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Firm behaviour and innovative performance An empirical exploration of the selection–adaptation debate

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Abstract

Innovation is a complex trade-off between routinisation and change, between reliability and accountability of firms and timely adaptation. This innovator's dilemma confronts innovation theory with the question, how to align routinisation with innovation induced organisational change and consistent performance. Obviously it is a complex issue. Dominant innovation theory neglects this subject due to its pro-innovation bias, while evolutionary organisation and innovation theory give opposite perspectives on this problem. The adaptation perspective considers pro-active behaviour as the best condition for innovative performance, whereas the selection perspective advances inert firm behaviour as the best alternative to achieve successful innovations. Our *research question* focuses on the explanatory value of either the selection or the adaptation perspective for the innovative performance of industrial firms. Our empirical findings confirm the adaptation perspective and reject the selection perspective. Comparatively, firm behaviour involving the highest risks and uncertainties—e.g., high environmental dynamics and high levels of adaptive activity—contributes most significant to the explanation of innovative performance. Inert, risk averse behaviour, conversely, does not improve or even impedes innovative performance compared with other types of firm behaviour.

Keywords: Innovative performance; Adaptation; Selection; Firm behaviour; Routines; Risks

1. Introduction

Technological competition and innovation confronts firms with the innovator's dilemma (Christensen, 1997). Basically this dilemma is a variant of the flexibility–stability dilemma, which revolves around the question: How do firms reconcile the need for persistence in the pursuit of organisational goals and the need for change in the pursuit of organisational survival? Indeed innovation is a trade-off between competing risks; the risk of changing products, processes and routines threatening the reliability and accountability of organisations and the risk of organisational decline or even death due to a lack of

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change. Innovation processes in organisations appear to have both effects. On the one hand empirical research revealed that innovation enhances the growth and survival of firms. [2] On the other hand innovation is a very complex and risky process, with low success rates, and sometimes lethal effects. [3]

Due to its pro-innovation bias and its adaptationist perspective (Drazin and Schoonhoven, 1996), much innovation research tends to stress that innovation benefits its producers and users, and simultaneously ignores the risks of the associated change processes (Abrahamson, 1991; Leonard-Barton and Doyle, 1996; Freeman and Soete, 1997), or disregards its complexity. [4] These theoretical and empirical flaws in innovation research hampered a full treatment of the innovator's dilemma.

In this paper we pursue a full treatment of the innovator's dilemma with the development of a theoretical framework that adjusts these flaws. This is achieved by an integration of two branches of evolutionary thinking on organisation and innovation: an adaptationist perspective derived from the evolutionary theory of the firm (Haveman, 1992; Teece and Pisano, 1998) and a selection perspective which builds on inertia theory (Hannan and Freeman, 1984) derived from population ecology. Despite many similarities, both perspectives have a different appraisal of firms' change capabilities and the impacts of change on survival. Inertia theory seems to rule out certain structures and practices that can overcome inertia and can increase the generation of innovation, whereas adaptation theory allows for the emergence of such strategies. The position of inertia theory challenges the key assumption of innovation theory pertaining to the capacity of firms to adapt and to innovate. The issue remains as to the validity of these claims for the explanation of innovative performance at the level of firms, because inertia theory is applied mainly at the level of population explaining population dynamics covering long periods (Baum, 1996). We tap into inertia theory to adjust the pro-innovation bias of much innovation research, by means of an elaboration of the inertia concept allowing for a comparative analysis of inertia with other kinds of organisational behaviour at the level of the firm. This yields four types of adaptive behaviour within three categories of adaptive behaviour pertaining to technology, strategy and organisation.

This paper performs several functions in innovation research. Our typology of adaptive behaviour indicates varying responses to feedback from one's environment and represents a fit or misfit between levels of environmental dynamics and activity levels. In general neither a full treatment of the environment–organisation nexus, nor a specification to distinctive organisational domain is the case in studies of organisational change or innovation. [5] An empirical exploration of the relation between different types and categories of adaptive behaviour and innovative performance is not available. In this study we sought to fill this empirical gap, which contributes to our insight in: (1) the prevalence of the claims of the selection and adaptation perspective for the relation between adaptive firm behaviour and innovative performance, (2) the validity of these claims for firm

[2] Innovation does contribute substantially to organisational survival by offering new growth opportunities (Brouwer and Kleinknecht, 1994; Audretsch, 1995; Metcalfe, 1995; Archibugi and Pianta, 1996; Lawless and Anderson, 1996).

[3] Innovations potentially disrupt and reform the organisational fabric, often in a fairly unpredictable and situation-specific way (Leonard-Barton, 1988; Dean and Snell, 1991; Lundvall, 1992; Zammuto and O'Connor, 1992; Dougherty and Hardy, 1996). One study revealed lethal effects of innovation (Barnett, 1994).

[4] To the extent that risks are associated with innovation, they are treated, as is the case for other decisions, as statistical uncertainties with a probability distribution known to all (Gopalakrishnan and Damanpour, 1997).

[5] Most studies concentrate on activities, or on effects of different environmental conditions (market structures, rivalry) on firm behaviour (Miller and Chen, 1994; Baum, 1996), which is also prevalent in industrial economics (Baldwin and Scott, 1987). Most researchers contemplating the opposition between both approaches, either take the selection approach as a starting point (Miller and Chen, 1994), or the adaptation approach (Haveman, 1992; Romanelli and Tushman, 1994). Young (1988) and Amburgey and Rao (1996) assert that existing studies contrasting adaptation and selection have tended to neglect the effects of changes in goals, authority, and technology on the life chances of organisations and their financial performance.

behaviour in distinct domains like technology, strategy and organisation, and (3) the sensitivity of these theoretical claims for effects of moderator variables like size × age, patterns of economic performance and learning problems.

This paper has the following structure. In Section 2, the selection and adaptation perspective on firm behaviour are reviewed and we describe the research model, the measurement of included variables and the research questions. Section 3 deals with our method, our population sample and analyses. In Section 4, our findings are presented. In Section 5, we discuss our findings and make some inferences with respect to innovation management and technology policy.

2. Towards a comparative research model

2.1. Inertia theory and adaptation theory

The selection and adaptation perspective have distinct appraisals of firms' capabilities to align conflicting internal and external demands. The selection perspective stresses environmental selection due to the limits of organisational influence over environments. The cognitive limits on strategic and efficient choice, increases the risks and uncertainties associated with change and consequently inert behaviour is considered as the best safeguard for survival (Stinchcombe, 1965; Aldrich, 1979; Hannan and Freeman, 1984, 1989; Singh et al., 1986). The adaptation perspective stresses the co-evolution of organisational competencies, behaviour and environmental dynamics and infers that a fit between strategic choice and environmental change significantly enlarges life chances of organisations (Nelson and Winter, 1982; Tushman and Romanelli, 1985; Haveman, 1992; Langlois and Robertson, 1995; Teece and Pisano, 1998).

Hannan and Freeman (1984) (p. 151) defined *structural inertia* in relative and dynamic terms. *Structural inertia* does not mean that organisational structures subject to strong inertial forces never change. It *means that organisations respond relatively slowly to the occurrence of threats and opportunities in their environments*. In particular structures of organisations have high inertia when the speed of reorganisation is much lower than the rate at which environmental conditions change. Inertia is caused by limited learning capabilities which makes continuous fine-tuning of strategies and structures to changing environmental circumstances unrealistic (Hannan and Freeman, 1984). Rational planning and controlled change is unfeasible because of the unpredictability of future environmental states, the political coalitions distorting rational organisational decision making and the loose coupling between intentions and outcomes, rendering every match between strategic action and environmental dynamics random. Since organisational change implies processes of dismantling one structure and building another it makes organisations and its routines unstable. Whereas inertia prevents organisations from the risk of lowering their performance in the short and medium term and from death in the long run. Due to the preference of market environments for consistent firm performance, inertia is the best behavioural alternative even in turbulent environments (Stinchcombe, 1965; Hannan and Freeman, 1984, 1989). This yields the following selection hypothesis: Inertia prevents risky managerial conduct and improves performance because of high routinization and the avoidance of dismantling organisational structure and building another making organisational action unreliable. Therefore, inert firms probably outperform pro-active firms (Fig. 1).

Evolutionary economists (Nelson and Winter, 1982; Langlois and Robertson, 1995; Teece and Pisano, 1998) certainly recognise inertial properties of organisations. Their account for inert behaviour builds on the notion of path dependence and routines, both limiting firms' learning capabilities. Nelson and Winter (1982) stressed that it is quite inappropriate to conceive of firm behaviour in terms of deliberate choice from a broad menu of alternatives that some external observer considers to be available for the organisation. The menu is not broad, but narrow and idiosyncratic; it is built into the firm's routines, and most of the choosing is also constrained by the available resources and routines. Teece and Pisano claim that firm's previous investments and its repertoire of routines constrains its future behaviour, while opportunities for learning

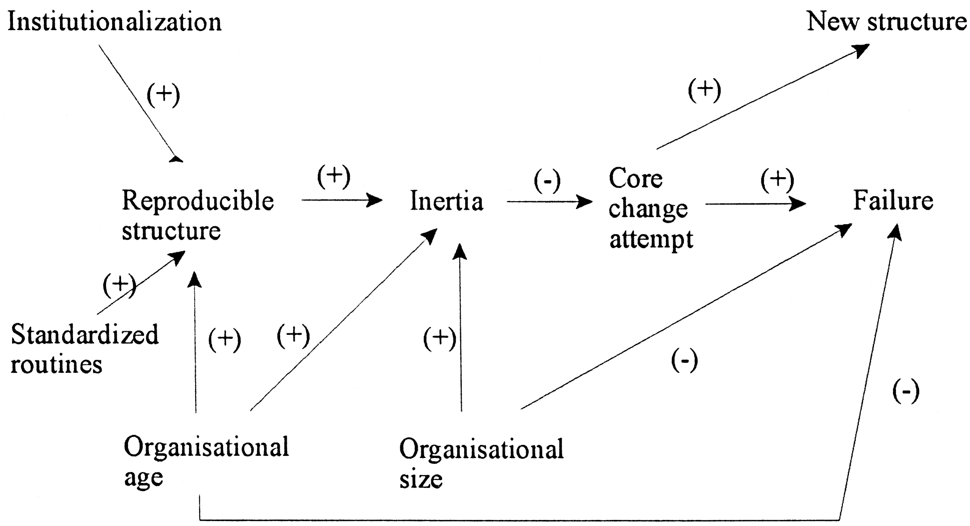

Fig. 1. A basic view of structural inertia (Kelly and Amburgery, 1991).

will be ‘close in’ to previous activities. They also stressed the risks of too much simultaneous change, because that might attenuate firms’ competencies to conduct meaningful natural quasi experiments (Teece and Pisano, 1998, p. 203). Leonard-Barton (1992) succinctly summarized these ideas noting that an organisations core capabilities can just as easily create ‘core rigidities’.

The major cleavage between inertia theory and evolutionary theory of the firm lies in the role of innovation. From inertia theory one can infer that innovation is a major risk that firms ought to avoid, whereas. Nelson and Winter (1982, p. 131) conceive innovative activities as a component of behavioural routines determining the competitive edge of firms. The benefits of inert behaviour are disputed by evolutionary economists because inertia implies the risks of not adapting. Inertia is deemed beneficial only in stable environments, while it is harmful in unstable environments. In unstable environments firms have to learn in order to survive. So if inertia hampers learning it is considered as a risk (Langlois and Robertson, 1995). Haveman (1994) contends that if the conditions that affect performance fluctuate greatly, then organisations that reproduce their previously effective structures will perform inconsistently. If the outputs required change frequently and by large amounts; the inputs available change in quantity, quality, or relative proportions; or the applied technologies change, then organisations will be forced to alter their structures and activity patterns to achieve consistent performance. Haveman (1994) concludes that especially in unstable and uncertain environments, selection pressures will favour flexible organisational forms—forms that adjust to perform consistently. In their reflections on dynamic capabilities of firms, Teece and Pisano (1998) (pp. 194, 201) also adhere an adaptation perspective. Winners in the global market places were able to demonstrate timely responsiveness and rapid and flexible product innovation, coupled with the management capability to effectively coordinate and redeploy internal and external competences. So, in dynamic environments, narcissistic organizations are likely to be impaired. This yields the adaptation hypothesis: Inertia inhibits learning processes and lowers performance because of growing deficiencies in competences to align behaviour with environmental demands. Therefore, pro-active firms probably outperform inert firms.

2.2. Research model, measurement and research questions

The integration of the selection and adaptation perspective aims at a full treatment of organisation–

Table 1
Categories of adaptive firm behaviour combining two levels of environmental dynamics with two levels of activities

Level of activities	Environmental dynamics	
	High	Low
High	fit alert	alert
Low	inert	fit inert

environment relations. Both perspectives link environmental dynamics and firms' responses. However, inertia theory concentrates on the most extreme version of consistency between strategic orientation and environmental conditions (Tushman and Romanelli, 1985) namely low levels of organisational change in volatile environments, whereas adaptation theorists tend to concentrate on first movers, risk takers, so firms with high levels of activities, relative to the environmental dynamics.

In order to compare effects of firm behaviour on innovative performance we first defined *categories of adaptive behaviour* covering all combinations of high and low activity levels with high and low levels of environmental dynamics. Each separate category signifies a specific level of change in organisational core features, in response to environmental changes (Levinthal, 1994). Inert and fit inert behaviour represent the selection perspective, whereas fit alert and alert behaviour represent the adaptation perspective (Table 1).

Secondly, we specificied these four categories of adaptive behaviour into *three types of adaptive firm behaviour* defined by the organisational domain in which the activities take place, which was not taken into account by Hannan and Freeman (1984, 1989). Furthermore, this elaboration fits the findings of an extensive body of empirical research, revealing that innovative performance depends on change in organisational features, as well as on change in innovative activities and change in strategies. These conceptual elaborations yield the independent variables in our research model.

First of all, successful innovation depends on technological competencies. If a firm is unable to judge and monitor technological developments and use them for its own product or process innovation or for decisions to adopt new technologies, successful innovative performance probably will not occur (Leonard-Barton and Doyle, 1996; Freeman and Soete, 1997). In our model categories of technological adaptation refer to the level of activity that a firm demonstrates in altering its processes and products technologically in relation to external innovation pressures. [6]

Strategic management also contributes to the success of process and product innovation. In particular the interaction of users and producers in the design and development contribute strongly to innovative success (Teubal, 1976; von Hippel, 1976; Lundvall, 1992, 1993; Meeus et al., 1999). Here categories of strategic adaptation are defined by the level of activity that a firm exhibits when it alters its competitive stance in areas such as pricing, advertising, new products or service introductions, and market scope

[6] For the operationalisation of technological inertia the following procedure was used. Environmental dynamics were calculated as the mean score of nine items indicating external innovation pressure: (1) customer asked for a new product, (2) customer asked a new operation method, (3) competitors had an equal new product, (4) competitor had an equal new process/equipment, (5) maintain market shares, (6) increase market share, (7) discovery of new markets, (8) adaptation to regulation, (9) standardization (DIN, ISO). The level of technological activity was measured with the number of radical product and process innovations. Next, the scores for innovation pressures and technological activity level were divided in two percentile groups, with relatively high and low levels of activities, high or low levels of innovation pressures, respectively. A combination of the groups on each dimension resulted in the four categories of adaptive firm behaviour in the domain of technology as presented in Table 1. Both the variables environmental dynamics and technological activities, were divided into two percentile groups, showing either relatively high or low levels of strategic activities, and relatively high or low levels of perceived environmental dynamics. A combination of these groups resulted in four categories of 'technological adaptation' as presented in Table 1. Each category was dummy coded. To avoid the idea that we interpret the scale inert–alert as an ordinal variable, we subsequently applied a dummy coding. If, and only if a firm is placed in a specific cell of Table 1, we assigned the value one for the concerning category of adaptive behaviour, otherwise we assigned the value zero to that firm. This procedure was applied for every category of strategic and technological adaptive firm behaviour. This procedure for dummy coding is often applied in comparative sector studies (Brouwer and Kleinknecht, 1994).

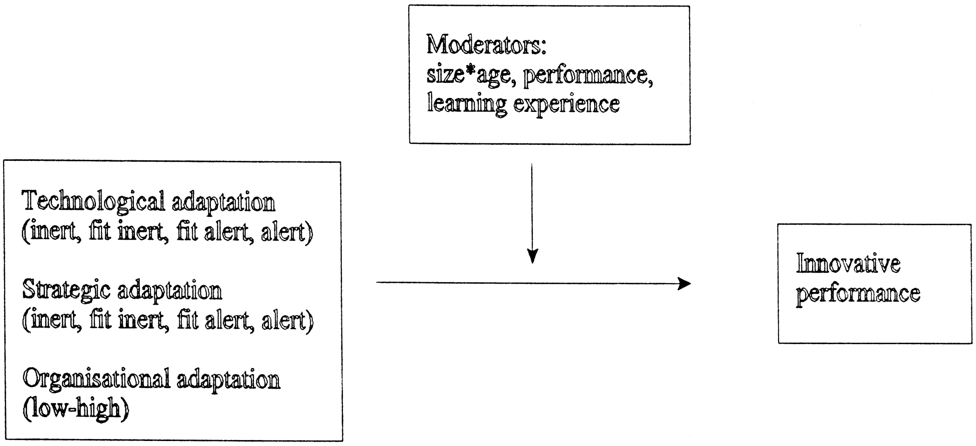

Fig. 2. A conceptual model of the relation between adaptive firm behaviour and innovative performance and its moderators.

relative to environmental dynamics in suppliers and buyers markets (Miller and Chen, 1994).[7]

There is also ample evidence showing that the successful adoption of process innovations depends on organisational, technical, and managerial interventions supporting those changes (Barley, 1986; Leonard-Barton, 1988; Dean and Snell, 1991; Meeus, 1994; Rosenkopf and Tushman, 1994; Dougherty, 1996). Tyre and Orlikowski (1997) show that the adoption of new process technologies demands several years of organisational adaptations. Levels of organisational adaptation are specified by the level of activity relative to dynamics in the internal organisational environment (Langlois and Robertson, 1995; Drazin and Rao, 1996). Organisational adaptation indicates the number of organisational changes in the production organisation associated with the implementation of product and process innovations (Dean and Snell, 1991).[8]

[7] In the operationalisation of strategic adaptation two variables were combined. The first variable describes the amount of perceived environmental dynamics. As Duncan (1972) argued, the perceived environmental dynamics is a good estimator of perceived environmental uncertainty. A mean score was calculated for nine items pertaining to the volatility of supplier and customer relations measured in terms of: (a) the level of change of the group of suppliers and/or customers in the period 1988–1993, (b) the frequency in which changes of suppliers and customer relations are considered. The second variable describes the level of strategic activities. A mean score was calculated for strategic activitiets implemented between 1988 and 1993. Eight strategic activities were distinguished: (1) cost reduction of purchase, (2) changing the production process or the organisational structure, (3) improving the marketing effort, (4) changing product–market combination, (5) expansion, merger, (6) reducing economic activities, (7) specialisation, (8) promote cooperation with suppliers and customers. Each category of strategic adaptation was dummy coded. See our argument in [6].

[8] Organisational adaptation was measured with eight indicators for the intensity of the changes in the production organisation due to internal innovation pressures. There were four related, but mutually exclusive items which dealt with the impacts of product and process innovations to the production process and to the product features or range. If firms report incremental innovations, they can only respond to the four items pertaining to the related items 2, 4, 6 and 8. Whereas firms reporting radical innovations they can only respond to items 1, 3, 5 and 7. Respondents were asked: (1) whether radical process innovations cause change in machinery and production organisation, (2) incremental process innovations caused changes in machinery and production organisation, (3) whether radical process innovations changed products, (4) whether incremental process innovations affected products, (5) whether the introduction of totally new products for the firm caused changes in machines or production organisation, (6) whether incremental product innovations affected machinery or production organisation, (7) whether introduction of totally new products caused changes in other products, (8) whether incremental product innovations caused changes in other products. A five-point scale was used, 1 indicating that there was no change at all and five indicating there were major consequences of incremental or radical process or product innovations on the production organisation. The variable organisational adaptation represents the mean score of four different items describing the mean impact of internal innovation pressures on other processes and products in an organisation. High values of this variable stand for major organisational changes in production under the condition of internal innovation pressures whereas low values imply relatively low levels of organisational change under the condition of internal innovation pressures.

The dependent variable in our research model is the innovative performance of firms defined as the contribution of product and process innovations to a firm's economic performance (Dornblaser et al., 1989; Brouwer and Kleinknecht, 1994; Archibugi and Pianta, 1996) (Fig. 2). [9]

From our research model we derived three research questions. (1) To what extent do inert and fit inert firms outperform fit alert and alert firms with regard to their innovative performance? (2) To what extent do predicted effects of adaptive behaviour on innovative performance derived from the selection and adaptation perspective apply to the domain of technology, strategy and organisation? [10] (3) To what extent are predicted effects of adaptive behaviour on innovative performance derived from the selection and adaptation perspective moderated [11] by size × age, performance patterns and innovation induced learning problems?

The first moderator variable to be considered is the combination of size and age. In population ecology there are numerous studies analysing age and size dependence of survival (Baum, 1996). Theorem 2 of inertia theory (Hannan and Freeman, 1984, p. 157) reads: structural inertia increases monotonically with age. This is often called the 'liability of newness' hypothesis (Stinchcombe, 1965). New organisations have lower levels of reproducibility as well as less legitimacy compared to older firms. Development of trust, smoothly working relationships and routines take time (Nelson and Winter, 1982). Although there is empirical support for the liability of newness hypothesis (Hannan and Freeman, 1984, 1989; Kelly and Amburgery, 1991). Baum (1996) (p. 79) criticised these studies because they did not control for size. He cites recent studies, controlling for organisational size showing that failure rates do not decline with age. In innovation studies the link between size and innovative activity is well documented. Yet, the results are inconclusive (Baldwin and Scott, 1987; Cohen and Levin, 1989; Freeman and Soete, 1997). Firm size has a dual effect on firm behaviour. On the one hand, large firms have qualitatively and quantitatively more comprehensive resource bases and therefore are better equipped to innovate successfully and to compete pro-actively and aggressively. Compared to small- and medium-sized firms, large firms are favoured by the availability of internal funds in a world of capital market imperfections. Cash flow for instance, a measure of internal financial capabilities, is empirically associated with higher levels of R&D intensity (Cohen and Levin, 1989, p. 1072). Simultaneously, slack resources buffer firms from competition and promote insularity, and it affords economies of scale that capitalize on inertial routines (Miller and Chen, 1994). On the other hand, large firms are more bureaucratic than small and medium-sized enterprises. The rigid rules and routines that so profoundly permeate many larger companies may make change difficult (Miller and Friesen, 1982, 1984; Starbuck, 1985; Tushman and Romanelli, 1985).

Since age and size are empirically associated—younger organisations tend to be smaller, and larger organisations tend to have a higher age (Mitchell and Singh, 1993, p. 167)—we shall combine size and

[9] The dependent variable in our research model is innovative performance. This variable is a mean score of eight items indicating performance improvements due to product and process innovations. Managers were asked to judge the performance improvements due to process and product innovations on a Likert scale with values (1) very little–(5) very much. For process as well as product innovations the items were: contribution of innovation to cost cutting, increase of turnover, increase of profits, quality improvement. The highest score could be 8, the lowest score could be 1.

[10] Given our operationalisations, a full confirmation of the selection perspective would imply: (a) positive betas for technological and strategic inert and fit inert behaviour, positive betas for organisational adaptation, (b) negative betas for technological and strategic fit alert and alert behaviour and negative betas for organisational adaptation. A full confirmation of the adaptation would imply the exact opposite pattern of beta signs. This applies for research questions 1 and 2.

[11] The effects of moderator variables are derived from a comparison between (a) the explained variance of the model for the total population (or the base line model) and for the subsamples, and (b) the number, the signs and strength of significant beta coefficients between the base line model and the model estimated for a subsample. In general, moderator effects are considered stronger if differences between the base line model and the models for the subsamples are larger.

age in three subsamples.[12] This enhances a systematic comparison of levels of bureaucracy, legitimacy, and the size of the resource base. So research question 3a reads: *To what extent is the relation between adaptive firm behaviour and innovative performance moderated by size × age.*

The second moderator variable taken into consideration is economic performance. Most accounts for the impacts of past performance on the probability of change are either motivational or cognitive. In early research on organisations, March and Simon (1958) and Cyert and March (1963) argue that organisations change in response to abnormally poor performance. Their theory of failure-induced change posits that performance below organisational expectations, causes managers to search for potential improvements. Poor performance, especially relative to competitors, is an indication that there exists an alternative organisational form with expected performance higher than current realized performance (Schaefer, 1998). Other researchers also paid attention to effects of high performance. Each time an organisation engages in a particular kind of change it increases its competency at that change. If a particular kind of change becomes linked with success in the minds of organisational decision-makers reinforcement effects will make repetition even more likely (Kelly and Amburgery, 1991, p. 606). Miller and Chen (1994) (pp. 4–5) compared the diverging effects of poor and good performance: (1) good performance induces managers to believe that they have 'gotten it right', making them reluctant to change, whereas poor performance widens the gap between managerial aspirations and achievements and thus motivates remedial action, (2) success can blind managers to the need for action, whereas failure provides managers with an incentive to scan their environments to find out what is wrong. Such problem-driven search can generate important information that will motivate corrective adjustments and promote new activities.

The issue remains whether patterns of economic performance weaken or strengthen the influence of categories of adaptive behaviour on innovative performance. In order to explore the moderating effects of patterns of economic performance we drew up three subsamples of innovative firms: (1) firms consistently expanding economic activities, (2) firms with decreasing economic performance, (3) firms with improving economic performance.[13] Thus, research question 3b is as follows: *To what extent do patterns of economic performance moderate the relation between adaptive firm behaviour and innovative performance.*

The third moderator variable we explored was 'the number of learning problems experienced during innovation processes'. This variable indicates the level of risk a firm has taken with the innovation

[12] Size was measured by asking an open question about the number of full-time employees working at the establishment at the time of data acquisition. Age was measured by asking an open question about the year in which the enterprise was founded. The combination of size and age classes produced three subsamples of firms: (1) small, young firms (< 10 years with 5–50 employees); (2) small, old firms (> 20 years with 5–50 employees); (3) large, old firms (> 20 years with > 100 employees). Because the sample of firms < 10 years and > 100 employees was much smaller than the other subsamples—it had only 11 cases whereas the other had 94, 223 and 139—it was not taken into account.

[13] Economic performance was measured by two questions measuring the shifts/stability in strategic position in 1988, respectively, in 1993 in terms of the development of economic activities (Dean and Snell, 1991; Mitchell and Singh, 1993). Because some researchers believe that the emerging type of adaptive behaviour is as much a product of failure as of success we combined both types of indicators (Miller and Chen, 1994). There were three possible answers: (1) we cut back our economic activities, (2) no cut back–no expansion of activities, (3) we expand our economic activities. We drew up three subsamples of firms: (1) a group of firms consistently expanding their economic activities between 1988 and 1993; (2) a group of firms with decreasing performance, which expanded their activities in 1988, while they were curtailing their activities in 1993; (3) a group of firms with improving performance, which economised their economic activities in 1988 and expanded these in 1993. Of course we are aware of the limitations of this indicator.

processes implemented by the firm.[14] Relatively many learning problems reveal that firms initiate innovation projects exceeding their competencies, available resources and routines, while the experience of few learning problems indicates that innovation projects fit the available capabilities and resources. In general the problematic of innovation is defined in terms of learning problems and uncertainties. Nelson and Winter (1982) distinguished two kinds of uncertainty. First, the precise nature of the achieved innovation is not predictable at its inception. Second, the consequences of employing the innovation—changing the routine—will only be predictable if a reasonable amount of actual operating experience has been accumulated. Dougherty and Hardy (1996) give an empirical account of a number of innovation problems, indicating the complexity of innovation processes. First, there is the challenge of connecting innovations with routine operations, because structures and strategies in mature organisations reinforce existing practices and are hostile to creativity. Second, an organisation with both innovation projects and mature businesses ideally will have a resource system that simultaneously channels money, equipment, expertise, and information to all these activities. This resource system should also nurture new ideas and continuously raise and solve problems. Unfortunately, resources do not always flow smoothly to innovation, particularly where prevailing practices support established activities. This yields research question 3c: *To what extent do different levels of innovation induced learning problems moderate the relation between adaptive firm behaviour and innovative performance*?

[14] The variable ‘number of learning problems’ contains a count of confirmative answers to a self-report question regarding problems that occurred in innovation processes between 1988 and 1993. We applied the following items: (1) problems with generation of ideas, (2) economic feasibility, (3) technical feasibility, (4) technical realisation, (5) implementation, (6) introduction in the market, (7) exceeding time limits, (8) product deficiencies, (9) technical deficiencies in production, (10) exceeding project budgets, (11) bad timing, (12) wrong partners in projects, (13) reaction of competitors, (14) shortcomings in market introduction. The total count of learning problems were recoded by means of the spss rank procedure in a two percentile group. This yields a group of innovative firms with a relatively low and a relatively high level of learning problems.

3. Method

3.1. Type of research and level of analysis

This research is exploratory. It introduces notions of population ecology in the field of innovation research, where it was never applied. Consequently, there is no empirical research that addresses the issue of innovative performance in the same way. Therefore, we could not draw up clear-cut hypotheses. Our variables are defined and measured at the micro level of firms. So our level of analysis is the organisation and not the population or community of organisations as is the case in most ecological research (Baum, 1996).

3.2. Sample

A survey was administered to industrial firms with five or more employees in the region of North Brabant (a province in the southern part of the Netherlands). The data acquisition took place between December 1992 and January 1993[15] in a Dutch region with specific features. First, this region is one of the most industrialized regions in the Netherlands. In 1992 the total number of persons with jobs in manufacturing was roughly 210.000. Manufacturing covers 28.8% of employment in North Brabant, in the Netherlands it was 19.5%. Second, at the time of the survey this sector faced a severe economic crisis. Large firms such as DAF, Volvo (automotive) and Philips (electronics) were confronted with extreme losses, which resulted in a massive loss of jobs and radical reorganisations. Naturally the small and medium-sized firms, often suppliers of the larger firms, felt the consequences too. In other words, there were strong environmental pressures on the firms in the region.

The region of North Brabant has an industrial population of firms with a mix of small, medium-

[15] The majority of our respondents returrned their questionnaires in 1993. To avoid confusion we shall only use 1988–1993 when we are discussing measurement or outcomes of variables covering a 5-year period. It is obvious though that the respondents who filled in the questionnaire in December 1992, answering questions about for instance their turnover of 5 years ago, these answers pertain to 1987.

sized, and large firms. Furthermore the manufacturing sector has shown a relatively high performance in R&D and exports (Oerlemans and Meeus, 1995). Because technological dynamics are an important issue in this paper, it is interesting to group industrial sectors according to Pavitt's taxonomy (Pavitt, 1984). This means that industrial sectors are categorised in terms of (a) the sources of technology used in a sector. In particular, the degree to which it is created within the sector, or is generated from outside through the purchase of production equipment, components or materials. (b) The nature of the technology produced in a sector, i.e., the relative importance of intra and extra-organisational knowledge sources and of product and process innovations. (c) The features of (innovating) firms, in particular their size, R&D effort and principal activities. These criteria were applied to the responding firms by Oerlemans (1996).

Table 2 shows that our sample has a high-tech bias due to the relatively high percentages of specialised suppliers and the science based industries. Yet, this sample bias is limited. The maximum difference between the proportion of a sector in the total population and our sample is within 11% boundaries. In our analyses we used data from 403 firms who reported innovations in the period between 1988 and 1993.

3.3. Analyses

In order to test our hypotheses OLS regression analyses were applied. Because our empirical model contains dichotomous as well as numeric operationalisations for adaptive firm behaviour as predictor variables, the interpretation of our findings deviates from standard models containing numerical variables only. [16]

Table 2
Population and sample of responding firms divided in Pavitt sectors

Pavitt sector	Population	% Population	Sample of responding firms
Supplier Dominated	1028	33.5%	22.9% (92)
Scale Intensive	1261	41.1%	34.1% (137)
Specialised Suppliers	417	13.6%	22.1% (90)
Science Based	363	11.8%	20.1% (84)
Total	3069	100%	100% (403)

The interpretation of our findings are straightforward. For the dummy coded variables (categories of technological and strategic adaptation) a significant positive beta of, for instance, technological inert behaviour means that those firms are comparatively better with regard to innovative performance, than the firms which are not technological inert. A negative beta for technological inert behaviour implies that these firms benefit less from their innovations, than the firms that are not technological inert. For organisational adaptation the interpretation of research findings is slightly different. Positive betas for organisational adaptation imply that higher scores—so higher levels of organisational change due to internal innovation pressures—co-vary with higher levels of innovative performance. In that case, organisational adaptation is conducive to innovative performance and allows firms to benefit from its innovations. Significant negative betas would mean that high levels of organisational adaptation are associated with low levels of innovative performance, and that low levels of organisational adaptation are associated with high innovative performance. In this case organisational adaptation hampers firms to benefit from their implemented innovations.

In our analyses we controlled for collinearity which means that different variables provide very similar information. The consequence is that the effects of individual variables are difficult to sepa-

[16] The least-square regression model can easily be extended to accommodate dichotomous predictors, including sets of dummy variables (Menard, 1995, p. 5; Harnett, 1982, pp. 571–575). With the dichotomous predictors for each category of technological and strategic adaptation, the intercept and the slope have a special interpretation compared to numerical variables measured at interval, or ratio level. It is still true that the intercept is the predicted value of the dependent variable when the independent variable is coded zero (e.g., not inert) but with only two groups the intercept now is the mean innovation outcome for the group coded as zero. The slope is still the change in the dependent variable associated with one-unit change in the independent variable, but with only two categories; that value becomes the difference in the mean scores in the criterion variable (innovative performance) between e.g. the first (not inert) and second group (inert). The sum of the slope and the intercept is therefore the mean innovation score for the second group (inert).

rate, which causes interpretation problems. Where collinearity occurred in the analyses, variables were excluded from the regression equation or deleted from the analysis. Control on collinearity was done using the variance inflation factor. [17]

4. Results

Table in Appendix A.1 displays the descriptive statistics of the variables in our research model. Science based industries have the highest mean score on innovative performance. Our sample has a relatively high number of fit alert firms (45.4% strategic fit alert firms, 53.6% technological fit alert firms). Yet there is also a substantial number of inert firms in the field of technology (17.9%), as well as in the field of strategy (20.1%). In general the mean score on organisational adaptation is very low. Obviously, most firms implement product as well as process innovations without much organisational adaptation, which contrasts strongly with the proactive behaviour in the domain of technology and strategy of the larger part of our sample.

Table in Appendix A.2 displays the relevant correlations between the predictor and criterium variables used in our regression analyses. These findings strongly support the adaptation perspective and reject the selection perspective. Inert and fit inert behaviour is negatively correlated with innovative performance, whereas fit alert behaviour is positively correlated with innovative performance, in the field of strategy and technology. In the field of organisation our data revealed the same result. Higher levels of organisational adaptation are positively associated with higher levels of innovative performance. Our findings pertaining to the impacts of organisational adaptation on innovative performance might cause some interpretation problems as to which perspective they support. Since the scores on organisational adaptation in general were no higher than three on a five point scale (five meaning radical organisational changes), and higher levels of organisational adaptation were positively correlated with innovative performance, one could infer that even marginal organisational changes bring about positive innovation outcomes. Nevertheless we reject such an inference and stick to our starting point that a confirmation of the inertia hypothesis means a significant negative relation between organisational adaptation and innovative performance. Only in that case higher levels of organisational adaptation would cause lower levels of innovative performance, which would confirm that organisational change is detrimental for innovative performance.

Table 3 (column 1) displays our findings of the regression of innovative performance on adaptive behaviour. Again our results clearly confirm the adaptation perspective and partially rejects the selection perspective. Fit inert behaviour is detrimental for the innovative performance, whereas fit alert and alert behaviour improves innovative performance.

Table 3 (column 1) also answers our second research question and suggests that alert and fit alert behaviour does not pay off in the context of strategy in the same way as it does in the field of technology and organisation. This implies that the claims of neither the selection, nor the adaptation perspective are valid in all organisational domains.

The findings in Table 3 (columns 2–4) regard research question 3a and partially confirm the moderator effect of size $\times$ age, except for organisational adaptation. Our results suggest that impacts of particularly technological and adaptive behaviour on innovative performance are very sensitive for the moderating effects of size $\times$ age. In the groups of firms with comparatively low resource levels and low legitimacy (column 2) technological fit alert and alert behaviour and higher levels of organisational adaptation are conducive to innovative performance, whereas strategic fit inert behaviour hampers innovation outcomes. Small firms older than 20 years (column 3) also benefit from technological fit alert and alert behaviour and higher levels of organisational adaptation. Yet, here the negative impacts of strategic fit inert behaviour disappeared. For older, large firms (column 4) the picture changes in so far that technological inert and fit inert behaviour appears to be detrimental for innovation outcomes.

Our results in Table 3 (columns 5–7) confirm the moderating effects of firms' economic performance

[17] This quantity is called the variance inflation factor (VIF) since the term is involved in the calculation of the variance of the ith regression coefficient (Norusis, 1990). The formula is: $\mathrm{VIF}_i = 1/(1 - R_i^2)$.

Table 3
Regression of innovative performance on adaptive firm behaviour (column 1), controlling for size × age (columns 2–4), performance patterns (columns 5–7), level of learning problems (columns 8–9)

Independent variable	Dependent variable								
	1, Innovative performance	2, Innovative performance of firms: < 10 years, < 50 employees	3, Innovative performance of firms: ≥ 20 years, < 50 employees	4, Innovative performance of firms: ≥ 20 years, ≥ 100 employees	5, Innovative performance of firms: expansion 1988, expansion 1993	6, Innovative performance of firms: expansion 1988, cut back 1993	7, Innovation outcomes of firms: cut back in 1988, expansion in 1993	8, Innovative performance of firms with relatively few learning problems	9, Innovative performance of firms with relatively many learning problems
Technological inert	–	0.07	0.12	− 0.35****	− 0.05	− 0.20*	− 0.15	0.14**	0.07
Technological fit inert	− 0.10***	− 0.04	− 0.10	− 0.34****	0.02	− 0.23**	− 0.69****	–	− 0.05
Technological fit alert	0.34****	0.32****	0.40****	0.01	0.34***	(− 0.36***)	0.06	0.53****	0.29***
Technological alert	0.18****	0.15*	0.23***	− 0.01	0.09	(0.27***)	0.10	0.35****	0.12
Strategic inert	− 0.02	0.02	− 0.02	0.08	0.10	− 0.06	0.18	0.05	(0.11**)
Strategic fit inert	− 0.09***	− 0.14***	− 0.06	− 0.06	− 0.06	− 0.02	–	− 0.05	− 0.05
Strategic fit alert	0.02	0.06	0.06	0.02	− 0.04	0.06	0.3*	0.13***	− 0.03
Strategic alert	− 0.05	0.06	0.02	− 0.06	− 0.02	0.00	− 0.20	− 0.01	− 0.02
Organisational adaptation	0.45****	0.57****	0.47****	0.42****	0.49****	0.61****	− 0.13	0.41****	0.53****
R^2	0.58	0.63	0.55	0.65	0.50	0.65	0.84	0.63	0.48
F-value	91.17	48.08	47.23	51.58	31.96	23.07	28.87	73.17	55.82
p	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
df	6,396	3,84	3,117	3,83	3,96	3,37	2,11	5,214	3,179

*: $p < 0.10$, **: $p < 0.05$, ***: $p < 0.01$, ****: $p < 0.001$.
–, Exceeding tolerance limit 0.000, variable deleted from analysis.
(...), Variable excluded from the model due to collinearity.

between 1988 and 1993 on the relation between adaptive behaviour and innovative performance except for organisational adaptation. Firms consistently expanding their economic activities (column 5) benefit from technological fit alert behaviour and higher levels of organisational adaptation. Firms with decreasing performance (column 6) attenuate their innovative performance with inert and fit inert behaviour, whereas they benefit from organisational adaptation. Firms with improved performance (column 7) benefit from strategic fit alert behaviour and aggravate their innovative performance with technological fit inert behaviour.

Finally, our findings in Table 3 (columns 8–9) provide partial support for the moderating effects of the learning problems experienced during innovation projects. Again effects of organisational adaptation on innovation outcomes turned out to be less sensitive for the effects of moderators. Under the condition of low learning problems (column 8) even technological inert behaviour appeared to be beneficial for innovative performance. However the general pattern of our findings remains in support of the adaptation perspective showing the benefits of technological fit alert and alert adaptive behaviour. Under the condition of higher levels of learning problems (column 9) the significant beta of technological inert behaviour disappears. Technological fit alert and high levels of organisational adaptation nurture innovative performance of industrial firms.

5. Discussion and conclusions

This is one of the first studies that provides evidence suggesting that fit inert and inert behaviour is detrimental for innovative performance whereas fit alert and alert behaviour is beneficial for innovative performance. Our findings in Table 4 leads us to question the validity of the selection perspective applied to the relation between firm behaviour and innovative performance. On the one hand our findings show that environmental changes absorbed by means of (fit) inert behaviour either are detrimental for innovative performance, or have no effect. On the other hand our results suggest that environmental change assimilated by means of particularly fit alert adaptive behaviour is beneficial for innovative performance. So, our findings in general support the adaptation perspective. One interpretation for this finding is that the risk avoidance inherent to inertness hampers the development of experimental behaviour and learning needed for successful innovation. Another interpretation is that the modes of experimental behaviour developed by inert firms do not fit internal and external environmental pressures. Conversely fit alert firms develop modes of experimentation which turn out to be beneficial for innovative performance.

Yet, the claims of the adaptation perspective have to be weakened. Our second research question dealt with the validity of the claims of the selection or the adaptation perspective in different organisational domains. Our results pertaining to research question 2 indicated that high activity levels are the most beneficial in the domains of technology and organisation and have a less clear pay off in strategy. This puts the role of strategy in explaining innovative performance in perspective. An explanation of this contrast between the effects of technological and strategic alertness is that technological activities focus directly on the innovation process, while strategic activities have a broader focus and other objectives than improving innovative performance.

Finally, our findings with respect to research question three also indicate that the claims of the adaptation perspective have to be weakened. Organisational features (rq 3a–c) controlling for differences in resource bases, legitimacy and bureaucracy (size × age), different patterns of economic performance, and learning experiences proved to partially moderate the relation between adaptive behaviour and innovative performance. Organisational adaptation is in general conducive to innovative performance and turned out to be virtually insensitive for moderator effects.

The findings pertaining to research question 3a show that neither the legitimacy effect, nor the limited resource base impacts on innovativeness of small firms. Small firms, whether young or old, benefit from both categories of alert behaviour (high activity levels) in the field of technology and organisation. Small firms seem to be able to develop adaptive behaviour that is conducive to their innovative performance with their limited resource base. Old, large

Table 4
An assessment of the empirical relevance of measures for adaptive firm behaviour predicting innovative performance

Independent variables	Number and value of significant β coefficients confirming the inertia hypothesis	Number and value of significant β coefficients confirming the adaptation hypothesis	Number of equations in which variable is included
Technological inert	1 (0.14)	2 (−0.20 to −0.35)	8
Technological fit inert	0	4 (−0.10 to −0.69)	8
Technological fit alert	0	6 (0.29 to 0.53)	8
Technological alert	0	4 (0.15 to 0.35)	8
Strategic inert	0	0	9
Strategic fit inert	0	2 (−0.09 to −0.14)	8
Strategic fit alert	0	2 (0.13 to 0.34)	9
Strategic alert	0	0	9
Organisational adaptation	0	8 (0.41 to 0.61)	9

firms suffer from either technological inert or fit inert (low activity levels) and have no benefits from high activity levels in the field of technology, while they do benefit from higher levels of organisational adaptation. Obviously higher levels of bureaucracy counteract positive effects of fit alertness on innovative performance in large firms, whereas higher resource levels and higher legitimacy do not enable large firms to reap the benefits of fit alert behaviour like small firms.

Our findings on research question 3b revealed that patterns of economic performance also moderated the conduciveness of adaptive behaviour to innovative performance. In part these outcomes contrast strongly with the notions of March, Schaefer, Kelly, etc., which implied that good performance breeds inertia and that poor performance motivates remedial action. Firms consistently expanding economic activities benefit from fit alert behaviour, so good performance does not counteract positive effects of fit alert behaviour on innovative performance. Recovering firms assimilating innovation induced change by means of technological fit inert or inert behaviour attenuate their innovative performance, whereas they benefit from strategic fit alert behaviour. For this specific group of firms the impetus of poor performance on adaptiveness indeed occurs as expected by aforementioned authors. Firms with decreasing performance are punished for their technological inertia. Here the impacts of poor performance are again rejected. These firms should have developed a high level of activity conducive to innovative performance, yet we found the opposite effect.

Finally, with respect to question 3c, we found that innovation projects fitting the learning capabilities of firms allow for a broad spectrum of types of adaptive behaviour to contribute to innovative performance. Innovation projects exceeding firms' learning capabilities contribute to innovative performance when they are assimilated by technological fit alert behaviour. Obviously, firms benefit most from high risk innovation projects, with high risk adaptive behaviour, whereas risk avoidance does not have a clear pay off.

Although we contend that the results of this study provide a valuable addition to the behavioural aspects of innovation theory, several cautions should be noted. The period covered by our data is relatively short—5 years—compared to most research in the field of population ecology. Compared to most innovation surveys, however, the time period covered is rather long. Our data are gathered in a relatively high-tech environment, which caused a pro-active bias in the firm behaviour. However, some findings allay our fear that this sampling bias also caused biassed research findings. First, fit alert behaviour in the domain of strategy impacts less frequently on innovative performance than technological fit alert behaviour. Second the relatively low mean scores on organisational adaptation.

Our findings have several implications. First it seems reasonable to infer that, although inertia the-

Appendix A

A.1. Descriptive statistics of innovation outcomes and adaptive firm behaviour

Sector	Innovative performance		Organisational adaptation		Categories of strategic adaptation[a]				Categories of technological adaptation[a]				Count row %
					Inert	Fit inert	Fit alert	Alert	Inert	Fit inert	Fit alert	Alert	
Supplier dominated	Mean	5.65	Mean	1.50	13	26	41	12	13	8	59	12	$n=92$
	Std. Dev.	2.06	Std. Dev.	1.16	14.1%	28.3%	44.6%	13%	14.1%	8.7%	62.1%	13%	100%
Scale intensive	Mean	5.66	Mean	1.41	31	32	57	17	22	12	74	29	$n=137$
	Std. Dev.	1.90	Std. Dev.	1.13	22.6%	23.4%	41.6%	12.4%	16.1%	8.8%	54%	21.2%	100%
Specialised suppliers	Mean	5.30	Mean	1.12	18	18	38	16	18	11	44	17	$n=90$
	Std. Dev.	2.04	Std. Dev.	1.20	20%	20%	42.2%	17.8%	20%	12.2%	48.9%	18.9%	100%
Science based industries	Mean	5.81	Mean	1.48	19	14	47	4	19	10	39	16	$n=84$
	Std. Dev.	2.01	Std. Dev.	1.35	22.6%	16.7%	56%	4.8%	22.6%	11.9%	46.4%	19%	100%
Total sample	Mean	5.61	Mean	1.38	81	90	183	49	72	41	216	74	$n=403$
	Std. Dev.	2.01	Std. Dev.	1.21	20.1%	22.3%	45.4%	12.2%	17.9%	10.2%	53.6%	18.4%	100%

[a] Percentages are row percentages.

A.2. Spearman rank correlations (listwise n = 403)

	1	2	3	4	5	6	7	8	9
1, Innovative performance									
2, Technological inert	−0.40****								
3, Technological fit inert	−0.40****	–							
4, Technological fit alert	0.55****	–	–						
5, Technological alert	0.00	–	–	–					
6, Strategic inert	−0.05	0.06	0.04	−0.09**	0.03				
7, Strategic fit inert	−0.22****	−0.02	0.16****	−0.22****	0.18****	–			
8, Strategic fit alert	0.27****	−0.10**	−0.16****	0.27****	−0.12***	–	–		
9, Strategic alert	−0.08**	0.10**	0.00	−0.02	−0.08*	–	–	–	
10, Organisational adaptation	0.77****	−0.49	−0.38****	0.55****	0.07	−0.06	−0.14***	0.23****	−0.10**

*: $p<0.10$, **: $p<0.05$, ***: $p<0.01$, ****: $p<0.001$.

–, No correlations calculated because of orthogonal operationalisation of variables.

ory is a powerful device in the explanation of population dynamics in the long run at the level of populations of organisations, this is not the case in the explanation of the variation in innovative performance of industrial firms in the short run. The benefits of inertia were nearly absent and the risks of alert behaviour were absent. In order to be a successful innovator, competing risks and risks amplifying each other, are effectively counteracted with fit alert behaviour: (1) fit alert and alert behaviour in general seem to neutralize the risks of change and death, in the sense that both influence innovative performance positively; (2) fit alert behaviour also counteracts the limited resource base of young, small firms; (3) fit alert behaviour is beneficial for innovative performance of firms consistently expanding economic activities and of firms recovering their economic position, thus it preserves and amplifies competitiveness; and finally (4) fit alert behaviour effectively counteracts the risks of innovation projects causing many learning problems. These findings correspond with the results of Rothwell (1992) suggesting that one of the corporate level factors positively affecting the success of innovations is the extent to which top management accepts risks. This yields an interesting counterintuitive finding, which implies that the best antidote for the risks and uncertainties caused by dynamics in technological, market and internal environments is a high risk strategy. In the context of innovation the problems of aligning internal and external demands cease to be well defined, in which case deductively rational decision-making becomes impossible and obviously is often replaced by inductively experimental behaviour (Metcalfe, 1995).

Second, these results also have implications for the relation between innovation management and technology policy. Most technology policies concentrate on resource allocation facilitating investment behaviour and counteracting market failure. In the evaluation protocol for the assignment of technology subsidies to firms neither the innovation management of firms, nor their general dynamic capabilities of firms are taken into account. Since our findings give serious indications for the conduciveness of fit alert behaviour to innovative performance, it might be worthwhile to add a company profile including innovation strategies to evaluation protocols for innovation projects. This would generate pressures for the adoption of competencies enhancing successful innovation strategies (Levinthal, 1994, p. 170).

Third, in a relatively nascent field such as innovation research, the adoption of ideas and perspectives from organisational sociology and evolutionary economics is especially important and useful in the development of more substantial theoretical accounts of firm behaviour and innovation, applicable in the development of innovation strategies and technology policies.

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