Endogenous Innovations in a Model of the Firm Theory and Empirical Application for West–German Manufacturing Firms

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Abstract:

In the paper, a theoretical model of the determinants of innovation behaviour and investment is developed. The model is estimated with a large micro-data panel of West-German manufacturing firms. The empirical results reveal positive effects from firm size and market power on innovations. In addition, exporters innovate more, and innovations depend positively on others innovations which indicates positive spillover effects. Finally, excess demand promotes innovations. This indicates the complementarity of innovations and investment and confirms the importance of financing constraints for innovation behaviour. It implies that temporary demand shocks affect output and productivity permanently.

Keywords: Endogenous innovations, market structure

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1 Introduction

The basic premise of most endogenous growth models is that technological progress is driven by innovations.[1] Firms innovate in order to reduce costs or to increase demand. Since the knowledge incorporated in innovations is non-rival and only partially excludable, firm size and market structure are important determinants of innovation behaviour:[2] Large firms on monopolistic markets must fear less imitation from competitors and gain more from scale economies associated with innovations; monopolistic profits permit an easier finance of risky innovation projects. Small firms on competitive markets, on the other hand, are forced to utilize the best available production technique and to develop better products; non-innovative firms must fear to be driven out of the market, while firms which successfully introduce an innovation gain from large increases in market shares.

However, the market structure itself is endogenous.[3] Innovations of firms change the market structure, and the intended change of the market structure is an important incentive for innovative activities: Firms develop differentiated products to earn more profits through a temporary monopolistic situation on the product market. In the long run, innovations of other firms destroy monopolistic rents, and the process of "creative destruction" is the driving force of endogenous technological change.[4]

In this paper, a theoretical model of the determinants of firms' innovation behaviour and investment is developed. The innovation decision is treated analogously to the investment decision, and the complementarity of innovations and capital investment is explicitely taken into account. A first topic is the discussion of market structure effects on innovations. Besides firm size, a measure of market power is derived from the price-setting behaviour of the firm, i.e. an information about the market structure is deduced from firms' market behaviour. A second topic is the analysis of the relation of innovations and the business cycle.[5] If the business cycle affects innovations, changes in aggregate demand affect output and productivity permanently. In the model, a delayed adjustment of innovations and investment with respect to demand shocks is assumed. The dynamic decision structure permits to discuss business cycle induced effects consistently within the framework of the theoretical model. A final topic are knowledge spillovers and the appropriability of the returns from innovations.

The model is estimated with a unique panel of annual firm-level data for West-German manufacturing. The data-set contains informations for 2405 firms

[1] See Romer (1990) and Grossman, Helpman (1994).

[2] See Kamien, Schwarz (1975), Cohen, Levin (1989) and Scherer, Ross (1990).

[3] See Dasgupta, Stiglitz (1980), Geroski, Pomroy (1990), Geroski (1995), and Smolny (1998b).

[4] See Aghion, Howitt (1992).

[5] See Blanchard, Quah (1987), Aghion, Saint-Paul (1993) and Geroski, Walters (1995).

for the period from 1980-1992 from the business survey, the innovation survey, and the investment survey of the ifo institute. The business survey contains the qualitative information, whether a firm has implemented product and/or process innovations, as well as data on price and output changes and capacity utilization. The innovation survey contains qualitative data on innovation activities and quantitative data on innovation expenditures. These data were matched with quantitative data on investment from the investment survey.

2 Theoretical framework

2.1 Assumptions

In the analysis, it is distinguished between the implementation of product and process innovations. It is assumed that process innovations affect the efficiency of labour and capital, and product innovations affect the demand curve. A successful product innovation implies that the quality of the product increases, and demand increases. In addition, process innovations are distinguished from capital investment. It is assumed that capital investment stands for quantity effects of homogeneous capital, while process innovations capture quality effects. Complementarities of product and process innovations, and of innovations and investment are taken into account.

In the theoretical model, a strong separability of the short-run and the long-run decisions of the firm is assumed. In the short run, output and prices are endogenous. In the long run, the firm decides on investment and innovations under uncertainty about demand. The analysis of a dynamic adjustment permits a consistent discussion business cycle induced effects on innovations within the framework of the model; the analysis of the adjustment in terms of delays and uncertainty reduces the dynamic decision problem of the firm to a sequence of static problems which can be solved stepwise. The analysis is carried out within a framework of monopolistic competition.[6] In order to distinguish demand shifts, the price elasticity of demand, and demand uncertainty, a log-linear demand curve for the firm's product is assumed:

$$\ln YD = \eta \cdot \ln p + \ln Z + \varepsilon, \qquad \eta < -1, \mathrm{E}(\varepsilon) = 0, \mathrm{Var}(\varepsilon) = \sigma^2 \tag{1}$$

Demand YD depends negatively on the price p with constant elasticity η, exogenous and predetermined factors incorporated in Z, and an error term ε which is not known at the time of the innovation and investment decision. Z, η, and σ are treated as predetermined in the short run; they depend on product innovations and on competitors' behaviour in the long run. Supply YS is determined by a short-run limitational production function with capital K and labour L as inputs:

$$YS = \min(YC, YL) = \min(\pi_k \cdot K, \pi_l \cdot L) \tag{2}$$

[6] See Blanchard, Kiyotaki (1989) and Smolny (1998a,b).

YC are capacities, YL is the employment constraint of the short-run production function, and π_l, π_k are the productivities of labour and capital. The factor productivities depend on the capital-labour ratio k and production efficiency θ, i.e. $\pi_l = \pi_l(k,\theta), \pi_k = \pi_k(k,\theta)$. Production efficiency depends on predetermined process innovations and productivity spillovers. Capacities and the capital-labour ratio are also treated as predetermined in the short run; they are determined by the long-run investment and innovation decision.

2.2 The dynamic adjustment of the firm

In the short run, the firm decides on output, prices, and employment. For the optimal solution, two cases can be distinguished:

- In case of sufficient capacities, the optimal price is determined by unit labour costs and the price elasticity of demand, $p(w) = w/(\pi_l \cdot (1+1/\eta))$. w is the wage rate. Output results from introducing this price into the demand function. The firm suffers from underutilization of capacities.

- In case of capacity shortages, output Y is determined from capacities, i.e. $Y = YC$. The price follows from solving the demand function for p at $YD = YC$. Insufficient capacities restrain output and the firm increases the price.

There is exactly one value of the demand shock $\varepsilon = \overline{\varepsilon}$ which distinguishes these cases, $\overline{\varepsilon} = \ln YC - \eta \cdot \ln p(w) - \ln Z$. Note that a large variance of demand shocks requires a high frequency of price and output adjustments. The model can be extended to allow for a slow adjustment of prices and employment.[7] In case of autocorrelated demand shocks, the model can be interpreted as an error correction model, i.e. prices and employment adjust to achieve an optimal utilization of employment. Then the medium-run adjustment of prices and employment with respect to demand shocks depends on the price elasticity of demand. A low absolute value of the price elasticity of demand $|\eta|$ favours quantity adjustments against price adjustments.

In the long run, the firm decides on capacities and innovations. Since there is uncertainty about the demand shock ε, the realized future values of output and prices are not known at the time of the investment decision. Optimization with respect to the capital stock yields:

$$\int_{\overline{\varepsilon}}^{\infty} [p(YC) \cdot (1+1/\eta) - w/\pi_l] \cdot \pi_k \cdot f_\varepsilon d\varepsilon - c = 0 \qquad (3)$$

f_ε is the probability distribution function of the demand shock ε. Marginal costs are given by the user costs of capital c. Marginal returns to capital are achieved only, if capacities become the binding constraint for output, i.e. if $\varepsilon > \overline{\varepsilon}$. They are given by the price, minus the price reduction of a marginal increase in

[7] See Smolny (1998a,b).

output, minus unit labour costs in the capacity constrained regime. A unique optimum exists, $p(YC)$ is decreasing in YC and K. It can be shown that the optimal value of $\overline{\varepsilon}$ depends only on the price elasticity of demand, relative unit factor costs, and the variance of demand shocks. A higher share of capital costs relative to wage costs reduces the optimal value of $\overline{\varepsilon}$: In case of high fixed costs, the firm chooses a higher probability of the capacity constrained regime; the choice of capacities can be understood as the optimal choice of the regime probabilities. A higher absolute value of the price elasticity of demand $|\eta|$ also reduces $\overline{\varepsilon}$; both, higher relative capital costs and more competition increase the ratio between the marginal costs and the marginal returns of capital. For a normal distribution of ε, it can be shown that an increase in uncertainty σ increases the optimal value of $\overline{\varepsilon}$ for plausible parameter values of the price elasticity of demand, uncertainty about demand shocks, and relative capital costs. Finally, optimal capacities are determined as:

$$\ln YC = \eta \cdot \ln p(w) + \ln Z + \overline{\varepsilon}\left(\eta, \sigma, \frac{c}{\pi_k}\frac{\pi_l}{w}\right) \tag{4}$$

Optimal capacities depend loglinear on the demand shift Z, expected demand shifts increase all quantities proportionally and do not affect prices or relative quantities. A higher share of capital costs relative to wage costs reduces capacities through the optimal value of $\overline{\varepsilon}$. A proportional increase in c and w leaves $\overline{\varepsilon}$, the regime probabilities, and capacity utilization unchanged, but increases all prices proportionally, i.e. the model exhibits linear homogeneity both in prices and quantities. Less competition reduces capacities through a lower optimal utilization and through higher prices; more uncertainty reduces optimal capacities through the lower optimal utilization which exhibits the same effect as higher capital costs.

The assumption of a delayed adjustment of capacities extends the deterministic model by introducing uncertainty and permits to analyse the resulting inefficiencies:

- Ex ante, the firm chooses capacities before knowing the location of the demand curve. Optimal capacities are linear in expected demand shifts Z and depend with elasticity η on proportional cost increases.

- Ex post, different regimes on the goods market and underutilization of capacities are possible. Short-run demand shocks can be identified from the utilization of capacities.

If the stochastic process generating the demand shocks ε is autocorrelated, a positive demand shock increases output and capacity utilization today. If the firm expects that the higher demand persists, it will, with a delay, increase capacities, i.e. the model can be understood as an error correction model for investment: Capacities adjust, if capacity utilization differs from the optimal value. Finally, credit market imperfections can be introduced into the model by specifying a constraint on the borrowing. In this case, the firm chooses a lower capital stock. Investment depends positively on cash flow and retained profits, i.e. unexpected demand shocks in the past and the price elasticity of demand exhibit an additional effect.

2.3 Endogenous innovations

Innovations are treated as investments in knowledge capital, analogously to capital investment. Most of the analysis here is confined to the case of discrete innovations. First, the data-set contains qualitative data on the implementation of product and process innovations for a large number of firms from the business survey; quantitative data are available only for a subset of the data and only for innovation activities. Second, the implementation of an innovation can be viewed as a discrete decision for the firm from theoretical arguments: Indivisibilities of innovation projects make the analysis of "marginal innovations" to some extent artificial. Accordingly, the probability of an innovation project can be written as:

$$\text{prob(inno)} = \text{prob}\left(\frac{\text{returns(inno)}}{\text{costs(inno)}}, \text{ financing constraints}\right) \tag{5}$$

The probability of an innovation project (inno) depends on the incentives to innovate, the costs of innovations, and the possibility to finance it; an innovation is performed only, if returns exceed costs, and if a financing of the innovation project is possible.

In the analysis, it is distinguished between the implementation of product and process innovations,[8] and process innovations are distinguished from capital investments. Process innovations affect the productivities of labour and capital through efficiency θ_l, θ_k. Product innovations affect the demand curve. A successful product innovation implies that the quality of the product increases, and demand increases. In addition, new and better products are probably more specialized which protects the firm from competition. In the model, it can be distinguished between effects on the level of demand Z, effects on the price elasticity of demand η, and effects on demand uncertainty σ. In Smolny (1998b), it was found that product innovations increase the level of demand Z and reduce competition, i.e. reduce the absolute value of the price elasticity of demand $|\eta|$: On average, product innovating firms set higher prices and increase output and employment. In addition, a large share of product innovators in the sector reduces price competition and demand uncertainty: The empirical results revealed that price and output adjustment are much less frequent in those sectors. A large share of process innovators in the sector, on the other hand,

[8] The distinction between product and process innovations is clear only at the disaggregate level. At the aggregate level, a product innovation of one firm can be a process innovation for another firm.

increases the frequency of output and price adjustments which indicates more price competition and more demand uncertainty.

Therefore, if innovations would be treated as a predetermined variable for the investment decision, an increase in investment for innovating firms is expected. However, the simultaneousness of the investment and innovation decision, and complementarities of product and process innovations, and of innovations and investment should be taken into account. First, new products often require new production processes, and new production processes permit to produce better products. Second, both product and process innovations may be complementary with capital investment. If the firm plans to expand capacities, it has more incentives to implement a process innovation. These complementarities imply that the probability to implement an innovation depends positively on the amount of investment, and the amount of investment depends positively on the implementation of innovations. Taken differently, the same incentives and constraints, that drive capital investment also affect innovation behaviour, and the determinants of innovations also affect investment.

A related area of research are effects of the business cycle. This connects the microeconomic analysis of the determinants of innovations to the macroeconomic discussion of the relation of growth and the business cycle.[9] If the business cycle affects innovations, changes in aggregate demand affect output and productivity permanently. The assumption of a dynamic adjustment of capacities and innovations provides a consistent framework to discuss demand-induced effects: First, the complementarity of capital investment and innovations implies a positive effect from capacity utilization on innovations. Second, increasing demand in the past indicates growing markets also in the future which favours innovations. Third, extraordinary cash flows and higher prices permit to finance a larger share of innovation expenditures from retained profits in period of excess demand. On the other hand, opportunity costs and intertemporal substitution imply positive effects from periods of slack demand on innovations. Non-production activities such as reorganizations of production processes, R&D, and training exhibit less opportunity costs in case of excess capacities.[10] Therefore, the effect of the business cycle on innovations cannot be derived unambigously from theoretical arguments.

A main difference between capital investments and innovations, i.e. investments in knowledge, is that the costs of the former are variable costs, while the latter impose at least partially a fixed cost. This implies that large firms exhibit a relative advantage as compared with small firms, since they can spread costs on a larger quantity of output. A related argument in favour of large firms are internal spillovers and complementarities of R&D activities, or economies of scope.[11] A third argument is based on the risk associated with innovations,

[9]For a discussion, see Blanchard, Quah (1987), Cambell, Mankiw (1987), Stiglitz (1993), Beaudry, Koop (1993), Caballero, Hammour (1994), and Geroski, Walters (1995).

[10]For a detailed discussion, see Aghion, Saint-Paul (1993).

[11]See Cohen, Levin (1989).

and credit market imperfections. Due to asymmetric information and adverse incentives, commercial banks hesitate to finance risky innovation projects of small firms.[12] Large firms have easier access to internal finance; in addition, they perform many innovation projects which spreads the risk and reduces the risk for the bank.

According to Schumpeter, the ability to earn large profits and expectations of a temporary monopoly cause firms to introduce innovations.[13] One argument in favour of innovations on monopolistic markets are monopoly profits that permit an easier finance of risky innovation projects. In the model here, the effects of market power depend on the effects of innovations:

- If a product innovation implies a simple shift of demand Z, less competition, i.e. a smaller value of the price elasticity of demand $|\eta|$ implies a larger increase in profits as compared with the competitive case.

- However, if a better quality of the product implies that the firm can sell the same quantity at a higher price, the effect on demand and profits depends on the price elasticity η: On competitive markets, a larger increase in the market share can be expected.

- The same holds for process innovations which reduce production costs: More competition implies that a firm can achieve larger increases in market shares with a reduction of costs and the price. In the model here, process innovations that affect costs proportionally and product innovations that affect only the level of demand are basically equivalent.

In addition, innovations change the market structure, and the intended reduction of the price elasticity of demand is an important incentive to innovate. However, it is not clear how existing market power changes the incentives of innovative activities in this case. On the one hand, it can be argued that on highly competitive markets, temporary market power vanishes quickly; i.e. the incentive to innovate is low. On the other hand, on markets with a small number of (large) firms, each firm watches each others innovations closely and reacts on others innovations. Then, the incentive to innovate is smaller on oligopolistic markets. In addition, monopolists have less incentives to introduce new products, because new products destroy the monopolistic rents of existing products. That means, market power tends to reduce the incentives but enhances the ability to innovate.[14]

[12] See Stiglitz, Weiss (1981), Fazzari, Hubbard, Peterson (1988), and Stiglitz (1993).

[13] For an overview, see Kamien, Schwarz (1975) and Cohen, Levin (1989).

[14] It should be distinguished between effects of firm size and effects of market power measured by the price elasticity of demand. Both capture to some extent market power, but the arguments are different. The (common) analysis in terms of market shares does not allow to identify the different effects of firm size, on the one hand, and market power, on the other hand, on innovations.

A final area of the analysis is the appropriability of the returns from innovations, and knowledge spillovers from other firms. On the one hand, spillovers from other firms reduce the costs of own innovations, i.e. own and others innovations can be viewed as complements.[15] On the other hand, spillovers reduce the returns of own innovations: If other firms imitate quickly, demand increases and monopolistic situations on the goods market are short-lived. A related variable which approximates technological opportunity is the own innovation behaviour in the past. Innovative activities in the past increase the stock of knowledge which is thought to exhibit a positive impact on the productivity of innovative activities in the present: Firms build on historically accumulated knowledge and exhibit advantages on the learning curve. On the other hand, new products destroy monopolistic rents of existing products. This implies that own innovations in the past and innovations of other firms enhance the ability to innovate but reduce the returns of innovations.

3 Data and empirical specification

3.1 Data

The data base for the estimation of the determinants of innovation behaviour and investment is a unique panel of West-German manufacturing firms over 13 years (1980-1992). The data stem from the surveys of the ifo institute, Munich. The panel consists of 2405 observation units from 1982 firms. Innovations are defined as novelties or essential improvements of the product or the production technique. In the business survey, the firms are asked, whether (within the year for a specific product) product and/or process innovations were implemented. Most firms in the panel innovate, at least in some years;[16] the relative frequency of both product and process innovations is quite evenly distributed within the range $\{0,1\}$. In the innovation survey, the firms are asked about innovation activities, as opposed to the implementation of innovations. That means, the question in the innovation captures the long-run propensity to innovate, and the question in the business cycle captures the timing of the introduction of a new product or a new production technique. In addition, the innovation survey contains quantitative data on innovations expenditures. Data on investment and sales are available from the investment survey.

The business survey also contains detailed monthly and quarterly informations on the short-run demand and supply conditions. First, it contains quarterly data on the degree of capacity utilization. Second, it provides a direct measure of expected demand. Once a year, the firms are asked about their estimate of the development of the product market in the medium run

[15] See Cohen, Levinthal (1989). Technology spillovers are central for many models of endogenous growth and received a lot of attention in the recent literature. See Bernstein, Nadiri (1986), Jaffe (1986), Levin, Reiss (1988), Nadiri (1993), and Smolny (1999).

[16] Some measures of the data are reported in the appendix.

(5 years). For the estimates, dummy variables were created for firms which expect a growing and a shrinking market, respectively; a stagnating market is the reference case. Third, every month the firms are asked about realized price and output changes, as compared with the preceding month. The information is qualitative, i.e. it is distinguished between increase, no change, and decrease. For the empirical analysis, annual net price and output increases are calculated as the difference of the annual number of increases and decreases, relative to the number of observations for each year.

The price and output data were also used to deduce some information about the market structure. In case of adjustment costs for prices, the frequency of price and output changes can serve as an indicator of the price elasticity of demand: Low competition, i.e. a low absolute value of the price elasticity of demand favours output adjustments against price adjustments. That means, the high frequency of the price and output data permits the analysis of market structure by market behaviour, i.e. price and output changes. For the estimation, the frequency of price and output changes is calculated as the relative sum of increases and decreases during each year.[17] Firm size is specified by dummies according to the average number of employees at the product level. In addition, a diversification dummy is included for those firms, where product level employment is below half of firm-level employment. A final indicator of the market structure is given by the information, whether the respective product is also exported.

3.2 Empirical specification

The endogenous variables in the empirical model are the probability of an implementation of a product (prod) and a process innovation (proc), the probability of innovation activities (ia), the amount of innovation expenditures relative to sales ie/s, and the share of investment in sales i/s. According to the simultaneousness of the investment and innovation decision, and complementarities of innovation behaviour and investment, the explanatory variables in the empirical model are the same for investment and for innovations. That means, a reduced form of the long-run model is estimated. Some direct evidence on complementarities of innovations and investment and on the dynamics of innovation behaviour is drawn from cross-tabulations.[18] In the empirical model, identification is sought through lagged values of the explanatory variables, i.e. the restrictions from the theoretical model are exploited for the estimation: The realization of the demand shock and the decision on output and prices takes

[17] In the theoretical model, a straightforward measure of the price elasticity of demand is given by the price/cost relation. In the model, prices are determined as mark-up over costs, and the mark-up is determined by the price elasticity of demand. However, the data-set does not contain informations on firm-specific cost conditions. In addition, past periods' profits can also result from unexpected demand shocks.

[18] The estimation of a dynamic simultaneous model of innovation and investment is beyond the scope of the work here. See e.g. Pohlmeier (1992) and Flaig, Stadler (1996).

place after the decision on innovations and investment; therefore lagged values of output, prices, and capacity utilization can be treated as predetermined for innovation behaviour and investment.

The explanatory variables are related to the demand conditions, to firm size and market power, and to the appropriability conditions. The degree of utilization of capacities U captures demand conditions. For investment, this describes the basic adjustment model for capacities. Innovations should depend on capacity utilization through the complementarity with capital investment and through cash flows. Additional indicators of the demand conditions are price Δp and output Δy increases in the past. Price increases also indicate market power. A direct indicator of growing markets are the medium-run demand expectations Z^+, Z^- of the firm. A final business cycle indicator is the average capacity utilization of the other firms in the sector U^s.[19] This should reflect increased competition from other firms in the market.

An indicator of the price elasticity of demand is given by the frequency of price (σ_p) and output adjustments (σ_y): Less competition favours output adjustments against price adjustments. The frequency of price and output adjustments at the sectoral level (σ_p^s, σ_y^s) supplies an additional information about the market structure. In addition, it is tested for firm-size effects $\bar{l}$. Firm size should increase innovations through fixed cost arguments and through the financing conditions. A firm-size effect on investment could stem from credit market imperfections and from the complementarity with innovations. A positive effect from diversification would indicate the importance of credit market imperfections and/or internal spillovers of R&D activities. The average size of the other firms in the sector $\bar{l}^s$ (in relation to the own firm size) is another indicator for market power, i.e. the price elasticity of demand; it also approximates appropriability conditions.

The average innovation behaviour of the other firms in the sector (sector mean) approximates technological opportunity and appropriability conditions. A final indicator of market structure, market size, and technological opportunity is given by the information, whether the product is also exported (export). This captures the competitiveness and therefore the quality of the product, i.e. it indicates the inventive capability of the firm. In addition, the world market is another source of spillovers. Finally, a complete set of 11 time dummies is always included in the estimates (not reported in the tables). These dummies shall capture effects from interest rates, wages, and prices of raw materials and intermediates; the data-set does not include information about those variables at the firm level.

[19] Sectoral means are calculated excluding the respective firm.

4 Estimation results

4.1 Innovation behaviour and investment

Some direct evidence on complementarities and the dynamics of innovation behaviour and investment is drawn from cross-tabulations. In the first columns of table 1, the (relative) numbers of product and process innovators are depicted. The sample consists of 22237 observations from 2399 firms. In about one half of the observations, the firms reported a product or a process innovation, respectively, i.e. firms implement a product and a process innovation every second year, on average. In about 1/3 of the observations, the firms reported no innovation.[20] In the next column, the average shares of innovation expenditures in sales ie/s are depicted for the different goups. The data reveal that innovation rates are higher both for product and for process innovators. The innovation rate is about 3 percent for all firms, about 4 percent for firms that implemented an innovation, and only 1.3 percent for firms that did not implemented an innovation.

The average shares of investment in sales $(i/s)_t$ are depicted in the next column. The investment rate for all firms is about 5 percent. As expected, investment is nearly 1 percentage point higher for firms that implement a process innovation. However, the data do not reveal that firms invest more, if they implement a product innovation. Firms that implemented a product innovation only invested even less than firms that did not innovate; the largest investment rates (7 percent) are observed for those firms that implemented a process innovation only (not reported). Therefore, the data indicate a complementarity of process innovations and investment, but no direct complementarity of product innovations and investment.[21] The investment rates in the subsequent period $(i/s)_{t+1}$ show that the largest correlation of process innovations and investment is contemporary, i.e. the data do not indicate that investment follows process innovations. The next columns contain informations about the complementarity of product and process innovations:

- About 72 percent of those firms that implemented a process innovation also implemented a product innovation in the same year, as compared with only 50 percent for all firms;

- about 66 percent of those firms that implemented a product innovation also implemented a process innovation in the same year, as compared with only 46 percent for all firms.

That means, product and process innovations are correlated. In addition, innovation behaviour is autocorrelated:

[20] Only about 15 percent reported a product or a process innovation only.

[21] These correlations should not be interpreted in a causal sense. They also reflect a similar development of the determinants of innovation behaviour and investment.

Table 1: Innovation behaviour and investment

	obs	obs%	$(ie/s)_t$	$(i/s)_t$	$(i/s)_{t+1}$	prod_t	prod_{t+1}	proc_t	proc_{t+1}
prod	11053	0.497	0.039	0.051	0.050	1	0.742	0.664	0.605
proc	10212	0.459	0.040	0.059	0.053	0.718	0.660	1	0.674
no inno	8308	0.374	0.013	0.044	0.049	0	0.240	0	0.242
all	22237	1.000	0.029	0.051	0.051	0.497	0.512	0.459	0.470

prod:	product innovation implemented
proc:	process innovation implemented
no inno:	neither product nor process innovation implemented
ie/s :	share of innovation expenditures in sales
i/s :	share of investment expenditures in sales

- 74 percent of those firms that implemented a product innovation in the current year also implemented a product innovation in the subsequent year, as compared with only 51 percent for all firms;

- 67 percent of those firms that implemented a process innovation in the current year also implemented a process innovation in the subsequent year, as compared with only 47 percent for all firms.

Correspondingly, only about 1/4 of those firms which did not innovate in the current year implemented a product or a process innovation in the subsequent year. Finally, innovative firms were more successful; they exhibited an about 2 percentage points higher capacity utilization rate and about 1 percentage point more output and employment growth, as compared with all firms (not reported).

These results together indicate complementarities of process innovations and investment. A corresponding direct correlation of product innovations and investment is not found, but product innovations are correlated with process innovations. The autocorrelation of innovation behaviour is consistent with the argument that past innovation behaviour enhances (indicates) the innovative capability of the firm. However, these correlations should not be interpreted in a causal sense; they might also result from (auto-)correlation of the determinants of innovation behaviour and investment.

4.2 Determinants of innovation behaviour and investment

In table 2, the estimation results of binary probit models for product innovations, process innovations, and innovation activities are reported. The table also contains the estimates of Tobit models for innovation rates and investment rates. Depicted are the coefficients and the correspondig t-values (in parantheses). In the last rows, the sample means of the endogenous variables and the number of observations for the equations are reported, the sample means of the explanatory variables are depicted in the last column.

The estimation results firstly reveal that a high capacity utilization rate in the preceding year U increases both the probabilities of implementing a product innovation (prod) and a process innovation (proc). Capacity utilization also exhibits the expected positive and significant effect on investment (i/s). This confirms both the assumptions of a slow adjustment of capacities and the autocorrelation of demand shocks. It is also a second hint for a complementarity of innovations and investment: Capacity utilization (and demand expectations) should be the most important determinants of investment, and a strong effect on innovations implies that firms implement innovations when they invest. This argumentation is confirmed by the larger effect of capacity utilization on process innovations. The coefficient exhibits about twice the value as those of product innovations; here a stronger complementarity was expected. The results also reveal that the effects from capacity utilization on the probability of innovation activities (ia) and innovation rates (ie/s) are smaller and hardly significant, i.e. the complementarity with capital investment is important mainly for the timing of the implementation of innovations but less for the long-run propensity to innovate.

The medium-run demand expectations exhibit a very strong effect on innovation behaviour and investment. A strong effect is revealed mainly for those firms that expect a growing market Z^+; firms that expect a shrinking market Z^- do not differ very much from those that report a stagnating market, the reference case. The quantitative effect is quite large: Firms that expect a growing market exhibit an about 10 percentage points higher probability to innovate and about 1 percentage point higher latent innovation and investment rates.[22] Output increases in the past Δy also favour innovations and investment, i.e. innovation activities and investment increase with the level of production activities. Note that the basic model of capacity adjustment implies a linear homogeneity of capacities and output. Innovations are related to the development of demand and output through the complementarity with capital investment.

Price increases Δp in the past, on the other hand, affect only the implementation of innovations, especially product innovations, but not innovation activities and investment. This indicates that cash flow and the financing conditions are mainly important for the implementation of innovations, the financing of innovation activities and investment does not depend that much on retained profits (cash flow) from a short-run excess demand situation on the goods market. The strong effect of price increases on product innovations can also be interpreted as a positive effect of market power. A high capacity utilization of competitors U^s significantly reduces innovations and investment. This variable

[22] The models for investment and innovation rates are estimated by Tobit, i.e. the coefficients reflect effects on the latent variables, not on the means of the variables.

stands for the competitive pressure from the other firms in the sector, i.e. the results confirm that strong competition and successful competitors impede own innovations and investment.

These results reveal that innovation behaviour and investment depend on the same set of cyclical variables, albeit with a different weighting for each. Price increases affect only the implementation of innovations. Capacity utilization affects mainly investment and the implementation of innovations, i.e. the timing of the introduction of a new product or a new production technique, but not long-run innovation activities. Output increases and medium-run demand expectations affect the implementation of innovations, innovation activities, and investment equally, growing markets favour innovations and investment. The positive effects of own capacity utilization, price and output increases, and demand expectations clearly outweigh the negative effect from others capacity utilization, the total effect of demand on innovations is positive. That means, excess demand in the short run promotes long-run growth. The complementarity of innovations and investment, the effect of cash flows on the financing conditions, and the expectation of a growing markets outweigh the effect of lower opportunity costs in recessions and intertemporal substitution.

Below, the results for the market structure indicators, i.e. the frequency of price and output changes, are reported. Market power permits an easier finance of risky innovation projects out of cash flow and retained profits. The estimates reveal that a high frequency of price changes of the firm (σ_p) or in the sector (σ_p^s) restrains innovations, and a high frequency of own output changes (σ_y) promotes innovations. Low competition favours quantity adjustment against price adjustments, i.e. the results indicate that market power promotes innovations. Investment, in contrast, is lower in sectors with frequent price changes which indicates a positive effect of competition. Albeit the coefficent is only weakly significant, it is consistent with the theoretical model: A higher absolute value of the price elasticity of demand should lead to price reductions and output (capacity) increases. The larger effect of market power on product innovations, as compared with process innovations, is consistent with the argument that price increases for new products imply a smaller effect on market shares on monopolistic markets. It is also consistent with the higher complementarity of process innovations and investment. Note that a large frequency of own output changes favours innovations, while frequent output changes of other firms in the sector reduce innovation activities. This indicates that firm-specific uncertainty is an incentive to perform innovations, while sectoral uncertainty impedes innovation activities.[23]

Different effects for innovations and investment are also revealed for firm size $\bar{l}$.[24] Firm size exhibits a strong positive effect on innovations, but hardly

[23] The positive (albeit only weakly significant) effect of frequent output changes in the sector on investment would imply that sectoral uncertainty exhibits a positive effect on investment.

[24] Although large firms are over-represented in the survey (as compared with total manufacturing), the sample consists mainly of small and medium-size firms. Less than 10 percent

Table 2: Determinants of innovation behaviour and investment

	prod	proc	ia	ie/s	i/s	mean
U	0.312 (3.4)	0.684 (7.5)	0.254 (1.8)	0.006 (0.8)	0.037 (5.9)	0.829
Z^+	0.272 (12.2)	0.236 (10.8)	0.239 (6.8)	0.014 (7.1)	0.009 (5.8)	0.433
Z^-	-0.065 (-2.0)	-0.031 (-1.0)	-0.069 (-1.4)	-0.004 (-1.5)	-0.001 (-0.5)	0.130
Δy	0.221 (5.0)	0.253 (5.9)	0.335 (4.9)	0.013 (3.5)	0.008 (2.8)	-0.036
Δp	0.198 (3.8)	0.077 (1.5)	0.023 (0.3)	-0.003 (-0.7)	-0.000 (-0.1)	0.062
U^s	-1.690 (-4.5)	-1.239 (-3.3)	-3.186 (-5.8)	-0.159 (-5.0)	-0.135 (-5.5)	
σ_p	-0.204 (-3.5)	-0.012 (-0.2)	-0.019 (-0.2)	-0.002 (-0.3)	-0.003 (-0.8)	0.160
σ_p^s	-0.739 (-4.2)	-0.456 (-2.9)	-1.033 (-4.2)	-0.058 (-4.2)	0.021 (2.1)	
σ_y	0.206 (5.0)	0.141 (3.5)	0.391 (6.2)	0.016 (4.6)	0.001 (0.4)	0.315
σ_y^s	-0.179 (-0.8)	0.201 (0.9)	-0.739 (-2.2)	-0.060 (-3.1)	0.025 (1.7)	
$\bar{l} < 20$	-2.034 (-12.3)	-1.989 (-13.6)	-2.313 (-6.0)	-0.090 (-10.4)	-0.013 (-2.7)	0.076
$20 \leq \bar{l} < 50$	-1.847 (-11.4)	-1.805 (-12.7)	-1.974 (-5.1)	-0.074 (-9.0)	-0.006 (-1.4)	0.143
$50 \leq \bar{l} < 100$	-1.593 (-9.9)	-1.641 (-11.6)	-1.716 (-4.5)	-0.067 (-8.3)	-0.004 (-1.0)	0.173
$100 \leq \bar{l} < 200$	-1.367 (-8.5)	-1.410 (-10.0)	-1.419 (-3.7)	-0.055 (-6.8)	0.000 (0.1)	0.206
$200 \leq \bar{l} < 500$	-1.244 (-7.8)	-1.352 (-9.6)	-1.226 (-3.2)	-0.047 (-6.0)	0.001 (0.2)	0.217
$500 \leq \bar{l} < 1000$	-1.081 (-6.7)	-1.176 (-8.3)	-0.926 (-2.4)	-0.044 (-5.5)	-0.001 (-0.2)	0.095
$1000 \leq \bar{l} < 2000$	-1.108 (-6.8)	-1.062 (-7.4)	-0.658 (-1.7)	-0.031 (-3.6)	0.004 (1.0)	0.051
$2000 \leq \bar{l} < 5000$	-0.700 (-4.1)	-0.885 (-5.9)	-0.580 (-1.4)	-0.023 (-2.6)	-0.001 (-0.3)	0.029
diversification	0.019 (0.9)	0.029 (1.4)	0.172 (4.8)	0.010 (5.3)		0.332
$\bar{l}^s$	-0.095 (-4.4)	-0.080 (-3.8)	0.037 (1.0)	0.001 (0.8)	-0.001 (-2.4)	0.476
sector mean	1.371 (15.6)	0.881 (8.0)	0.959 (8.8)	0.550 (8.2)	0.673 (19.3)	
export	0.436 (13.6)	0.180 (5.9)	0.361 (8.6)	0.016 (6.1)	-0.006 (-3.3)	0.824
sample mean	0.512	0.469	0.627	0.028	0.051	
observations	18232	18232	8341	7872	10819	

affects investment. The effect is equally strong for the probability of process innovations, product innovations, and innovation activities, i.e. firm size does not affect the composition of innovative activities. Note that the positive effect on the probability to innovate does not imply that large firms innovate more per unit of sales; it also depicts the simple scale argument that in large firms, the probability of at least one innovation is higher. However, significant and quantitatively strong firm-size effects are also revealed for innovation rates: Small firm with less that 50 employees spend more than 7 percentage points less for innovations than large firms with more that 5000 employees, the reference case.[25] The coefficients depict a clear positive relation of firm size and innovation rates. Investment rates, in contrast, are hardly affected by firm size; the fixed cost argument is mainly important for innovation behaviour.

The positive effect on the probability of innovative activities and the about 1 percentage point higher innovation rates of diversified firms indicate positive spillovers of innovation activities for different products and/or an easier financing of innovation expenditures in large firms.[26] A large size of the other firms in the sector $\bar{l}^s$, on the other hand, significantly reduces the probability to implement an innovation and investment rates. This variable is another measure of the degree of competitive pressure from other firms and the comparative advantage of large firms in the sector which reduces the incentives for own innovations and investment.[27]

Others innovations (sector mean) strongly promote own innovations. The share of innovators in the sector exhibits a significant positive effect on the implementation of innovations, innovation activities of other firms also increase the probability and the extent of own innovation activities.[28] This indicates that positive spillover effects from others innovations outweigh negative displacement effect through less appropriability of the returns from innovations. The effect is stronger for product innovations than for process innovations which indicates that it is easier to imitate others new products than others production technique.

Finally, exporters exhibit a higher probability to innovate and higher innovation rates. The coefficients are highly significant and quantitatively very important: Exporters exhibit about 1.6 percentage points higher latent innovation rates, ceteris paribus. This result indicates spillovers from foreign markets

of the observations stem from firms with more than 1000 employees.

[25]The average innovation rate in the sample is about 2.8 percent, the standard deviation is about 5 percent.

[26]The estimates do not reveal a significant difference of the probability to implement an innovation in diversified firms. Note that the coefficient of the diversification dummy becomes significantly negative, if firm size is specified as the number of employees of the whole firm. The sample for investment excludes the diversified firms, therefore this variable is left out here.

[27]$\bar{l}^s$ is specified in 1000's of employees, i.e. the effect is significant but not very strong.

[28]The investment rates of the other firms in the sector also exhibit a positive effect. This variable captures the different capital intensities of the sectors.

which affect the costs of innovations and technological opportunity. Note the stronger effect on product innovations: Firms that act on international markets can imitate from a larger pool of competitors' products. This indicates again that positive spillover effect outweighs the negative effect from less appropriability of the returns and more competition.[29] Remarkable are lower investment rates of exporters. This could reflect the stronger competition on the world market which forces firms to a careful investment policy and/or more investment in foreign countries. For this variable, the results for innovations and investment differ sharply. For innovations, positive spillover effects outweigh negative effects from more competitive pressure, for investment the second effect dominates.

Taken together, the results indicate that market power enhances innovations, i.e. the positive effect of monopolistic profits on the ability to finance innovation projects outweighs the negative effect on the incentives to innovate. The probability of innovation projects and innovation rates increase with firm size but decrease with others firm size. The total effect of firm size on innovations is positive, i.e. the positive effect of own firm size outweighs the negative effect of the size of other firms. A comparable firm-size effect on investment is not found. Scale economies are important for innovations but not for investment. Finally, the probability of innovations is higher, if other firms in the sector innovate also, and if the product is exported: Positive spillover effects and technological opportunity outweigh the negative effects from less appropriability of the returns and more competitive pressure.

5 Conclusions

Innovations increase the quality of goods and reduce the input requirement. Innovative firms are more successful and can achieve a temporary monopolistic situation on the product market. On the other hand, innovations depend on the market structure and on the demand situation of the firm. In this paper, a theoretical model of the determinants of innovation behaviour and investment is developed. It is assumed that price and output adjustments take place in the short run, innovation behaviour and investment are determined in the long run. Innovations are treated as investments in knowledge capital, analogously to investments in physical capital. The assumption of a delayed adjustment of innovations and investment under uncertainty of demand permits to discuss business cycle induced effects consistently within the framework of the theoretical model. Demand shocks affect prices and output in the short run, and affect the financing conditions for innovations and investment. The complementarity of innovations and investment emphasizes the similarity of the investment and innovation decision. Market power affects innovation behaviour through

[29] The result confirms the finding of intra-sectoral across-border spillovers and productivity convergence in Smolny (1999).

effects on the financing conditions, and firm size is important in case of scale economies associated with innovations. A measures of the market structure is derived from the price-setting behaviour of the firms.

The model is estimated with a large panel of micro data for West-German manufacturing firms. The empirical results reveal strong positive effects for the different demand indicators on innovation behaviour and investment. Short-run demand disturbances and the business cycle affect long-run growth. Excess demand in the short run promotes investment which enhances innovations, innovations are the source of long-run advances in technology and productivity growth. Firm size and market power also promote innovations. This indicates scale economies associated with innovations, and hints towards the financing of innovation activities out of cash flow and retained profits. Innovations of competitors also promote own innovation activities. Own and others innovations are complements: Firms imitate others new products and production processes; positive spillover effects outweigh negative effects from more competitive pressure and less appropriability of the returns of innovations. Positive spillover effects from international trade are indicated by higher innovation rates of exporters.

Endogenous innovations and knowledge spillovers are important concepts in endogenous growth models. From a theoretical perspective, they allow to understand technological change as endogenously determined by the profit maximizing behaviour of competing firms within the economic system. From a welfare economic perspective, knowledge spillovers deserve attention since they indicate an inefficiency of decentralized market systems. If knowledge is distributed for free, as spillover models suggest, firms have too low incentive to engage in innovative activities. This enhances the interest into further empirical investigations of innovation behaviour and the extent of spillovers.

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Data appendix

The data base for the empirical application is a panel of West-German manufacturing firms over 13 years (1980–92). The panel consists of 2405 observation units from 1982 firms. The data stem from the business survey, the innovation survey, and the investment survey of the ifo institute, Munich.

Innovations and investment

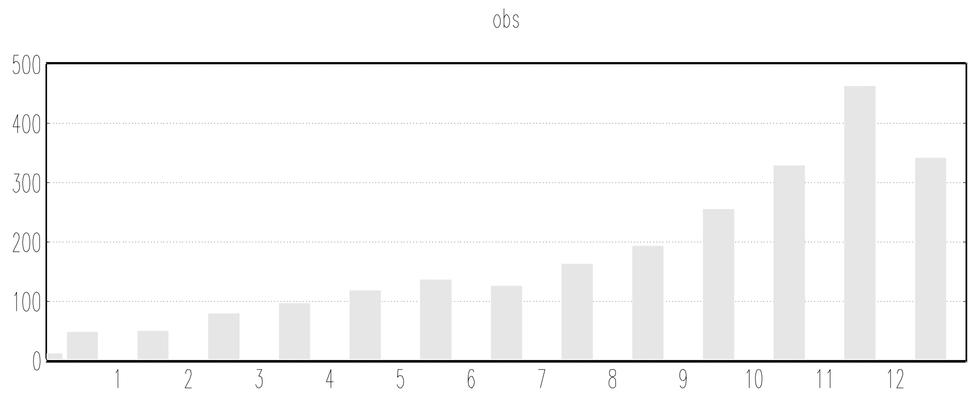
	prod	proc	obs	ia	obs	ie/s	σ	obs	i/s	σ	obs
$\bar{l} < 20$	0.189	0.198	1559	0.261	853	0.019	0.058	813	0.045	0.081	691
$20 \leq \bar{l} < 50$	0.284	0.304	3072	0.418	1578	0.022	0.051	1470	0.054	0.103	1724
$50 \leq \bar{l} < 100$	0.410	0.384	3839	0.562	1884	0.022	0.046	1750	0.053	0.079	2192
$100 \leq \bar{l} < 200$	0.522	0.486	4537	0.692	1958	0.027	0.047	1779	0.052	0.070	2449
$200 \leq \bar{l} < 500$	0.593	0.517	5026	0.777	2196	0.032	0.048	1955	0.052	0.073	3416
$500 \leq \bar{l} < 1000$	0.677	0.596	2089	0.854	925	0.032	0.051	808	0.050	0.041	1894
$1000 \leq \bar{l} < 2000$	0.668	0.643	1195	0.906	427	0.044	0.062	364	0.052	0.043	1113
$2000 \leq \bar{l} < 5000$	0.810	0.888	642	0.934	258	0.054	0.060	232	0.046	0.035	615
$5000 \leq \bar{l}$	0.948	0.706	232	0.991	108	0.087	0.065	100	0.047	0.029	568
all	0.497	0.459	22237	0.641	10236	0.028	0.051	9318	0.051	0.071	14662

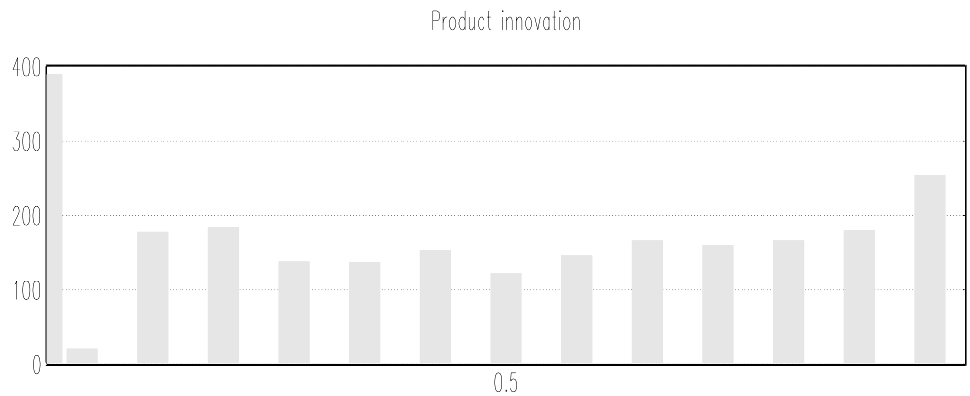
Innovations, economic success, and investment

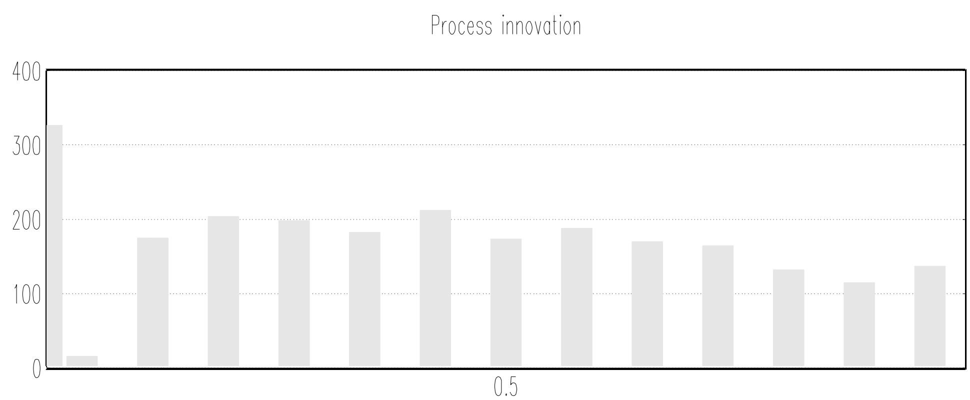
	obs	obs%	$\Delta \ln l_t$	$\Delta \ln s_t$	U_t	$(i/s)_t$	$(i/s)_{t+1}$	$(ie/s)_{t-1}$	$(ie/s)_t$
prod	11053	0.497	-0.004	0.043	0.847	0.051	0.050	0.040	0.039
proc	10212	0.459	0.001	0.045	0.851	0.059	0.053	0.041	0.040
prod only	3717	0.167	-0.014	0.035	0.830	0.043	0.048	0.033	0.033
proc only	2876	0.129	-0.001	0.041	0.839	0.070	0.057	0.032	0.034
no inno	8308	0.374	-0.019	0.022	0.803	0.044	0.049	0.015	0.013
all	22237	1.000	-0.009	0.035	0.829	0.051	0.051	0.030	0.029

prod:	product innovation implemented
proc:	process innovation implemented
prod only:	product innovation, but not process innovation implemented
proc only:	process innovation, but not product innovation implemented
ia:	innovation activity
no inno:	neither product nor process innovation implemented
$\Delta \ln l$:	growth rate of employment
$\Delta \ln s$:	growth rate of nominal sales
U:	capacity utilization rate
i/s :	share of investment expenditures in sales
ie/s :	share of innovation expenditures in sales

Frequency of product and process innovations







The first bar denotes 0, the class width is 1 (1/13).

Innovations in the business survey: Most firms in the panel innovate, at least in some years. Only about 400 (300) firms never implemented and 250 (140) firms implemented a product (process) innovation in each year. The relative frequency of both product and process innovations is distributed quite evenly within the range $\{0, 1\}$; on average, firms implement a product and a process innovation every second year; the data reveal a strong positive relation between the proportion of innovators and firm size. The share of innovators is below 30 percent for firms with less than 50 employees, and exceeds 80 percent for the large firms with more than 2000 employees. The sectoral correlation of product and process innovations is large.

Innovations in the innovation survey: These data are available only for a sub-sample of the data-set, which is caused mainly by the low response rate of this survey. The response rate for the question on innovations in the business survey is about 90 percent but below 50 percent in the innovation survey. The total number of observations from the business survey is above 22000, as compared with only about 10000 for the innovation survey. In the innovation survey, the firms are asked about innovation activities, as opposed to the implementation of innovations in the business survey. The innovation survey contains also quantitative data on innovation expenditures. The average share of innovation expenditures in sales is slightly below 3 percent. For small firms the innovation rate is about 2 percent, for large firms, it exceeds 6 percent. Remarkable is also the large variance of innovation expenditures within the size classes.

Data on investment are available from the investment survey. On average, the share of investment in sales is about 5 percent which corresponds roughly to the respective figure for total manufacturing. The averages do not reveal important differences according to firm size, but the variance of investment rates is lower for large firms. Since data on investment are available only at the firm level, while data for the explanatory variables of the model are available only at the product level, for the investment equation, a constrained sample of those firms is constructed, where product level employment is at least half of firm-level employment. For the investment equations, firm size is measured by dummies according to the average number of employees at the firm level.

Innovative firms were more successful; they exhibited a higher capacity utilization and more output and employment growth. Average employment change per year is about –1 percent for all firms. The shrinking of employment is nearly 2 percent per year for firms that did not innovate; innovating firms exhibited a nearle stable employment path. The figures for sales growth and capacity utilization are similar: Average sales growth (capacity utilization) for all firms was 3.5 percent (83 percent), innovators exhibited about 1 percentage point more sales growth and a 2 percentage points higher capacity utilization rate.

Price and output changes

size	Δp	σ	σ_p	σ	Δy	σ	σ_y	σ	obs
$\bar{l} < 20$	0.038	0.231	0.151	0.202	-0.096	0.273	0.329	0.269	2147
$20 \leq \bar{l} < 50$	0.044	0.249	0.186	0.219	-0.067	0.284	0.326	0.264	4014
$50 \leq \bar{l} < 100$	0.075	0.228	0.169	0.199	-0.034	0.293	0.339	0.261	4860
$100 \leq \bar{l} < 200$	0.068	0.220	0.165	0.201	-0.024	0.274	0.323	0.258	5774
$200 \leq \bar{l} < 500$	0.068	0.200	0.152	0.182	-0.028	0.261	0.304	0.256	6096
$500 \leq \bar{l} < 1000$	0.064	0.180	0.135	0.167	-0.021	0.259	0.288	0.264	2541
$1000 \leq \bar{l} < 2000$	0.070	0.181	0.148	0.186	-0.002	0.255	0.282	0.263	1443
$2000 \leq \bar{l} < 5000$	0.049	0.158	0.125	0.172	-0.006	0.257	0.278	0.265	815
$5000 \leq \bar{l}$	0.079	0.148	0.121	0.124	0.020	0.191	0.237	0.256	272
all	0.062	0.216	0.160	0.195	-0.036	0.274	0.315	0.262	28069

Other explanatory variables

size	U	σ	export	Z^+	Z^-	divers	$\bar{l}_f$	$\bar{l}_p$	exit%
$\bar{l} < 20$	0.726	0.171	0.511	0.275	0.196	0.427	71	11	0.033
$20 \leq \bar{l} < 50$	0.798	0.131	0.668	0.355	0.157	0.345	129	33	0.030
$50 \leq \bar{l} < 100$	0.826	0.126	0.758	0.407	0.144	0.308	250	72	0.021
$100 \leq \bar{l} < 200$	0.838	0.120	0.868	0.460	0.119	0.370	571	142	0.020
$200 \leq \bar{l} < 500$	0.855	0.112	0.924	0.456	0.121	0.298	1146	317	0.016
$500 \leq \bar{l} < 1000$	0.859	0.108	0.979	0.510	0.094	0.304	2340	713	0.016
$1000 \leq \bar{l} < 2000$	0.859	0.110	0.967	0.491	0.115	0.345	5304	1350	0.007
$2000 \leq \bar{l} < 5000$	0.854	0.110	0.975	0.530	0.094	0.328	8717	3020	0.007
$5000 \leq \bar{l}$	0.858	0.118	0.974	0.658	0.054	0.227	28200	15520	0.000
all	0.829	0.129	0.824	0.433	0.130	0.332	1403	476	0.021

The business survey contains monthly and quarterly informations on the short-run demand and supply conditions. Average capacity utilization U is 83 percent, the standard deviation is about 13 percent. The business survey also provides a direct measure of expected demand. In addition, every month the firms were asked about realized price and output changes, as compared with the preceding month. The information is qualitative, i.e. it is distinguished between increase, no change, and decrease. On average, each month 11 percent of the firms reported that they had increased their prices, and 5 percent reported that they had decreased their prices, i.e. there is about one price increase every year, and one price decrease every second year for each firm. The corresponding figures for output are 14 percent for increases and 18 percent for decreases, price changes were less frequent than output changes. About 80 percent of the firms are exporters; nearly all large firms export their product.