the enterprises are also asked about the proportion of turnover in 1992 accounted for by products which were new or changed (during the period 1990-1992) not only from the point of view of the enterprise in question, but for the whole market.

There is also a distinction among product innovations between radical innovations and incremental innovations, i.e. between products which are new or radically changed and products which are incrementally changed. The enterprises are asked how large proportion of sales in 1992 each category accounts for. This distinction is independent of the distinction between products which are innovations from the point of view of the market and products which are innovations from the point of view of the enterprise, but not for the whole market.

These are the main variables which will be considered in the following. We will occasionally also comment on other variables.

We will here proceed in the following manner. First we will present and discuss the model which seems to fit best given our data. We will then comment on variables which do not contribute significantly to predicting the values on the dependent variable. We choose the 5 per cent significance level to distinguish between significant and not significant. We will invariably use two-tailed probabilities.

Our point of departure here is that investments as an independent variable makes a significant contribution to predicting the operating profit ratio in 1992, as we have already seen. The question then is whether the inclusion of additional variables adds significantly to the variation already accounted for by the investments variable.

We here use investments as a proportion of sales (in 1992), where the positive values are ranked and divided into 10 equal groups, with the group of enterprises without investments getting the value 0. As the dependent variable in an ordinal logistic regression we use the operating profit ratio variable for 1992 ranked and divided into 10 groups.

When this investments variable is entered as the only independent variable, we get a chi-square for the likelihood ratio of 20.5544, which is highly significant (p-value less than 0.0001). Can we then improve significantly on this fit by adding innovation variables?

It turns out that the best model we seem to find is one where four innovation variables are added to the investment variable. This model gives a chi-square for the likelihood ratio of 40.5488 with 5 degrees of freedom (p-value less than 0.0001). The addition to chi-square is here 19.9944 with 4 degrees of freedom, which is also highly significant (the p-value for the addition is 0.0005). Let us look closer at this model. The main results are reproduced in Table 9, below (which is simply a copy of parts of the SAS output).

Table 9 Results from ordinal logistic regression model with equal odds ratios, with operating profit ratio 1992 (divided into 10 categories) as dependent variable and investments, dichotomous product innovations variable, proportion of sales 1992 accounted for by product innovations, dummy for missing values on the latter variable, and machinery innovation expenditures as independent variables.

The LOGISTIC Procedure

Response Variable	OP92G10
Number of Response Levels	10
Number of Observations	637

Score Test for the Proportional Odds Assumption

Chi-Square	DF	Pr > ChiSq
48.5749	40	0.1658

Testing Global Null Hypothesis: BETA=0

Test	Chi-Square	DF	Pr > ChiSq
Likelihood Ratio	40.5488	5	<.0001
Score	38.9644	5	<.0001
Wald	39.4936	5	<.0001

Analysis of Maximum Likelihood Estimates

Parameter	DF	Estimate	Standard Error	Chi-Square	Pr > ChiSq
Intercept	1	-2.6234	0.1666	248.0042	<.0001
Intercept2	1	-1.7843	0.1388	165.1684	<.0001
Intercept3	1	-1.2151	0.1274	90.8968	<.0001
Intercept4	1	-0.7527	0.1215	38.3920	<.0001
Intercept5	1	-0.3294	0.1184	7.7365	0.0054
Intercept6	1	0.0974	0.1178	0.6829	0.4086
Intercept7	1	0.5583	0.1204	21.5183	<.0001
Intercept8	1	1.1137	0.1287	74.8591	<.0001
Intercept9	1	1.9254	0.1545	155.2321	<.0001
INV10	1	0.0662	0.0242	7.4639	0.0063
PROD	1	-0.8703	0.2565	11.5097	0.0007
NEWPROD	1	1.7449	0.4842	12.9884	0.0003
NEWPMISS	1	1.2181	0.4485	7.3773	0.0066
MACH10	1	0.0584	0.0294	3.9387	0.0472

Let us first explain the variables used.

Inv10 is the investments variable, as already defined.

Prod is the dichotomous product innovations variable, coded 1 for enterprises with product innovations and 0 for enterprises without product innovations.

Newprod is the proportion of sales 1992 accounted for by product innovations. This is the wide definition of product innovations, i.e. irrespective of whether they are new to the market or only to the enterprise, and irrespective of whether they are radical or incremental innovations. It varies from 0 for enterprises whose sales in 1992 consists only of unchanged products to 1 for enterprises whose sales are wholly accounted for by product innovations.

The variable *newpmiss* needs a more detailed explanation. Of the 193 enterprises in the sample who report product innovations during the period 1990-1992, 21 or 10.9 per cent at the same time report that the proportion of sales in 1992 accounted for by these product innovations is 0. This is not inconsistent in a logical sense. They may for instance have introduced a new or changed product in 1990, which then turned out not to be a success, so that by 1992 they had stopped selling it. However, it does not seem likely that this should apply to as much as 10 per cent of the enterprises who report product innovations. An alternative hypothesis may thus be that this 0 value is in fact a *missing* value. We have thus made a new dichotomous variable, called *newpmiss* (for 'new products missing'), where the enterprises which we believe to have a missing value on the *newprod* variable, i.e. the 21 enterprises with the value 1 on the product innovations (*prod*) variable and 0 on the *newprod* variable, have got the value 1 and all other enterprises the value 0. That the coefficient for this *newpmiss* variable is in fact very significant (significant at the 1 per cent level) supports the assumption that these 0 values are in fact missing values.

Mach10 is investments in machinery and equipment related to product or process innovations in 1992, expressed as a proportion of sales in 1992, and then grouped into 10 classes for the enterprises with positive values plus a 0 class for enterprises who report no investments in machinery and equipment connected to innovations.

We then go on to look at the coefficients.

The independent variables are correlated among themselves. Therefore, the chi-square for the contribution of the investments variable, which was about 20.5 when entered alone, is down to 7.5 when entered along with the other variables.

The machinery innovation expenditures variable in particular is quite strongly correlated with the investments variable. Thus, when the model is run without the investments variable, but with the four other variables, the machinery innovation expenditures variable is highly significant, with a chi-square of 15.8 and a p-value less than 0.0001. However, also when we control for the investments variable, the machinery innovation expenditures is significant at the 5 per cent level, although only just, with a p-value of 0.0472.

It should be noted that with a couple of alternative methods, this latter variable just fails to be significant at the 5 per cent level. Dividing the dependent variable into 4 rather than 10 groups, we get a p-value for the machinery innovation expenditures variable of 0.0576, and with an ordinary least squares regression analysis with the 10 most extreme values deleted (we thus have 627 observations left), we get a p-value of 0.0671. These are two-tailed probabilities, and one might say that we really should be using one-tailed probabilities here, since an implicit assumption here all the time is that innovation has a *positive* effect on economic performance. In that case, all these p-values would be halved, and would still be significant at the 5 per cent level. However, we should also remember that we here examine many models and then pick out the ones which give the best fit. This indicates that the actual significance level is less demanding than the nominal 5 per cent.

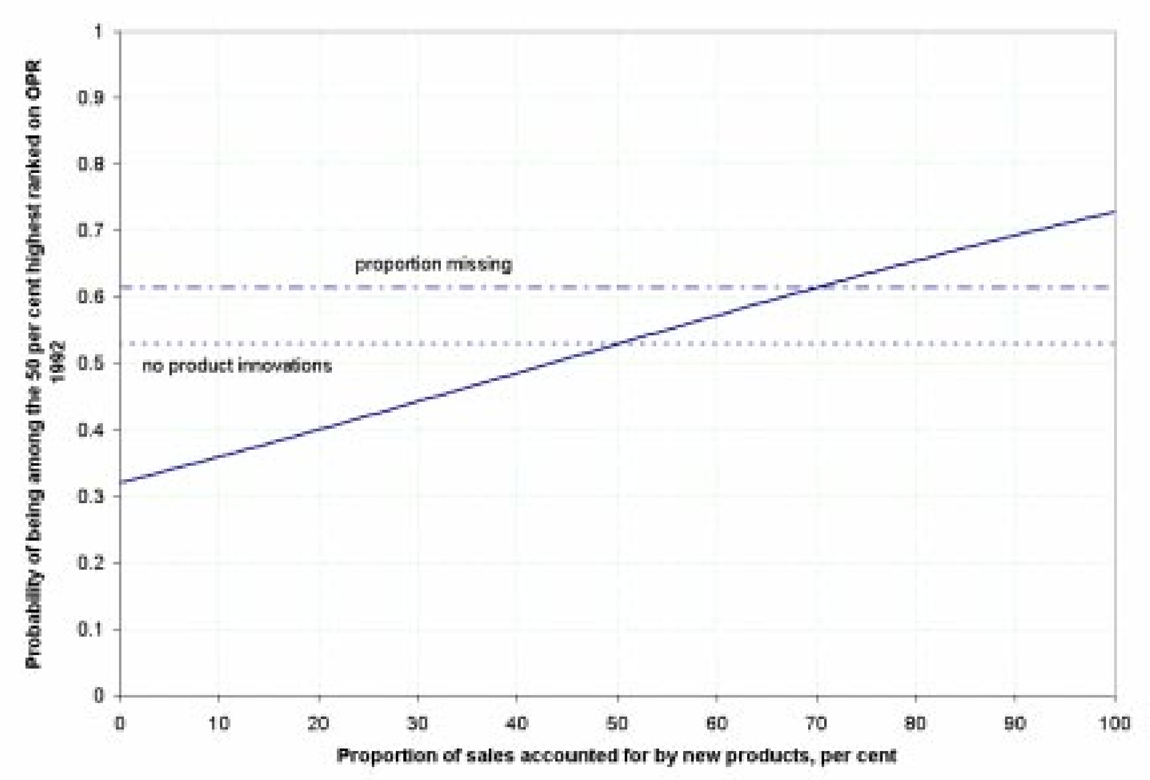
Machinery innovation expenditures is one type of innovation expenditures. Neither for innovation expenditures as a whole nor for R&D expenditures nor for innovation expenditures other than R&D and machinery do we find any significant effect on operating profit ratio in 1992. It is perhaps not wholly unreasonable that precisely for expenditures on machinery and equipment there may be a fairly quick effect in terms of improved economic performance, while especially for R&D expenditures we would expect some delay for effects in terms of improved economic performance to show up.

The most interesting coefficients in the model are perhaps the ones connected with product innovations. They must be seen together. We see that the coefficient for the dichotomous *prod* variable, distinguishing enterprises with and without product innovations, is negative, while the coefficient for the *newprod* variable, the proportion of sales accounted for by new products, is positive. This in effect means that there is a special kind of non-linearity in the relationship between the proportion of sales in 1992 accounted for by new products and operating profit ratio in 1992. Indeed, the dichotomous *prod* variable is not significant when it is entered without the quantitative *newprod* variable; adding also the *newpmiss* variable makes the effect of the dichotomous product innovations variable stand out even clearer. Conversely, neither the quantitative *newprod* variable nor the dichotomous proportion of new products missing variable are significant when entered without the dichotomous *prod* variable.

The substantive meaning of this is that enterprises with product innovations (in 1990-1992) tend to have lower operating profit ratio in 1992 than enterprises without product innovations, *unless* these product innovations are successful in the sense of accounting for a certain proportion of the sales of the enterprise in question. I.e., enterprises with product innovations, where these product innovations account for a small proportion of sales, tend to have lower operating profit ratio than enterprises without product innovations. However, among enterprises with product innovations, operating profit ratio tends to be higher the higher the proportion of sales accounted for by these product innovations.

These relationships are shown graphically in Figure 3, below, for the probability of being among the 50 per cent highest ranked enterprises on operating profit ratio 1992, i.e. of having the value 6 or higher on the 10 categories version of the operating profit ratio 1992 variable.

Figure 3 Graphical representation of results from above logistic regression model. Probability of being among the 50 per cent highest ranked enterprises on operating profit ratio in 1992, by proportion of sales 1992 accounted for by product innovations. Investments and machinery innovation expenditures held constant.



The figure shows probabilities contingent on the values of the three product innovation variables. This means that the values on the two other independent variables in the model are held constant. We have here chosen to hold the investments variable on the value 5 (which means that investments as a proportion of sales is between 2.35 per cent and 2.99 per cent) and the machinery innovation expenditures variable on the value 2 (machinery innovation expenditures as a proportion of sales are between 0.28 per cent and 0.57 per cent).

We see that given these values on the investments and machinery innovation expenditures variables, enterprises without product innovations have a probability of about 53 per cent of being among the 50 per cent highest ranked. Enterprises with product innovations, but where these account for close to 0 per cent of sales in 1992, have only a probability of 32 per cent of being among the 50 per cent highest ranked. This probability then rises steadily with increasing proportion of sales accounted for by product innovations, until it reaches almost 72.8 per cent for enterprises where product innovations account for 100 per cent of sales in 1992. For enterprises with product innovations but where the proportion of sales accounted for is (probably) missing, the probability is 61.4 per cent. This is equal to the probability we find for enterprises where product innovations account for 70 per cent of the sales in 1992. We also see that for enterprises with product innovations, these product innovations must account for 50 per cent of sales for the probability to equal the probability among enterprises without product innovations.

In exactly the same way, the model predicts the probability of being among the 10 per cent highest ranked on operating profit ratio 1992, among the 20 per cent highest ranked, etc. This is just a matter of which intercept is used (for the probability of being among the 50 per cent highest ranked, one must use intercept no. 5 in the model), since the model assumes equal odds ratios.

To sum up, we find that expenditures on machinery and equipment in relation to innovations in 1992 are significantly associated with operating profit ratio 1992, even when we control for total investments, i.e. investments regardless of whether they are connected to innovations or not. The effect of product innovations on operating profit ratio 1992 is dependent on the successfulness of these product innovations in terms of how large proportion of sales in 1992 they account for. Enterprises with product innovations, but where these account for a small proportion of sales in 1992, tend to have lower profit ratios than enterprises without product innovations. However, the larger the proportion of sales accounted for by product innovations, the higher the profit ratio tends to be.

Let us now comment on some of the variables which we find do not contribute significantly to predicting the values on the dependent variable.

The concept of product innovations operative in the variables in the present model is a concept of products which are innovations from the point of view of the enterprise in question, regardless of whether they are also innovations from the point of view of the whole market in which the enterprise operates. However, both for the dichotomous product innovations variable and for the proportion of sales accounted for by product innovations it is possible for us to distinguish between products which are innovations in this broader sense that they are innovations from the point of view of the enterprise and products which are innovations in the stricter sense of also being innovations from the point of view of the market. Adding this distinction to the model gives no significant contribution to the explanation of the dependent variable. That is to say, among enterprises with product innovations in the broader sense, we find no significant difference in operating profit ratio between enterprises who also have introduced products which are new to the market and enterprises who have not. And controlling for the proportion of sales accounted for by product innovations in the broader sense of being innovations from the point of view of the enterprise, we find no significant association between the proportion of sales accounted for by products which are innovations also from the point of view of the whole market and operating profit ratio in 1992.

The product innovation variables in the model also refer to innovations regardless of whether they are incremental (products which are incrementally changed, from the point of view of the enterprise) or whether they are radical (products which are new or radically changed, still from the point of view of the enterprise). Making this distinction makes no significant contribution to predicting the values on the dependent variable either. Operating profit ratio in 1992 varies with the proportion of sales accounted for by product innovations, but whether these are radical innovations or incremental innovations makes no difference.

We find no evidence of any effect of the dichotomous process innovations variable. There appears to be no significant differences in operating profit ratio in 1992 between enterprises with and enterprises without process innovations in 1990-1992, regardless of which other variables we control for.

Of the innovation expenditures variables, we find a significant effect on operating profit ratio 1992 only of the expenditures on machinery in connection with innovations variable. The intensity of total innovation expenditures has no significant effect, nor has R&D intensity. Furthermore, we find no significant differences in operating profit ratio 1992 between enterprises with and without *R&D cooperation*, regardless of which other variables we control for.

We find no significant effect of adding industry or enterprise size to the model.

As for interaction effects of enterprise size and/or industry with other variables, this becomes quite complex when there are many variables to interact with, as in the present model. There are many possible types of interaction here, and in the absence of any specific hypotheses as to precisely what kinds of interaction effects one would expect to find, it is difficult to know what to make of any such effects which should turn out to be significant. The possibility of finding ‘significant’ effects by chance is considerable, and ‘the more complex the interaction, the greater the danger of “over-fitting” the data.’[29] We find no indication of any interaction effects between industry and any of the product innovation variables. However, we do find some evidence of interaction between enterprise size (measured by *log* of number of employees) and the dichotomous product innovation variable (p-value of 0.03 for the addition of the enterprise size variable plus the interaction between enterprise size and product innovation variable): the larger the enterprise, the less negative the effect of having product innovations. On the other hand, there is no significant interaction between enterprise size and the proportion of sales accounted for by product innovations. Unless one expected the former kind of effect rather than the latter, one should perhaps not make much of the fact that the former actually turned out to be significant, at least not unless it turned out to be very significant. A similar remark applies to an interaction between the share of sales accounted for by exports in 1992 and the dichotomous product innovations variable, which also turned out to be just significant at the 5 per cent level.

<u>Operating profit ratio 1992: adding operating profit ratio 1991 as an independent variable</u>

Above we discussed the possibility that an association between innovation and economic performance might express the effect on both variables of unobserved third variables connected to the specific business units: the association might for instance express the fact that a well-managed, efficient enterprise both tends to be innovative and show good results, rather than an effect of innovation on performance. Specifically, we discussed Robert Jacobson’s argument that one should use lagged measurements of the dependent variable to control for such unobservable factors. We noted that we had little opportunity for doing this with our data, but that there was

[29] James Jaccard, Robert Turrisi and Choi K. Wan, *Interaction Effects in Multiple Regression*, Sage University Paper series on Quantitative Applications in the Social Sciences, 07-072, Newbury Park: Sage Publications, 1990, p. 65.

some justification for using operating profit ratio in 1991 as a control variable when explaining operating profit ratio in later years, since this variable may be said at least partly to refer to a date prior to the measurements for the innovation variables.

The results of entering operating profit ratio in 1991 as a control variable when explaining operating profit ratio in 1992 are quite interesting. The model we end up with is presented in Table 10, below.

Table 10 Results from ordinal logistic regression model with equal odds ratios, with operating profit ratio 1992 (divided into 10 categories) as dependent variable and operating profit ratio 1991, dichotomous product innovations variable, proportion of sales 1992 accounted for by product innovations, dummy for missing values on the latter variable, and machinery innovation expenditures as independent variables.

The LOGISTIC Procedure

Response Variable	OP92G10
Number of Response Levels	10
Number of Observations	640

Score Test for the Proportional Odds Assumption

Chi-Square	DF	Pr > ChiSq
49.5634	40	0.1429

Testing Global Null Hypothesis: BETA=0

Test	Chi-Square	DF	Pr > ChiSq
Likelihood Ratio	216.9786	5	<.0001
Score	179.6121	5	<.0001
Wald	202.1014	5	<.0001

Analysis of Maximum Likelihood Estimates

Parameter	DF	Estimate	Standard Error	Chi-Square	Pr > ChiSq
Intercept	1	-4.8240	0.2459	384.7822	<.0001
Intercept2	1	-3.8750	0.2194	311.9312	<.0001
Intercept3	1	-3.2195	0.2042	248.6581	<.0001
Intercept4	1	-2.6749	0.1924	193.3815	<.0001
Intercept5	1	-2.1649	0.1822	141.1771	<.0001
Intercept6	1	-1.6544	0.1736	90.8003	<.0001
Intercept7	1	-1.1032	0.1673	43.5047	<.0001
Intercept8	1	-0.4475	0.1656	7.3013	0.0069
Intercept9	1	0.4882	0.1801	7.3484	0.0067
OP91G10	1	0.3719	0.0277	180.4604	<.0001
PROD	1	-0.7172	0.2579	7.7346	0.0054
NEWPROD	1	1.3837	0.4851	8.1346	0.0043
NEWPMISS	1	0.6286	0.4512	1.9409	0.1636
MACH10	1	0.0752	0.0253	8.8461	0.0029

Due to the presence of a few extreme outlier values, we choose to divide also the operating profit ratio 1991 variable into 10 categories. We treat this variable as a quantitative variable. That the coefficient for this variable is extremely significant is to be expected, since the correlation between operating profit ratio in 1991 and 1992 of course is a high one. It is entered here first and foremost as a control variable.

The first thing to notice here is that the investments variable (*inv10)* is not included in the above model, but that the machinery innovation expenditures variable (*mach10*) is. These two variables are of course quite strongly correlated, but when both are entered in the model together with operating profit ratio 1991 and the three product innovations variables, the machinery innovation expenditures variable is significant at the 5 per cent level (p-value 0.0369), while the ordinary investment variable is not significant at all (p-value 0.39).

We also in essence find intact the effect of the three product innovation variables, although somewhat weakened. We see that the dummy for proportion of new products missing (*newpmiss*) is not in itself significant, and it may be a question of whether it should be kept in the model. However, we have chosen to see the three product innovation variables as logically belonging together here, and the presence of the proportion missing variable makes the two other variables more significant. The three product innovation variables as a whole are significant at the 5 per cent level (p-value 0.0251).

Thus, controlling for operating profit ratio in 1991 when trying to account for operating profit ratio in 1992 does not make the effects of the innovation variables disappear. Rather, this is what happens to the 'ordinary' investments variable, that is, investments without regard to whether they have anything to do with innovations or not. In contrast, the innovative investments variable appears *more* significant when we control for operating profit ratio in 1991. Also, the set of effects of the three product innovation variables, although somewhat weakened, is basically intact. This gives an indication that we here are dealing with a genuine effect of innovation on operating profit ratio, not just a spurious relationship which may wholly be accounted for by unobservable attributes of the business units.

<u>Operating profit ratio 1993</u>

After 1992, the effect of the innovation variables on operating profit ratio quickly disappears.

For operating profit 1993 the investments in machinery and equipment in relation to innovations variable does not contribute significantly, over and above the 'ordinary' investments variable. The three product innovations variables (the dichotomous variable, the proportion of sales accounted for by product innovations, and the proportion missing variables) together are significant at the 10 per cent level, but not at the 5 per cent level, while for operating profit ratio 1992 they were significant at the 1 per cent level. Apart from this, we find the same pattern of relationship as for operating profit 1992: the dichotomous variable is negative, the quantitative proportion product innovations is positive, and the dichotomous proportion missing variable is also positive.

If we control for operating profit 1991, the two main product innovation variables are still significant at the 10 per cent level, but the proportion missing variable here contributes virtually nothing. The investments variable is now not significant at all, as when we controlled for operating profit 1991 when explaining operating profit 1992.

Controlling for enterprise size or industry changes nothing to this picture. Neither do we find any strong evidence of interaction effects between the innovation variables and the background variables on operating profit 1993.

Operating profit ratio after 1993

For operating profit after 1993, that is between 1994 and 1997, we find no evidence of effects of any innovation variables. This also holds when we control for industry or enterprise size, and when we allow the effect of innovation variables to vary with enterprise size or industry, i.e. when we control for interaction effects. It is true that a couple of times we do get interaction effects which are just significant at the 5 per cent level, but not in any consistent way, so this is just what we would expect to happen by chance when we test many different interaction effects.

Summary

Using innovation variables referring partly to the year 1992, partly to the three year period 1990-1992, as well as investments and some other background variables referring to 1992, we find some quite clear and highly significant effects of the innovation variables on operating profit ratio for 1992. However, these effects do not last much longer than 1992. For operating profit 1993 we still partly find them, but no substantially weaker and significant at the 10 per cent level only. For operating profit 1994 and later, we find no effect of the innovation variables from 1990 to 1992. Controlling for enterprise size or industry and for the interaction of these background variables with the innovation variables does not change this picture.

5.2 Return on investment (ROI)

The second profitability measure we have looked at is *return on investment* (ROI), defined as net income this year divided by total assets last year, where net income here includes financial income and costs in addition to sales and operating costs. Basically, we find the same relationships here as we found for the operating profit ratio, but there are also differences.

The basic similarities is that we find a very clear positive relationship between innovation and profit ratio for the first year (1992), but this relationship quickly weakens and then disappears as we move to later years. Furthermore, also here we find that economic performance is positively related to the proportion of sales accounted for by product innovations. However, while also here statistically significant at the 5 per cent level for *return on investment* in 1992, the effect is smaller and less significant than the corresponding effect in the case of *operating profit ratio*.

Let us now briefly look at the relationships in more detail.

Return on investment 1992

For operating profit ratio in 1992 we found that, in addition to the investments variable, a set of three variables relating to product innovations were highly significant. The dichotomous product innovations variable, saying whether the enterprise had as opposed to had not product innovations, was negative. The quantitative proportion of sales accounted for by product innovations was positive and highly significant, and also a variable indicating whether the enterprise both had product innovations and had failed to report the proportion of sales accounted for by the product innovations, was positive and clearly significant. In addition, the intensity of expenditures on machinery and equipment in relation to innovation was positive and significant at the 5 per cent level.

For return on investment 1992 we do not find any significant effect of expenditures on machinery and equipment in relation to innovation. However, the other significant effects from the operating profit ratio analysis we find in essence also here. The 'ordinary' investments variable, investments in machinery and equipment without regard to whether they relate to innovation activity or not, is significant and positive also here. Here we express investments as a proportion of total assets.

Furthermore, we basically find the same type of effect of product innovations, where simply having product innovations has a negative effect (the dichotomous product innovations variable is negative), but once one has product innovations, return on investment tends to grow with increasing proportion of sales accounted for by these product innovations (the quantitative proportion product innovations in sales is positive). However, the coefficients for the product innovations variables are smaller and less significant than in the operating profit ratio case, and the proportion missing variable is not significant here.

In addition, for return on investments 1992 we find that the dichotomous variable saying whether the enterprise has *process* innovations or not, is clearly significant and *positive*. Thus, the dichotomous product innovation variable is negative and the dichotomous process innovations variable is negative. We then made a new dichotomous variable indicating whether the enterprise had process innovations *only*. It has the value '1' if the enterprise has process innovations, but *not* product innovations, and the value '0' if it has neither product nor process innovations, if it has product innovations but not process innovations, or if it has *both* types of innovation. It turns out that entering this new process only variable makes the two other dichotomous innovation variables far from significant, and that this new variable *alone* accounts for more of log likelihood variance than the dichotomous product innovations and process innovations variables did together. It is this process innovations only variable which is entered in the model we end up with, the two other dichotomous innovation variables are excluded.

In addition, and unlike the operating profit ratio case, the export intensity variable (proportion of sales in 1992 made up by exports) is significant, and negative.

The results of the model are reproduced in the table below.

Table 11Results from ordinal logistic regression model with equal odds ratios, with return on investment 1992 (divided into 10 categories) as dependent variable and investments, dichotomous process innovations only variable, proportion of sales 1992 accounted for by product innovations, and export intensity as independent variables.

The LOGISTIC Procedure

Response Variable	RO92G10
Number of Response Levels	10
Number of Observations	637

Score Test for the Proportional Odds Assumption

Chi-Square	DF	Pr > ChiSq
30.2234	32	0.5566

Testing Global Null Hypothesis: BETA=0

Test	Chi-Square	DF	Pr > ChiSq
Likelihood Ratio	35.3961	4	<.0001
Score	34.7868	4	<.0001
Wald	34.5572	4	<.0001

Analysis of Maximum Likelihood Estimates

Parameter	DF	Estimate	Standard Error	Chi-Square	Pr > ChiSq
Intercept	1	-2.5248	0.1668	229.2280	<.0001
Intercept2	1	-1.6947	0.1399	146.7799	<.0001
Intercept3	1	-1.1342	0.1292	77.0259	<.0001
Intercept4	1	-0.6802	0.1239	30.1530	<.0001
Intercept5	1	-0.2641	0.1213	4.7395	0.0295
Intercept6	1	0.1607	0.1210	1.7633	0.1842
Intercept7	1	0.6242	0.1238	25.4250	<.0001
Intercept8	1	1.1839	0.1322	80.1658	<.0001
Intercept9	1	2.0178	0.1585	162.1443	<.0001
INVC10	1	0.0522	0.0211	6.1404	0.0132
PCONLY	1	0.7872	0.2193	12.8850	0.0003
NEWPROD	1	0.7958	0.3265	5.9410	0.0148
EXPINT	1	-0.7282	0.2406	9.1570	0.0025

Here *invc10* is investments in machinery and equipment as a proportion of total assets, *pconly* is the dichotomous process only variable, *newprod* is the proportion of sales accounted for by product innovations, and *expint* is the proportion of sales accounted for by exports.

Here the exports intensity variable is negative. Having a clear positive correlation with the proportion of product innovations in sales, it is more strongly negative when entered together with than without this variable. Conversely, including export intensity makes proportion of product innovations in sales more strongly positive than when export intensity is excluded.

Return on investment 1993

Basically, we find the same relationships for return on investment in 1993, and, unlike in the operating profit ratio 1993 case, the innovation variables are significant at the 5 per cent level.

Also unlike the operating profit ratio case, the investments variable is no longer significant. As we saw above, for operating profit ratio investments in 1992 correlated significantly with this performance measure all the years from 1992 up until 1997. For return on investment we found a significant correlation with investments in 1992 only for 1992, but not for later years.

Another point is that while the proportion of sales accounted for by product innovations variable is significant at the 5 per cent level, the variable measuring the proportion of sales accounted for by product innovations which are innovations from the point of view of the enterprise *but not from the point of view of the market*, contributes even more to explained log likelihood variance and is consequently even more significant. In other words, this variable considers only those innovations which are imitations or copies of products already introduces by other enterprises, and not those which the enterprise in question is the first to introduce. We have decided to use this more significant variable our model, the results of which are shown in the table below.

Table 12 Results from ordinal logistic regression model with equal odds ratios, with return on investment 1993 (divided into 10 categories) as dependent variable and dichotomous process innovations only variable, proportion of sales 1992 product innovations from the point of view of the enterprise but not also of the market, and export intensity as independent variables.

The LOGISTIC Procedure

Response Variable	RO93G10
Number of Response Levels	10
Number of Observations	640

Score Test for the Proportional Odds Assumption

Chi-Square	DF	Pr > ChiSq
22.7631	24	0.5338

Testing Global Null Hypothesis: BETA=0

Test	Chi-Square	DF	Pr > ChiSq
Likelihood Ratio	16.8551	3	0.0008
Score	15.8180	3	0.0012
Wald	17.6168	3	0.0005

Analysis of Maximum Likelihood Estimates

Parameter	DF	Estimate	Standard Error	Chi-Square	Pr > ChiSq
Intercept	1	-2.2036	0.1443	233.1652	<.0001
Intercept2	1	-1.3856	0.1146	146.2614	<.0001
Intercept3	1	-0.8389	0.1036	65.5395	<.0001
Intercept4	1	-0.3886	0.0989	15.4356	<.0001
Intercept5	1	0.0257	0.0977	0.0692	0.7924
Intercept6	1	0.4398	0.0992	19.6358	<.0001
Intercept7	1	0.8919	0.1043	73.1391	<.0001
Intercept8	1	1.4402	0.1155	155.4816	<.0001
Intercept9	1	2.2578	0.1452	241.6989	<.0001
PCONLY	1	0.3780	0.2081	3.2992	0.0693
IMITP	1	1.1528	0.4252	7.3526	0.0067
EXPINT	1	-0.8107	0.2373	11.6716	0.0006

Here *imitp* is the proportion of sales accounted for by product innovations which are imitations of products already introduced by other enterprises.

We see that the whole model is significant at a p-level less than 0.001. The innovation variables are not significant alone, but when entered together with the export intensity variable, their contribution is significant almost at the 1 per cent level, with a p-value of 0.0106.

Return on investment after 1993

For return on investment after 1993, we no longer find clear evidence of any effect of our innovation variables. For return on investment in 1995, we find that the intensity of total innovation expenditures, when entered together with export intensity, is positive and significant on the 5 per cent level, but this is no longer the case when we control for industries. Then the p-level rises to 0.1121. Also for return on investment in 1996 and 1997 this innovation cost variable is positive with a p-value of about 0.12 – 0.13 when we control for industry. This is too occasional and too weak to make much of.

Interaction of innovation variables with industry and enterprise size

Again we have tested quite extensively the hypothesis that the effect of innovation variables varies with industry or enterprise size. We find no evidence of this. Occasionally there occurs an interaction effect with a p-value of less than 0.05, but there is nothing to suggest that this expresses anything more than random variation.

5.3 Asset growth

Above we have looked at the relationship between innovation and two measures of profitability, operating profit ratio and return on investment. We have seen that any effect of innovation and innovation activity as measured partly for the year 1992, partly for the three year period 1990-1992, quite quickly vanishes. We find some highly significant effects on both performance measures for the year 1992, but then little or nothing for later years.

However, for growth of total assets we have reason to believe that the picture is different. We saw above that the dichotomous innovation variable correlates positively and significantly with asset growth from 1991 to every later year for which we have data, i.e. up to 1997. We will now look more closely at the relationship between innovation and asset growth by means of multivariate logistic regression analysis, to see what happens when we bring in other variables. For instance, we saw that investment is correlated with both asset growth and innovation, and there is thus again the possibility that the effect of innovation will turn out to be not significant when we control for investment. Furthermore, we will also here introduce other innovation variables.

In the following, we will look first look at asset growth from 1991 to 1992, then from 1991 to 1995, and lastly from 1991 to 1997.

As our investments indicator we will here use investments as a proportion of total assets. This seems the most logical version here, as we are precisely examining the growth of total assets. Furthermore, of the three investments indicators, this is also the one which correlates most strongly with growth of total assets for five of the six years, the exception being asset growth from 1991 to 1992. Of the three investments indicators, this should thus be the one which exposes the hypothesis of an effect of innovation on asset growth to the most difficult test, so to speak.

Growth of total assets from 1991 to 1992

As Table 7, above, shows, the dichotomous innovation variable is positively correlated with asset growth from 1991 to 1992, a relationship which is significant at the 1 per cent level. This means that there is a tendency for innovative enterprises to have higher growth in total assets from 1991 to 1992 than non innovative enterprises. However, the same table also shows that the investments variable is much more strongly correlated with asset growth from 1991 to 1992, and since investments also is positively correlated with innovation, there is a possibility that the association between innovation and asset growth will disappear when we control for investments.

This also turns out to be the case. We again here use ordinal logistic regression with cumulative probabilities, assuming equal odds ratios. As explained above, the dependent variable is the asset growth from 1991 to 1992 variable, ranked and divided into 10 groups with an approximately equal number of observations in each. In the same way the investments variable has been divided into 10 categories, with an additional category with the value 0 for the units with the value 0 on the investments variable. When used as an independent variable, this variable is treated as quantitative. When we here use both investments and the dichotomous innovation variable to predict asset growth from 1991 to 1992, the coefficient for the innovation variable becomes practically 0 (the p-value is 0.82).

We have then tried other variables as independent variables, both innovation variables and other control variables, to see if we can significantly improve the predictive power of the model over and above what we get with only investments as independent variable. The model we found to be best in the sense of giving the highest chi-square for the likelihood ratio while only including variables which are significant at the 5 per cent level is shown in Table 13, below.

Table 13 Results from ordinal logistic regression model with equal odds ratios, with growth of total assets from 1991 to 1992 (divided into 10 categories) as dependent variable and investments in 1992 (as a proportion of total assets), proportion of sales in 1992 accounted for by exports, total innovation expenditures per employee in 1992, dichotomous product innovations variable, and proportion of sales in 1992 accounted for by products which are new to the market as independent variables (N=637).

The LOGISTIC Procedure

Response Variable	AG92G10
Number of Response Levels	10
Number of Observations	637

Score Test for the Proportional Odds Assumption

Chi-Square	DF	Pr > ChiSq
42.3097	40	0.3716

Testing Global Null Hypothesis: BETA=0

Test	Chi-Square	DF	Pr > ChiSq
Likelihood Ratio	79.8339	5	<.0001
Score	73.8252	5	<.0001
Wald	75.4863	5	<.0001

Analysis of Maximum Likelihood Estimates

Parameter	DF	Estimate	Standard Error	Chi-Square	Pr > ChiSq
Intercept	1	-2.7440	0.1736	249.7493	<.0001
Intercept2	1	-1.8665	0.1449	165.9862	<.0001
Intercept3	1	-1.2783	0.1330	92.4095	<.0001
Intercept4	1	-0.7871	0.1265	38.7298	<.0001
Intercept5	1	-0.3497	0.1232	8.0573	0.0045
Intercept6	1	0.0898	0.1225	0.5378	0.4633
Intercept7	1	0.5643	0.1250	20.3822	<.0001
Intercept8	1	1.1246	0.1331	71.3796	<.0001
Intercept9	1	1.9632	0.1588	152.8363	<.0001
INVC10	1	0.1024	0.0224	20.9437	<.0001
EXPINT	1	-0.8104	0.2446	10.9745	0.0009
COEMP10	1	0.1130	0.0311	13.2052	0.0003
PROD	1	-0.7936	0.2161	13.4884	0.0002
NEWMARK	1	2.5114	0.6972	12.9753	0.0003

Let us first explain the variables.

Invc10 is investments as a proportion of total assets in 1992, divided into 11 categories, as explained above.

Expint is the proportion of sales in 1992 accounted for by exports, varying between 0 and 1.

Coemp10 is total innovation expenditures (including R&D, expenditures on machinery and equipment in relation to innovation, and other innovation expenditures), divided into 10 categories plus a 0 category, in the same way as for the investments variable.

Prod is the dichotomous product innovation variable, which we discussed when examining the determinants of the operating profit ratio, above.

Newmark is the proportion of sales accounted for by product innovations which are innovations not only from the perspective of the enterprise in question, but for the whole market in which the enterprise operates.

We will next comment on the model. We see that all coefficient are highly significant. None have p-values above 0.001.

The investments variable is the single variable which contributes most to the model. This is not surprising.

The coefficient of the exports variable (expint) is negative. This means that the higher the share of sales in 1992 accounted for by exports, the lower the growth of total assets from 1991 to 1992. At the same time, this variable is positively correlated with the other variables in the model, and especially with the three innovation variables. Thus, when entered alone, the coefficient for this variable is less negative and less significant than when we control for the other variables. Holding the other variables constant, the effect of the exports variable is quite negative, but since there is a tendency for innovation activity in general to rise with the proportion of exports in sales, and since the innovation variables mostly tend to be positively associated with growth in assets, the bivariate relationship between the proportion of sales accounted for by exports and asset growth is less negative.

Asset growth from 1991 to 1992 is also positively associated with the intensity of total innovation expenditures, here measured against the number of employees (*coemp10*). When we looked at operating profit ratio for 1992, we found that what mattered were the innovation expenditures on machinery and equipment, not total innovation expenditures. The intensity of innovation expenditures on machinery and equipment is, of course, highly correlated with the intensity of total innovation expenditures, and both are correlated with the ‘ordinary’ investment intensity. Thus, when machinery innovation expenditures intensity is entered in the model without the total innovation expenditures variable, but with the ordinary investments variable, it is significant at the 1 per cent level. However, when also total innovation expenditures intensity is entered, it is not significant at all, while the total innovation variable is. The same argument as for machinery innovation expenditures intensity applies to R&D intensity and to the intensity of the residual category of innovation expenditures (design, training connected to the development of innovations, etc.). Thus, in the case of asset growth from 1991 to 1992, it is total innovation expenditures which counts, irrespective of whether they are expenditures on machinery or R&D or other kinds of innovation expenditures.

Lastly, we basically find the same kind of structure for the effect of the product innovation variables as we found when we discussed operating profit ratio 1992. As pointed out in that discussion, this is in fact a special kind of non-linear relationship between product innovations and the performance variable. Having product innovations in itself, so to speak, i.e. when these product innovations are not successful as measured by the proportion of sales which they account for, tends to lower asset growth from 1991 to 1992. However, the higher the proportion of sales the product innovations account for, the higher the growth of assets from 1991 to 1992, so that for at a certain proportion of sales accounted for by product innovations, predicted asset growth again equals that for enterprises without product innovations. For this model, this happens for a proportion of sales accounted for by product innovations of about 32 per cent (0.7936 divided by 2.5114). For proportions above this, enterprises with product innovations have higher predicted asset growth than enterprises without product innovations.

An important difference from the operating profit ratio 1992 case, however, is that for the growth of assets from 1991 to 1992 it is the proportion of proportion of sales accounted for by products which are innovations not only from the point of view of the enterprise itself, but also for the whole market which matters. These two variables are substantially correlated, of course. When entered without the proportion new to the market variable (*newmark*), the proportion new to the enterprise variable (*newprod*) also contributes significantly, but less than when the former variable is used. When both are entered together, however, the latter variable is no longer significant, but the former is. If we divide the proportion new to the enterprise variable into the proportion new to the market variable and a proportion new only to the enterprise (but not to the market) variable, this result is equivalent to finding that the new to the market variable contributes significantly, but not the new only to the enterprise variable.

An additional, but less important difference from the operating profit ratio case is that in the present case the dummy variable for missing value on the proportion of new products in sales variable is not at all significant.

Thus, even when we control for investments, innovation variables have highly significant effects on the growth of total assets from 1991 to 1992. Both the intensity of innovation expenditures and the success of product innovations as measured by the proportion of sales in 1992 which these account for are positively and highly significantly related to asset growth, also when each is controlled for the other. It is interesting that what is important regarding the latter is the proportion of sales accounted for by products which are innovations also from the point of view of the whole market rather than simply from the point of view of the individual enterprise. Thus, performing well here seems to be related to succeeding with genuine innovations rather than with simply imitating products developed by others.

Growth of total assets from 1991 to 1995

We will now examine growth in total assets from 1991 to 1995. Again we start by referring to Table 7, above, where we found that both the dichotomous innovation variable and the investments variable are correlated with asset growth from 1991 to 1995, and the size of the coefficients are about the same (0.10 and 0.11, respectively, both significant at the 1 per cent level). When we control for investments by enter both innovation and investments in a logistic regression model, the coefficient for the innovation variable is thus reduced compared to the bivariate case, and just fails to be significant at the 5 per cent level.

However, when we also control for size of enterprise, as measured by *log* of number of employees, the coefficient for the innovation variable rises again and becomes once more significant at the 1 per cent level. This is further strengthened if we also include the proportion of sales accounted for by exports variable. The p-value for the innovation variable then goes down to 0.002.

Thus, when we also take account of size of enterprise and of exports, the dichotomous innovation variable has a highly significant effect on asset growth from 1991 to 1995, even when we control for investments.

However, when we introduce also other innovation variables, more precisely, the proportion of sales accounted for by product innovations and, especially, the intensity of innovation expenditures, the dichotomous innovation variable becomes not at all significant. These other innovation variables are of course highly correlated with the dichotomous innovation variable. This means that what counts here is innovation expenditures and the success of product innovations in the sense of how large proportion of sales in 1992 they account for, not simply being innovative in the sense of having introduced some product or process innovation in the period 1990-1992. In other words, innovative enterprises with no innovation expenditures and no product innovations do not differ significantly from non innovative enterprises in terms of asset growth from 1991 to 1995.

Proceeding in the same manner as for the growth of total assets from 1991 to 1992, above, the best model we find for the growth of total assets from 1991 to 1995 is the one presented in Table 14, below.

Table 14 Results from ordinal logistic regression model with equal odds ratios, with growth of total assets from 1991 to 1995 (divided into 10 categories) as dependent variable and investments in 1992 (as a proportion of total assets), proportion of sales in 1992 accounted for by exports, log *of number of employees in 1992, total innovation expenditures per employee in 1992, and proportion of sales in 1992 accounted for by products which are new to the market as independent variables (N=600).*

The LOGISTIC Procedure

Response Variable	AG95G10
Number of Response Levels	10
Number of Observations	600

Score Test for the Proportional Odds Assumption

Chi-Square	DF	Pr > ChiSq
50.8493	40	0.1168

Testing Global Null Hypothesis: BETA=0

Test	Chi-Square	DF	Pr > ChiSq
Likelihood Ratio	53.9645	5	<.0001
Score	50.2694	5	<.0001
Wald	52.3969	5	<.0001

Analysis of Maximum Likelihood Estimates

Parameter	DF	Estimate	Standard Error	Chi-Square	Pr > ChiSq
Intercept	1	-2.2724	0.2360	92.7486	<.0001
Intercept2	1	-1.4399	0.2175	43.8407	<.0001
Intercept3	1	-0.8642	0.2110	16.7669	<.0001
Intercept4	1	-0.3760	0.2083	3.2570	0.0711
Intercept5	1	0.0556	0.2077	0.0718	0.7888
Intercept6	1	0.4702	0.2085	5.0884	0.0241
Intercept7	1	0.9338	0.2111	19.5727	<.0001
Intercept8	1	1.4958	0.2173	47.4067	<.0001
Intercept9	1	2.3143	0.2352	96.8514	<.0001
INVC10	1	0.0608	0.0229	7.0512	0.0079
EXPINT	1	-0.6914	0.2670	6.7078	0.0096
LOGEMP	1	-0.1195	0.0584	4.1885	0.0407
COEMP10	1	0.0840	0.0266	9.9292	0.0016
NEWMARK	1	2.2090	0.7145	9.5573	0.0020

Compared to the previous model (for asset growth from 1991 to 1992), only the *logemp* variable is new here. It stands for the *log* of number of employees.

The first thing to note here is that we no longer find the special non linear relationship between the proportion of sales accounted for by product innovations and economic performance. The dichotomous product innovations variable is here not significant, and, indeed, is very far from being significant. This means that enterprises with product innovations, but where these account for a low proportion of sales in 1992, do *not* have a significantly lower growth of total assets from 1991 to 1995 than enterprises without product innovations. Instead, enterprises where product innovations account for a very small proportion of sales do not differ significantly from enterprises without product innovations here.

Second, the enterprise size variable, as measured by number of employees (*logemp*), only becomes significant when we control for other variables in the model. For the bivariate relationship between number of employees and asset growth from 1991 to 1995, we find no significant correlation. However, number of employees is positively, and substantially, correlated with all the other variables in the model. Holding these other variables constant, we find a significant negative effect of number of employees on asset growth. Since three of the four other variables in the model are positively correlated with asset growth, in the bivariate relationship between enterprise size and asset growth the tendency for enterprise size to be negatively associated with asset growth when we hold the other variables constant is counterbalanced by the tendency for innovation activity and investment intensity to grow with enterprise size.

Conversely, inclusion of the number of employees variable strengthens the effect of investment intensity, innovation cost intensity and product innovations on asset growth. The latter three variables are positively and significantly associated with asset growth from 1991 to 1995. When we control for number of employees, they become even more so.

The exports variable (proportion of sales in 1992 accounted for by exports) functions in the same way as the enterprise size variable, to enhance the effect of the other variables on asset growth. Alone it is not significant at the 5 per cent level, but it becomes quite significant when these other variables are included.

We should also note that since the exports variable and the enterprise size variable are correlated and function in the same manner, they each appear less significant when entered together than when just one of them is entered together with the other variables. For instance, in the model above, where both are included, the p-value for the *logemp* variable is 0.0407. If we exclude the *expint* variable, the p-value for the *logemp* variable becomes 0.0013.

An interesting difference between this model and the former model is that the importance of the innovation variables seem to increase relative to the investments variable when we move from the growth from 1991 to 1992 model to the growth from 1991 to 1995 model. This appears so from inspection of the chi-square of the individual variables. The impression is further confirmed if we look at the addition to chi-square for the likelihood ratio which the different sets of variables represent. For the 1991 to 1992 model the investments variable contributes 20.4, while the three innovation variables together contribute 31.6. For the 1991 to 1995 model the investments variable contributes only 7.0, while the now only two innovation variables together contribute 31.6. Thus it here appears that the effects of the factors measured by the innovation variables last longer than the effects of what is measured by the investments variable.

That we here still see a clear effect of innovation expenditures on asset growth is perhaps only what we should expect if we would hope to find any effects of innovation on economic performance at all in this study. But it is quite interesting that our quantitative measure of product innovations, which captures not only if there were introduced product innovations in the period 1990-1992, but also their success in the sense of how large proportion of sales in 1992 which they account for, should have an effect on asset growth from 1991 to 1995, and even when we control for other variables, notably the intensity of innovation expenditures. This seems to give support to the notion that successful innovations promote the growth of enterprises. Reciprocally, this gives credibility to our concepts. We really seem to be grasping something which has to do with the success of product innovations by asking about the proportion of sales accounted for by product innovations

Of course, we have not in this connection any possibility of controlling for third variables, for 'unobservable' factors which may be thought of as relatively permanent attributes of the individual business units. The association between the innovation variables and asset growth may thus express an effect of these 'unobservable factors' on both sets of variables. We saw that when we did try to control for these unobservable factors in the case of operating profit ratio 1992, the indication was that the effects of the innovation variables did not disappear. This might fall out differently for asset growth, of course. In further research, with the addition of appropriate data, we should try to investigate this more systematically, as we mentioned above.

Lastly, we again should note that for the proportion of sales accounted for by product innovations, what matters here is the products which are innovations also from the point of view of the whole market (the *newmark* variable), not simply from the point of view of the enterprise in question. The same argument applies here as in the case of asset growth from 1991 to 1992, above. When entered without the proportion new to the market variable (*newmark*), the proportion new to the enterprise variable (*newprod*) also contributes significantly, but less than when the former variable is used. When both are entered together, however, the latter variable is no longer significant, but the former is.

<u>Growth of total assets from 1991 to 1997</u>

We now proceed to examining growth in total assets from 1991 to 1997. We again take Table 7, above, as our point of departure. Both the dichotomous innovation variable and the investments variable correlate significantly, and positively, with asset growth from 1991 to 1997, the innovation variable at the 5 per cent level, the investments variable at the 1 per cent level. When we control the relationship between the dichotomous innovation variable and asset growth first only for investments and then both for investments and enterprise size, exactly the same thing happens as in the case of asset growth from 1991 to 1995, above. When we control for investments, the innovation variable is no longer significant, but when we also add the enterprise size variable, it gets significant at the 5 per cent level again (p-value 0.0166), and actually more so than the investments variable (which now has a p-value of 0.0227). In contrast to the case above, the exports variable does not contribute significantly.

However, also as in the case above, when we also add other innovation variables, specifying more closely in what ways and to what extent the enterprise is innovative, the nature and intensity of the innovation effort, etc., the dichotomous innovation variable is no longer significant at all. Following the same logic as previously, the model which we end up with as the one which best predicts asset growth from 1991 to 1997 is the one presented in Table 15, below.

Table 15 Results from ordinal logistic regression model with equal odds ratios, with growth of total assets from 1991 to 1997 (divided into 10 categories) as dependent variable and investments in 1992 (as a proportion of total assets), log of number of employees in 1992 and R&D expenditures per employee in 1992 as independent variables (N=576).

```
                 The LOGISTIC Procedure

         Response Variable              AG97G10
         Number of Response Levels      10
         Number of Observations         576


         Score Test for the Proportional Odds Assumption

               Chi-Square       DF     Pr > ChiSq

                 32.5800       24        0.1132


             Testing Global Null Hypothesis: BETA=0

     Test                 Chi-Square       DF     Pr > ChiSq

     Likelihood Ratio        26.4134        3         <.0001
     Score                   25.4887        3         <.0001
     Wald                    26.4414        3         <.0001


            Analysis of Maximum Likelihood Estimates

                                      Standard
Parameter     DF    Estimate         Error    Chi-Square    Pr > ChiSq

Intercept      1     -2.0486        0.2360       75.3579        <.0001
Intercept2     1     -1.2186        0.2178       31.2997        <.0001
Intercept3     1     -0.6714        0.2123        9.9992        0.0016
Intercept4     1     -0.2037        0.2103        0.9383        0.3327
Intercept5     1      0.2035        0.2103        0.9367        0.3331
Intercept6     1      0.6305        0.2117        8.8716        0.0029
Intercept7     1      1.0796        0.2148       25.2513        <.0001
Intercept8     1      1.6355        0.2217       54.4105        <.0001
Intercept9     1      2.4770        0.2416      105.0756        <.0001
INVC10         1      0.0556        0.0217        6.5408        0.0105
LOGEMP         1     -0.1670        0.0563        8.8090        0.0030
RD2E10         1      0.1096        0.0277       15.5893        <.0001
```

Compared to the models discussed so far, there is just one new variable introduced in the present model, *rd2e10*. This is R&D intensity, measured as R&D expenditures per employee in 1992, divided into 10 positive categories plus a 0 category, in the same way as previously explained for other variables.[30]

We see that there are only three variables in this model: the investments variable, the enterprise size variable and one innovation variable.

---

[30] The digit *2* in *rd2e10* refers to the fact that the respondents are asked about R&D expenditures in two separate places in the questionnaire. First they are asked about R&D expenditures as one type of innovation expenditures, such as expenditures on industrial design, trial production, and investments in machinery and equipment in relation two innovations. Later they are asked about R&D expenditures in the context of R&D activities, along with R&D cooperation, but without other innovation expenditures being mentioned. There is a tendency for respondents to report higher R&D expenditures in the latter connection, when no other kinds innovation expenditures are specified, than in the former connection. We have chosen here to use the latter variable, the responses in the connection where other innovation expenditures are not mentioned. We the get a model with slightly higher predictive power than when we use the former R&D variable. But the results essentially are the same.

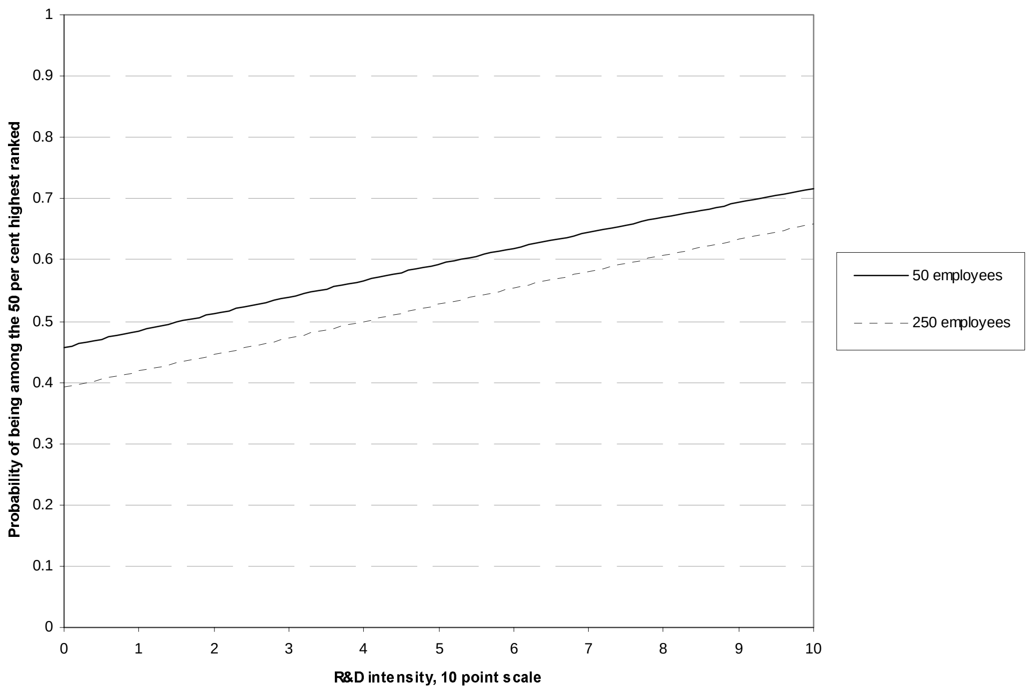
The investment variable is here slightly less significant than in the previous model, but it is still significantly associated with asset growth from 1991 to 1997, also when we control for innovation variables.

The enterprise size variable (*logemp*) functions in exactly the same way as in the previous model. In itself, that is in the bivariate case, it is not significantly correlated with asset growth. However, controlling for the other variable it becomes quite significantly negative (at the 1 per cent level). Furthermore, it serves to amplify and make more significant the effects of the other variables, as explained in connection with asset growth from 1991 to 1995, above.

The innovation variable included in the model is R&D intensity. As we can see, it is highly significant, with a p-value of less than 0.0001. It contributes substantially more to the model than the investments variable.

In Figure 4, below, we show graphically the effect of the R&D intensity variable on the growth of assets from 1991 to 1997 for two different values of the enterprise size variable, 50 employees and 250 employees. The investments variable is held constant at the value 5, which means that investments were between 4.2 and 5.3 per cent of total assets in 1992. The figure shows the probability of being among the 50 per cent highest ranked enterprises on asset growth from 1991 to 1997 for different combinations of values on the R&D intensity and enterprise size variable.

Figure 4 Probability of being among the 50 per cent highest ranked enterprises on asset growth from 1991 to 1997, by R&D intensity (10 point scale), for enterprises with 50 and 250 employees. Investments as a proportion of total assets held constant at the value 5 (on 10 point scale).



All the time holding the investments variable constant at the value 5, we find that for enterprises with 50 employees the probability of being among the 50 per cent highest ranked enterprises on asset growth from 1991 to 1997 is about 45.7 per cent for enterprises without R&D expenditures. This rises to about 71.6 per cent for enterprises with the value 10 on the 10 point R&D intensity scale, which means R&D expenditures of more than 65,000 Norwegian kroner per employee in 1992. For enterprises with 250 employees, the probability is 39.2 per cent for enterprises without R&D expenditures, rising to 65.8 per cent for the value 10 on the 10 point R&D intensity scale. Thus, holding the R&D intensity variable constant, we also see that the probability of being among the 50 per cent highest ranked enterprises on asset growth from 1991 to 1997 is higher among enterprises with 50 employees than among enterprises with 250 employees, for instance 45.7 per cent as against 39.2 per cent for enterprises without R&D expenditures. However, there is a clear relationship between these two independent variables. Using an ordinary least squares regression, we find that the predicted R&D intensity value for enterprises with 50 employees is 1.8, while for enterprises with 250 employees it is 3.0. These R&D intensity values correspond to a probability of being among the 50 per cent highest ranked enterprises on asset growth from 1991 to 1997 of 50.6 and 47.2 per cent, respectively, which are very close to the probabilities we get when we run the model without the R&D intensity variable. This means that the difference between enterprises with 50 and 250 employees in terms of the probability of being among the 50 per cent highest ranked enterprises is substantially larger when we control for R&D intensity than when we do not. This is reflected in the fact that the enterprise size variable is highly significant, at the 1 per cent level (p-value 0.003), when we control for R&D intensity, while it is not significant even at the 5 per cent level when we do not control for R&D intensity (p-value 0.0975). The same argument applies to controlling for the investments variable, which here is held constant at the value 5. If we remove also this variable and only use enterprise size as independent variable, this variable becomes not at all significant (p-value 0.2491). In this case, the probability of being among the 50 per cent highest ranked becomes 49.5 per cent for enterprises with 50 employees, 47.2 per cent for enterprises with 250 employees, i.e. a yet smaller difference.

It is interesting that it is the R&D intensity variable which gives the best fit here, not the intensity of total innovation expenditures, as in the previous model. These variables are of course highly correlated. Also the innovation expenditures intensity variable is significant when entered without the R&D intensity variable, but it contributes less. When both are entered together, intensity of total innovation expenditures is not significant, but R&D intensity is.

We can tell a story which makes some sense here. Innovation expenditures are to a large extent expenditures for enhancing the capacity for growth in the future, and this in particular applies to R&D expenditures. Therefore, it is interesting that while investments intensity contributes more than innovation expenditures to the model for asset growth from 1991 to 1992, it is the other way round for the models for asset growth from 1991 to 1995 and from 1991 to 1997. Furthermore, for the model for asset growth from 1991 to 1995, it is the intensity of total innovation expenditures which contributes most of the innovation expenditures variables, while for the model for asset growth from 1991 to 1997, it is R&D intensity. Thus, with 1991 as the point of departure, as we examine asset growth to 1992, then to 1995, then to 1997, the more important innovation expenditures become relative to investments, and among the former, the more important R&D expenditures relative to total innovation expenditures.

We also here note that the product innovations success variable, the proportion of sales in 1992 accounted for by product innovations (in any of its definitions), is no longer significant in this model. More precisely, it is not significant when entered together with R&D intensity. These variables are, of course, strongly correlated among themselves, so when the proportion of sales accounted for by product innovations is entered without the R&D intensity variable, it is clearly significant (p-value 0.0025), but not so much as the R&D intensity variable. However, when both variables are entered, proportion of sales accounted for by product innovations variable fails entirely to be significant, but R&D intensity still is. When we do find a relationship between proportion of sales accounted for by product innovations and asset growth from 1991 to 1997 when we do not control for R&D intensity, this comes about because enterprises with high proportions of product innovations in sales also tend to have high R&D intensity, and vice versa. We thus find no independent effect of the proportion of sales in 1992 accounted for by product innovations on asset growth from 1991 to 1997. The effect we found for asset growth from 1991 to 1995 does not last all the way down to 1997, so to speak.

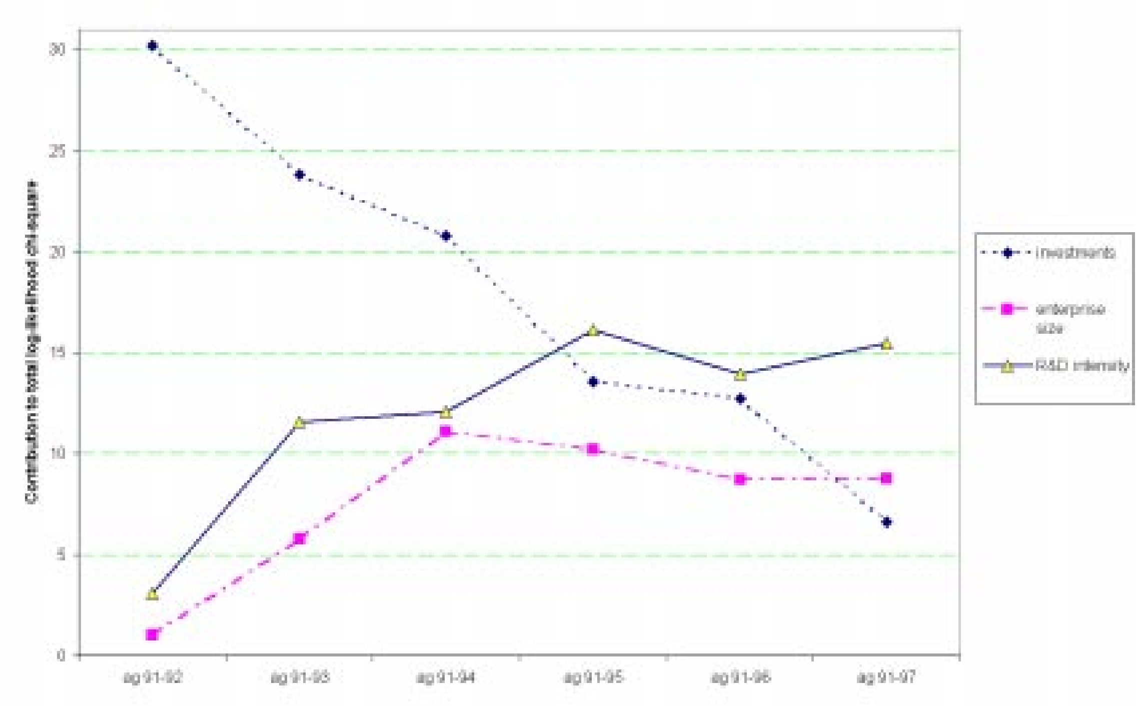
Changes in the relative importance of variables over time

We will here briefly look more explicitly at the changes in relative importance of the different variables over time. We will do this by using the model for asset growth from 1991 to 1995 and the model for asset growth from 1991 to 1997 to predict asset growth form 1991 to each of the years afterwards up to 1997.

Let us start with our model for asset growth from 1991 to 1997. Here we had three independent variables: investments, enterprise size and R&D intensity. We will now run this model also for asset growth from 1991 to 1992, from 1991 to 1993, etc. We will then look at how each variable's contribution to the model, in terms of its Wald chi-square, develops over time. Since this measure is also dependent on the number of observations, we will here only use the observations for which we have data for all the years, i.e. we exclude those who have dropped out after 1994. Thus, in the following we use only 573 observations in all the models, also asset growth from 1991 and up to 1994, where we actually have 637 observations. Otherwise these chi-squares for the different variables should be comparable, and may be thought of as each variable's marginal contribution to the total log likelihood chi-square of the model, i.e. the addition to log likelihood chi-square generated by adding the variable in question to a model containing all the other variables.

The marginal contribution of each variable when the model for asset growth from 1991 to 1997 is run also for asset growth from 1991 to each of the other years up to 1997 is shown in Figure 5, below.

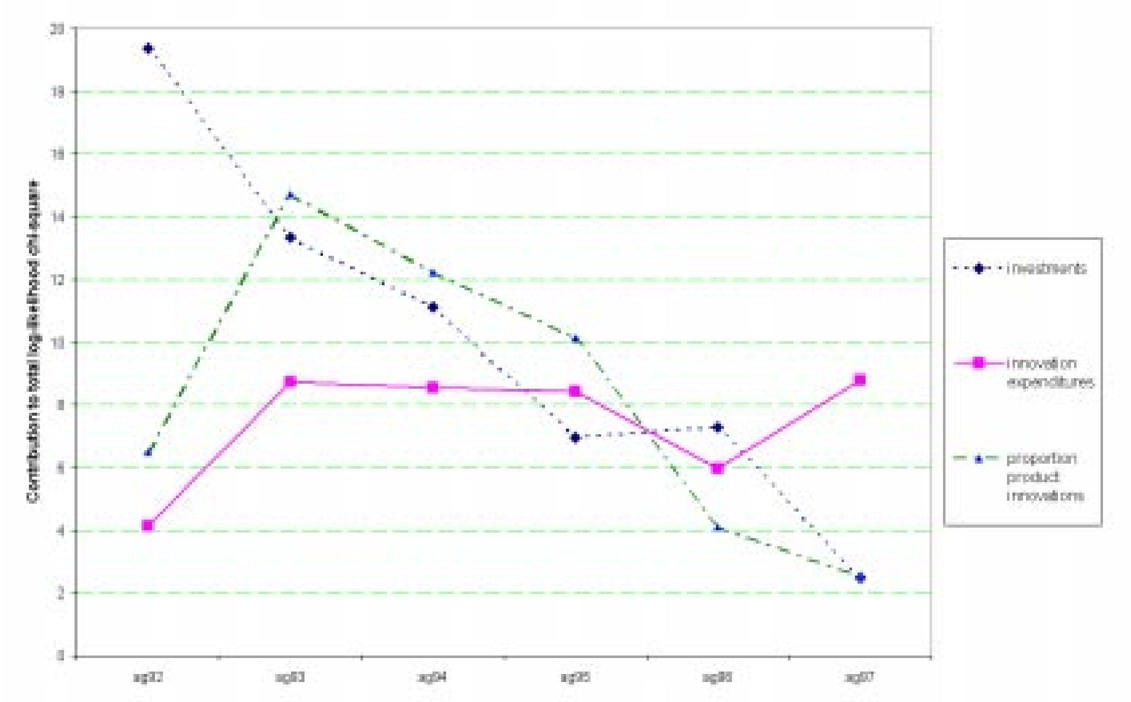
Figure 5 Marginal contribution to total log-likelihood chi-square of each variable when model for asset growth from 1991 to 1997, with investments, enterprise size and R&D intensity as independent variables, is run for asset growth from 1991 to each year afterwards up to 1997 (N=573).



The further away from 1992, the date to which the independent variables refer, the less well the model as a whole fits. For asset growth from 1991 to 1993, log-likelihood chi-square is 40.2, and then gradually drops to 26.4 for asset growth from 1991 to 1997. The decrease in the contribution of the investments variable is evident, as is the increase in the relative importance of the R&D intensity variable.

In the same way we have run the model for asset growth from 1991 to 1995 on asset growth from 1991 to each year afterwards through to 1997. The contributions of the individual variables are shown in Figure 6, below.

Figure 6 Marginal contribution to total log-likelihood chi-square of each variable when model for asset growth from 1991 to 1995, with investments, exports intensity, enterprise size, innovation expenditures intensity and proportion of sales accounted for by product innovations as independent variables, is run for asset growth from 1991 to each year afterwards up to 1997. Chi-square for exports intensity and enterprise size not shown in the figure (N=573).



This model contains five variables. We have only shown the chi-squares for three of them here, investments and the two innovation variables, proportion of sales accounted for by product innovations and innovation expenditures intensity. The contributions of enterprise size and proportion of sales accounted for by exports are not shown. As in the case of the model for asset growth from 1991 to 1997, the further away from 1992 we get, the less well the model as a whole fits.

Again, we see that the contribution of the investments variable decreases as we move away from 1992. The contribution of innovation expenditures intensity is quite stable, consequently, the relative importance of this variable increases with time. We also see that the effect of the success of products innovation variable decreases over time, but is significant for asset growth from 1991 all the way to 1996.

Controlling for 'unobservable factors'

Let us briefly return to the issue of controlling for 'unobservable factors' by using earlier measurements of the dependent variable as a control variable. We have pointed out that we have little opportunity for doing this with the data which we have available here. We also saw how this gave quite interesting results when we tried it in one case, namely by using operating profit ratio in 1991 when predicting operating profit ratio in 1992.

Also in the case of asset growth we have tried to use earlier measurements of the dependent variable as a control variable. Our solution here was to try to explain, i.e. use as the dependent variable, not asset growth from 1991 to later years, but asset growth from *1992* to later years, and then use asset growth from 1991 to 1992 as a control variable. Specifically, we have looked at asset growth from 1992 to 1995 and from 1992 to 1997, including as a control variable asset growth from 1991 to 1992 among the independent variables.

Again, the results are quite interesting. It turns out that asset growth from 1991 to 1992 does not at all correlate with neither asset growth from 1992 to 1995 nor with asset growth from 1992 to 1997. Furthermore, investments intensity (in 1992) is only weakly, and not significantly, correlated with asset growth from 1992 to 1995 and asset growth from 1992 to 1997. However, the innovation variables from the models for asset growth from 1991 to 1995 and from 1991 to 1997 are still significant when we instead look at asset growth from 1992 to 1995 and from 1992 to 1997. In Table 16, below, we show the results for the model for asset growth from 1992 to 1995.

Table 16 Results from ordinal logistic regression model with equal odds ratios, with growth of total assets from 1992 to 1995 (divided into 10 categories) as dependent variable and log of number of employees in 1992, total innovation expenditures per employee in 1992, and proportion of sales in 1992 accounted for by products which are new to the market as independent variables (N=604).

The LOGISTIC Procedure

Response Variable	AG25G10
Number of Response Levels	10
Number of Observations	604

Score Test for the Proportional Odds Assumption

Chi-Square	DF	Pr > ChiSq
29.9745	24	0.1856

Testing Global Null Hypothesis: BETA=0

Test	Chi-Square	DF	Pr > ChiSq
Likelihood Ratio	16.9832	3	0.0007
Score	17.4002	3	0.0006
Wald	16.2752	3	0.0010

Analysis of Maximum Likelihood Estimates

Parameter	DF	Estimate	Standard Error	Chi-Square	Pr > ChiSq
Intercept	1	-1.9983	0.2226	80.6053	<.0001
Intercept2	1	-1.1666	0.2038	32.7628	<.0001
Intercept3	1	-0.6202	0.1983	9.7823	0.0018
Intercept4	1	-0.1634	0.1965	0.6916	0.4056
Intercept5	1	0.2487	0.1965	1.6007	0.2058
Intercept6	1	0.6668	0.1981	11.3265	0.0008
Intercept7	1	1.1139	0.2015	30.5562	<.0001
Intercept8	1	1.6650	0.2086	63.7061	<.0001
Intercept9	1	2.4794	0.2281	118.1497	<.0001
LOGEMP	1	-0.1208	0.0537	5.0710	0.0243
COEMP10	1	0.0548	0.0243	5.0960	0.0240
NEWMARK	1	1.4809	0.6944	4.5480	0.0330

We remember that in the model for asset growth from 1991 to 1995, the exports variable, i.e. the proportion of sales (in 1992) accounted for by exports, was also significant. However, for asset growth from 1992 to 1995, this variable is not at all significant.

The enterprise size (*logemp*) variable functions in exactly the same way as in the previous models where it has been present. Alone it is not at all significant, but when we control for the innovation variables, it is significant, with a negative coefficient (the larger the enterprise, the lower the growth in assets, holding innovation constant). Conversely, its presence strengthens the effect of the innovation variables.

Both innovation variables, the intensity of total innovation expenditures and the proportion of sales accounted for by product innovations (new to the market), are significant at the 5 per cent level. However, these two variables are themselves highly correlated, so that considered together, they are much more significant. Their combined contribution to the log likelihood chi-square of the model is 15.8855, which gives a p-value of 0.0004.

We next look at the model for asset growth from 1992 to 1997. The results are shown in Table 17, below.

Table 17 Results from ordinal logistic regression model with equal odds ratios, with growth of total assets from 1992 to 1997 (divided into 10 categories) as dependent variable and log of number of employees in 1992 and R&D expenditures per employee in 1992 as independent variables (N=579).

```
                    The LOGISTIC Procedure

          Response Variable            AG27G10
          Number of Response Levels    10
          Number of Observations       579

          Score Test for the Proportional Odds Assumption

                Chi-Square       DF     Pr > ChiSq

                   17.5308       16         0.3521

              Testing Global Null Hypothesis: BETA=0

      Test                 Chi-Square       DF     Pr > ChiSq

      Likelihood Ratio        13.9464        2         0.0009
      Score                   13.7427        2         0.0010
      Wald                    13.7316        2         0.0010

             Analysis of Maximum Likelihood Estimates

                                     Standard
Parameter     DF     Estimate          Error    Chi-Square    Pr > ChiSq

Intercept      1      -1.9411         0.2274       72.8442        <.0001
Intercept2     1      -1.1316         0.2090       29.3282        <.0001
Intercept3     1      -0.5706         0.2033        7.8764        0.0050
Intercept4     1      -0.1255         0.2017        0.3873        0.5337
Intercept5     1       0.2906         0.2019        2.0720        0.1500
Intercept6     1       0.7038         0.2036       11.9423        0.0005
Intercept7     1       1.1507         0.2072       30.8339        <.0001
Intercept8     1       1.6953         0.2144       62.5081        <.0001
Intercept9     1       2.5120         0.2342      115.0112        <.0001
LOGEMP         1      -0.1242         0.0555        4.9993        0.0254
RD2E10         1       0.0978         0.0274       12.7767        0.0004
```

Comparing with the model for asset growth from 1991 to 1997, we see that the investments variable is no longer included, because it is not significant. The R&D intensity variable, on the other hand, is still highly significant.

To sum up, our attempt to use an earlier measurement of the dependent variable to control for unobservable effects by using asset growth from 1992 to 1995 respectively 1992 to 1997 instead of from 1991 to 1995 respectively 1991 to 1997 as the dependent variable, and then use asset growth from 1991 to 1992 as a control variable, took a quite unexpected turn, in that it turned out that asset growth from 1991 to 1992 was not at all correlated neither with asset growth from 1992 to 1995 nor with asset growth from 1992 to 1997. It is nevertheless interesting to note that for asset growth from 1992 to 1995 and from 1992 to 1997, the innovation variables from the corresponding previous models with 1991 as the starting point, as well as the enterprise size variable, are still significant, and highly so in the case of the innovation variables, while the investments variable is no longer significant, and neither is the export intensity variable. This strengthens our confidence that we do here have a quite robust positive relationship between innovation and asset growth.

A note on background variables and interaction effects

Concentrating here on asset growth from 1991 to 1995 and from 1991 to 1997, we have seen that enterprise size, as measured by the *log* of the number of employees, is an important variable. In addition to contributing significantly to the predictive power of the models when entered together with the innovation variables, it also affects the relationship between the innovation variables and asset growth, which becomes strengthened when the enterprise size variable is entered.

By contrast, we find no significant effect of industry on asset growth, neither when we use the 5 industry nor the 13 industry classification. This also means that controlling for industry does not significantly modify the relationship between innovation and asset growth.

We have also tested quite extensively for interaction effects between the enterprise size and innovation and between industry and innovation. For industry, we have tested both with both the 5 industry and the 13 industry classification. For asset growth from 1991 to 1997, we have examined the interaction between these background variables and R&D intensity. For asset growth from 1991 to 1995 we have examined the interaction with both the intensity of total R&D expenditures and the proportion of sales accounted for by product innovations. We have found no significant interaction effects between these background variables and the innovation variables on asset growth. This means that we have found no evidence that the effect of the innovation on asset growth should vary significantly across industries or by enterprise size.

Only in one case have we found evidence of any significant interaction effects, and this case concerns neither enterprise size nor industry, but exports intensity. For asset growth from 1991 to 1997 we find a significant interaction effect between exports intensity and R&D intensity. We saw that in our main model for asset growth from 1991 to 1997, with investments, enterprise size and R&D intensity as independent variables, R&D intensity was highly significant. Adding only exports intensity does not contribute significantly to the model. However, adding *both* exports intensity *and* the interaction between R&D intensity and exports intensity does contribute significantly to the model. In this new model, the R&D intensity variable is positive, while the exports intensity variable is negative and the interaction between R&D intensity and exports intensity is positive. This means that at 0 R&D intensity (no R&D expenditures) the effect of exports intensity is negative, while vice versa at 0 exports intensity (no exports) the effect of R&D intensity is positive. Then, from this point of departure, the higher the exports intensity, the stronger the effect of R&D intensity on asset growth. This seems to make sense and is potentially interesting. It may be worth exploring this relationship further in future research. However, here the evidence for this interaction effect is not overwhelming. The contribution made by adding the two variables exports intensity and the interaction between exports intensity and R&D intensity is significant at the 5 per cent level, with a p-value of 0.0362. Since this is the only interaction effect of the type which we find and not something which is robust across different models, we should not make too much of it at this point.

Summary

We can tell a fairly consistent story here. Innovation variables have a clear and highly significant association with asset growth from 1991 all the way up to 1997. The innovation variables contrast with the ‘ordinary’ investments variable in that effect of the latter weakens much faster as time goes beyond 1992, so that the importance of the innovation variables relative to the investments variable grows over time. Among the innovation variables, the importance of the innovation cost variables relative to the proportion of sales accounted for by product innovations variable also grows over time. Lastly, among the innovation cost variables, there is a growing importance over time of R&D intensity relative to the intensity of total innovation costs. All this seems to make good sense.

5.4 Sales growth

Also for sales growth we have made the same kind of analysis as for operating profit ratio, return on investment, and asset growth. Sales growth has simply been measured as the value of sales in one year divided by the value of sales in the year of departure. We have simply used nominal values, since adjusting for changes in the general level of prices would not affect the relationship among the enterprises.

The results we get for sales growth are quite similar to the ones we got for asset growth. Therefore, we will be fairly brief in this section. We will in the following only use 1991 as the base year and not consider sales growth from later years.

If we first look only at sales growth from 1991 to 1992, from 1991 to 1995 and from 1991 to 1997, the general picture emerges quite clearly. For sales growth from 1991 to 1992, only investment is significant (‘ordinary’ investments in machinery and equipment, regardless of whether they are related to innovations or not). For sales growth from 1991 to 1995, investment is no longer significant, but both enterprise size (*log* of number of employees), the proportion of sales accounted for by product innovations, and the intensity of total innovation expenditures are. For sales growth from 1991 to 1997, the proportion of sales accounted for by product innovations is no longer significant, but enterprise size and the intensity of total innovation expenditures are.

Let us look at the similarities and differences between these results and those we found for asset growth.

As regards the effect of the investment variable, in both cases its absolute and relative importance decreases clearly as we go from growth from 1991 to 1992 to growth from 1991 to 1997. However, in the asset growth case, this variable is significant all the way up to growth from 1991 to 1997, starting out with a relatively strong effect for growth from 1991 to 1992. In the sales growth case, the effect is much smaller at the outset, falling to virtually zero when we come to growth from 1991 to 1995.

The enterprise size variable functions in exactly the same way as in the assets growth case. It has a negative effect on sales growth, i.e. the larger the enterprise, the lower the sales growth, but, having a relatively strong positive correlation with the two innovation variables (*tau-b* is 0.29 with the intensity of innovation expenditures and 0.27 with the proportion of product innovations in sales) its effect is substantially lower when entered alone than when entered together with one or both of the innovation variables (in fact, when entered alone it is not even significant for sales growth from 1991 to 1995). Conversely, it makes the effect of the innovation variables appear much more clearly, the effects of these being substantially larger when we control for enterprise size than when we do not.

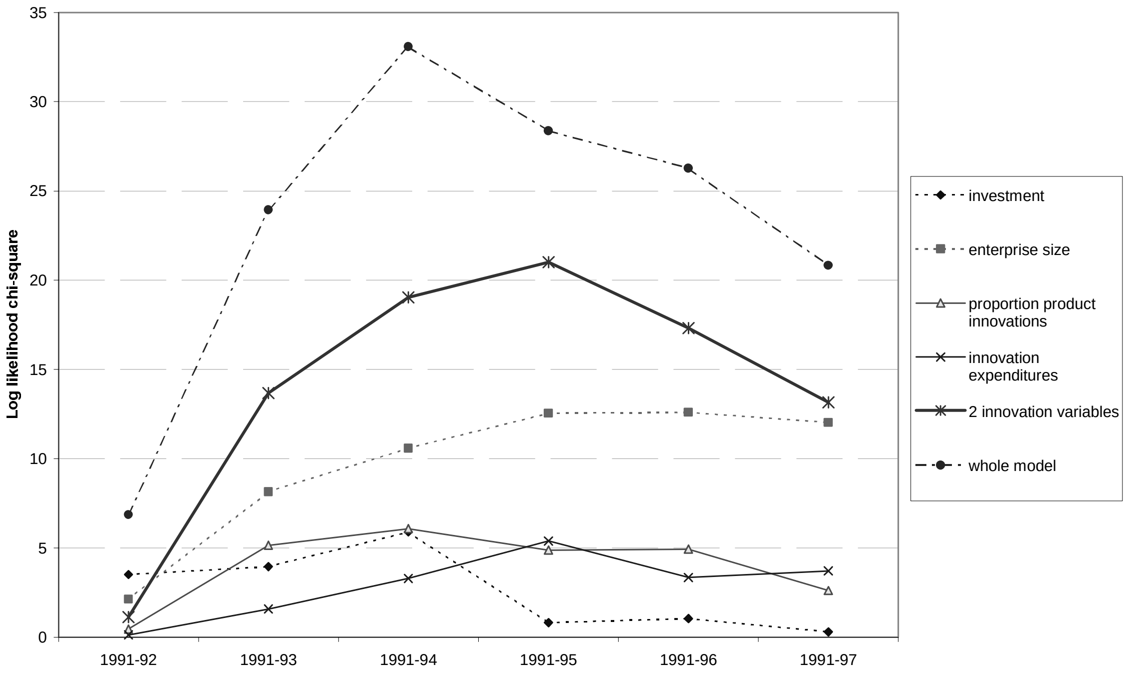
The innovation variables are both positive. Their effects for sales growth from 1991 to 1992 are close to zero. They are then both highly significant for sales growth from 1991 to 1995. For sales growth from 1991 to 1997, only the innovation expenditures variable is significant when both are entered together with enterprise size. When only one is entered together with enterprise size, they are both significant, but innovation cost intensity contributes more to log likelihood variance than the proportion of product innovations in sales.

Unlike in the asset growth case, there is no indication that the intensity of R&D expenditures at any point contributes more than the intensity of total innovation expenditures. Neither does the proportion of product innovations which are innovations also from the point of view of the market at any point contribute more than the proportion of product innovations which are innovations from the point of view of the enterprise without regard to whether they also are from the point of view of the market.

We will now look how the effect of these variables on sales growth varies as we move away from 1992, the year in which they are measured, and consider sales growth from 1991 and to each year afterwards up till 1997. We do this by running the same model for sales growth over all these six periods, with all the four variables considered above included as independent variables. Since the chi square increases with the number of observations, we use the same number of observations for all the periods, which means that we only include those units for which we have positive sale figures for all the years 1991-1997, as well as non missing values for the independent variables.

The results are summarized in the figure at the following page.

Figure 7 Marginal contribution to total log-likelihood chi-square of each variable when model with investments, enterprise size, innovation expenditures intensity and proportion of sales accounted for by product innovations as independent variables, is run for sales growth from 1991 to each year afterwards up to 1997. Also shown the joint contribution of the two innovation variables and the total variance explained by the model (N=572).



Let us recapitulate the critical chi square values for statistical significance at the 5 per cent level: for one degree of freedom, it is 3.841, for two degrees of freedom (the two innovation variables), it is 5.991, and for four degrees of freedom (the whole model), it is 9.488.

With 1991 as the departure of each period, and going from 1992 to 1997 as the end point, we see that the model at first, for growth to 1992, explains very little. Then this increases sharply to reach its maximum for growth to 1994, and then again the combined effect of the four variables wears more slowly off as we move to growth to 1997. For growth from 1991 to 1992 the model is not even significant at the 5 per cent level (indeed, not only at the 10 per cent level). However, the investment variable when entered alone gives a chi square of 4.4, and with one degree of freedom this is significant at the 5 per cent level. At the other end of the period the model is still highly significant for growth to 1997.

As for the 'ordinary' investments variable, we see that it is significant for growth up until 1994, but after that contributes nothing over and above the other variables.

The effect of the two innovation variables combined is virtually zero for the first year, but then is highly significant for the rest of the period. It increases gradually to reach its maximum for growth up to 1995, then wears gradually off to 1997.
As regards the marginal contribution of each of the two innovation variables when entered together, we should note that these are highly correlated with each other, with a *tau-b* of 0.61. Thus each when entered without the other contributes far more

than what it contributes without the other. This also means that their joint contribution is far greater than the sum of their marginal contributions, as clearly emerges in the figure above.

Also, both of these variables are substantially correlated with the ‘ordinary’ investments variable, so that when this variable is taken out, the marginal contribution of the innovation variables increases. This applies to both of them, but especially to the innovation expenditures variable, since this is more strongly correlated with the ‘ordinary’ investments variable than is the case for the proportion of product innovations (*tau-b* is 0.34 as against 0.16, respectively).

To illustrate, let us look at the contribution of the innovation expenditures variable to the log likelihood chi square for sales growth from 1991 to 1997, where only this variable and the size of enterprise variable is included in the best model we find with only variables significant at the 5 per cent level included. When all four variables are included, the contribution of the innovation cost variable is a chi square of 3.7. If we then first take out the investments variable, it increases to 5.4. When we remove also the proportion of product innovations variable, it rises still further to 13.2. However, in accordance with how we saw the size of enterprise variable functions, if also this variable is removed so that the innovation cost variable is entered alone, its contribution drops substantially again, to 7.3.

In conclusion, we see a clear positive relationship between innovation and sales growth. The variables which contribute most to explaining the variance in sales growth are innovation cost intensity and the proportion of sales accounted for by product innovations. The effect does not appear already the same year to which the innovation variables relate, i.e. we find no effect on sales growth from 1991 to 1992. However, already the next year, for sales growth from 1991 to 1993, we find a clear effect of the innovation variables, and this effect increases gradually to reach its maximum for sales growth from 1991 to 1995. Then it gradually diminishes, but the effect is still highly significant for sales growth from 1991 to 1997. The effect of innovation costs (in 1992) seems to last longer than the effect of the proportion of product innovations in sales (in 1992).

The effect of the innovation variables here stands in marked contrast to the effect of the ‘ordinary’ investments variable, also as measured for 1992. This variable has some effect already for sales growth from 1991 to 1992. It continues to have some effect over and above variables for sales growth from 1991 to 1993 and 1994, although here far less than the innovation variables. However, for sales growth from 1991 to 1995 and later, it contributes nothing over and above the innovation variables.

Thus, we seem to have evidence here that innovation, as measured here, has an effect on sales growth which lasts at least over a five year period. It does not make itself felt the first year, but then takes effect to reach its maximum after 2-4 years, and then gradually wears off.

Controlling for industry does not alter this picture. In fact, not only does controlling for industry not alter the effect of the innovation variables on sales growth, adding industry does not even make a significant contribution to the models.

Chapter 6. Variation in performance

We have also examined the relationship between innovation and the *variation* in economic performance. We have looked at variation in two different senses.

The hypothesis of a sharper polarization in performance among innovators

The first, and perhaps more important, meaning of variation relates to an hypothesis we mentioned at the beginning of this paper. Innovation is risky. If one succeeds, one may do very well, increase market shares, earn money, grow, etc. However, there is also the risk that one does not succeed, and thus lose money, is forced to shut down or contract or to make costly investments in redirecting one's efforts, etc. We might therefore expect to find larger variation in economic results among innovators than among non innovators, and the larger the more intensively one engages in innovative investments. Successful innovators have a good chance of doing particularly well, but, on the other hand, for unsuccessful innovators there is a heightened risk of doing particularly bad.

We have investigated this hypothesis of a positive relationship between innovation and the *variation* in performance for all our four performance measures and at several times of measurement or over several time periods, for instance operating profit ratio in 1992, for average profit ratio 1993-94, and 1995-97, for sales growth from 1991 to 1995 and from 1991 to 1997, etc.

To investigate this question, for each performance measure we have made a new variable measuring each unit's absolute distance from the median value. Again, we use the median because of the presence of extreme outliers, which makes the mean less reliable as a measure of central tendency. Then we ask if there is a tendency for innovating enterprises to lie further away from the median than non innovating enterprises, whether this is in the positive or negative direction. For the quantitative variables the question becomes whether there is a tendency for the absolute distance from the median to increase with the intensity of the innovation effort (the expenditure variables) or the quantitative measure of innovative success (the proportion of sales accounted for by product innovations). These distance from the median variables are treated as ordinal variables, in the same way as the performance variables themselves, and for the same reason.

However, the results of these investigations are quickly summarized. We find no consistent evidence that innovation is related to the variation in performance for any of the performance measures. Innovative enterprise do not tend to lie further away from the median than non innovative enterprises, but neither do we find any tendency in the opposite direction.

Variation in performance from year to year

We have also briefly looked at variation in performance in a different sense, namely variation from year to year for each enterprise. For the two profit rate measures our indicator of year to year variation has simply been the standard deviation of each enterprise's values for each year, both for the period 1992-1994 and the whole period 1992-1997 (for operating profit ratio also the year 1991 has been included in both cases). For the two growth variables our point of departure has been the growth from one year to the next, i.e. from 1991 to 1992, then from 1992 to 1993, and so on. Then, for each enterprise, we have taken the standard deviation of these growth rates, both for the period 1991-1994 and the whole period 1991-1997. For each performance measure and each of these two periods, each enterprise then ends up with a deviation measure expressing how much the performance measure has varied over the period in question. Also these variation measures have been treated as ordinal.

Neither for this kind of variation do we find any evidence that the performance of innovative enterprises varies more than the performance of non innovative enterprises. If anything, it would rather seem to be the other way around. However, the patterns are not very clear and difficult to make sense of. We will not go further into this at this stage.

Chapter 7. Conclusion

As discussed in the theoretical and methodological section in the beginning of the paper, this study has been predominantly exploratory in character. We have some broad ideas of what kinds of results we would expect, but no very specific hypotheses. Partly this reflects doubts as to whether the kind of data we have here are suited for discovering any relationships between innovation and economic performance. Even if we should have strong reasons to believe that innovation tends to lead to better economic performance over time, we may doubt whether the time period covered in our data is long enough to unmask this relationship.

Another important consideration is that our innovation indicators cannot be considered established, well tested measures of innovation. On the contrary, they are quite recent developments, being part of an ongoing process of devising and refining indicators which allow us to better measure innovation. Here there is a need to test and evaluate indicators, keeping and developing further those which seem to function well, altering or perhaps discarding completely those who do not, and of course develop new indicators. In addition, as we briefly referred to in the methodological section, there has been much discussion of the adequacy of accounting data for measuring economic performance.

Thus our study is not only an empirical study, but also a methodological study, in the sense that we at the same time try to evaluate the indicators that we use. Accordingly, if we were to find no kind of relationship between innovation and performance, or nothing which would seem to make any meaning, we would be hesitant to simply interpret this in a substantive sense, concluding that this suggests there is no relationship between innovation and performance. Rather, a methodological interpretation, that our indicators are not good enough, that there is too much measurement error for relationships to emerge consistently, could not have been ruled out. On the other hand, should we actually find clear relationships which we could make reasonably sense of, this would strengthen both our confidence in the indicators and make us more confident in reporting our results as substantive, empirical findings.

As we have seen above, we do find clear, highly significant relationships between innovation and economic performance in our data. Moreover, the associations we find in general seem to make good sense.

As we argued it would be reasonable to expect to find, the association with innovation is more consistent over time for the growth performance variables than for the profit ratio variables. Both for sales growth and asset growth, innovation variables are highly significant for growth from 1991 all the way up to 1997. The innovation variables here contrast with the ‘ordinary’ investments variable, i.e. investments in machinery and equipment without regard to whether they are related to innovations or not. The investments variable has its largest effect the first year, i.e. for growth from 1991 to 1992. Then the effect decreases as we move away from 1992 and consider growth from 1991 to 1993, then from 1991 to 1994, and so on down to growth from 1991 to 1997. Thus, the importance of the innovation variables relative to the investments variable increases over time, as we move forward from the year in which they are measured. This seems reasonable, since innovation is particularly connected to enhancing the capacity for growth in the future, as we argued above. The innovation variables which remain significant when we control for other variables are first and foremost innovative success as measured by the proportion of sales in 1992 accounted for by product innovations, and innovation expenditures. As we move forward in time, innovation expenditures gains in importance relative to the proportion of sales accounted for by product innovations. This also seems plausible, since proportion of sales in 1992 accounted for by product innovations partly will reflect innovation expenditures at a still earlier date.

Also as expected, we find much less consistent association between the innovation variables and the profit ratio performance measures. However, there was perhaps no reason to expect the more precise result that we find a quite clear association for the first year, 1992, then a weaker but still significant or nearly significant association for 1993, and then no association after 1993. Perhaps one reason is that the key innovation variable here, the proportion of sales in 1992 accounted for by product innovations, lies quite close to the income side of the profits of precisely 1992. Anyway, the general form of the relationship we find here is quite interesting: for those enterprises which have product innovations, the profit ratio tends to be higher the higher the proportion of sales these product innovations account for. simply having product innovations has a negative effect, so that those enterprises which have product innovations but where these account for a small proportion of sales tend to do worse than the enterprises without product innovations.

In sum, we find several very clear and statistically highly significant relationships between innovation and economic performance. Moreover, mostly they make perfectly good sense. However, it should be pointed that even if several of the associations are clear and highly significant, they are not strong in the sense that the independent variables account for a large proportion of the variation in the dependent variable. For instance, if we run our model for asset growth from 1991 to 1997 as an ordinary least squares regression model (with *log* of asset growth as dependent variable, deleting one extreme outlier observation) we get an R^2 of 0.05. This model has R&D intensity, ('ordinary') investments and enterprise size as independent variables. If we leave out R&D intensity we get an R^2 of 0.02. Adding the innovation variable in question thus increases R^2 from 0.02 to 0.05.

However, there are very good reasons for not expecting high explained variance in this kind of study. As we saw above, explained variance is generally low in studies where economic performance is the dependent variable. General factors often explain little, 'unobservable' factors specific to the business unit in question are emphasized as important. Specifically for our study, the set of indicators that we use is in the process of being developed. Our measures are admittedly very rough, and there probably is much measurement error. Not least, we should keep in mind that our measures refer to one single year (1992), and that the definition of having innovations in the first place refers to products or processes introduced only during one single three year period (1990-1992). The innovative competence of an enterprise, its ability to develop successful new or higher quality products and processes, on the other hand, is typically something which has to be built up over several years. Thus what we want to measure here is necessarily only very imperfectly reflected in indicators for one year only. Likewise, if for instance many enterprises introduce innovations intermittently, say every five years, defining innovations relative to the last three years (at the time of survey) will bring in additional random variation.

Considering the foregoing, we should emphasize the fact that we actually do find very clear and highly significant relationships in our, which moreover generally make good sense, and not focus too much on explained variance. This makes us confident that this kind of study is relevant for examining the relationship between innovation and economic performance, and that this work is thus worth pursuing further. Especially it is interesting that the indicators developed in the context of the European innovation surveys seem to function quite well. As an example we may take the proportion of sales in 1992 accounted for by product innovations (defined by reference to the three year period 1990-1992). This is a new indicator, intended to measure innovation output or success. It is not obvious that it would function well, but in fact it is significantly and positively related to both sales growth and asset growth from 1991 and up to at least 1995, even when we control for other variables.

To go further from here we could, firstly, do the same kind of analysis for the Norwegian innovation survey 1997 which we have here done for the innovation survey 1992, i.e. merge also the 1997 survey with comparable accounting data. It would then be highly interesting to see if we got broadly speaking the same results with the new survey, or whether parameter values had changed in important respects. This would serve as a check on the robustness and reliability of the results, but would also, of course, be an investigation of whether circumstances had changed in important respects since the former survey. Which of the two would appear the more likely interpretation in the case of substantially different results, low reliability or substantive change, would of course be a question of how much sense we could make of the differences as substantive changes.

However, an important gain in the quality and relevance of the research should be possible if we could also merge the innovation surveys from 1992 and 1997 with each other and with accounting data over a longer period (for instance, from 1991 to 2001). This would mean fewer observations, but we would probably still have a fairly large sample. The great advantage of doing this would be the opportunity to study the relationships between the innovation variables at two different times and performance measured each year from immediately before the first innovation study to 3-5 years after the second. We would thus be able to address more complex questions concerning the causal processes involved. We hope to be able to do both kinds of study in the near future.

A more ambitious project would then be to integrate these kinds of study inside a wider framework where the question of the relationship between the enterprise level and the societal level is addressed. This should recognize that what matters most is not what happens to each individual enterprise, but how the activities carried on within them contribute to the economic performance of society as a whole. Here several different kinds of contribution will have to be recognized. For instance, time bound enterprises and projects may often make valuable contributions, and may thus be highly successful even if they do not survive for very long. Here should also be recognized that it is not necessarily an advantage that all enterprises be innovative.

Perhaps a more relevant consideration is whether an economy has a reasonable balance between enterprises which are innovative and thus invest in capacities for future growth, and enterprises which in Lazonick's phrase are adaptive, who predominantly reap the returns on past investments. Basically, questions of reproduction and growth cannot be understood separately from questions of transformation and renewal.[31] This should involve addressing both the issue of life cycles of individual business units and the issue of structural change.

[31] For a discussion of some fundamental issues here, cf. Anthony Giddens, *New Rules of Sociological Method*, London: Hutchinson, 1976, especially pp. 93-129 (the chapter entitled 'The production and reproduction of social life').

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STEP-gruppen ble etablert i 1991 for å forsyne beslutningstakere med forskning knyttet til alle sider ved innovasjon og teknologisk endring, med særlig vekt på forholdet mellom innovasjon, økonomisk vekst og de samfunnsmessige omgivelser. Basis for gruppens arbeid er erkjennelsen av at utviklingen innen vitenskap og teknologi er fundamental for økonomisk vekst. Det gjenstår likevel mange uløste problemer omkring hvordan prosessen med vitenskapelig og teknologisk endring forløper, og hvordan denne prosessen får samfunnsmessige og økonomiske konsekvenser. Forståelse av denne prosessen er av stor betydning for utformingen og iverksettelsen av forsknings-, teknologi- og innovasjonspolitikken. Forskningen i STEP-gruppen er derfor sentrert omkring historiske, økonomiske, sosiologiske og organisatoriske spørsmål som er relevante for de brede feltene innovasjonspolitikk og økonomisk vekst.

The STEP-group was established in 1991 to support policy-makers with research on all aspects of innovation and technological change, with particular emphasis on the relationships between innovation, economic growth and the social context. The basis of the group's work is the recognition that science, technology and innovation are fundamental to economic growth; yet there remain many unresolved problems about how the processes of scientific and technological change actually occur, and about how they have social and economic impacts. Resolving such problems is central to the formation and implementation of science, technology and innovation policy. The research of the STEP group centres on historical, economic, social and organisational issues relevant for broad fields of innovation policy and economic growth.