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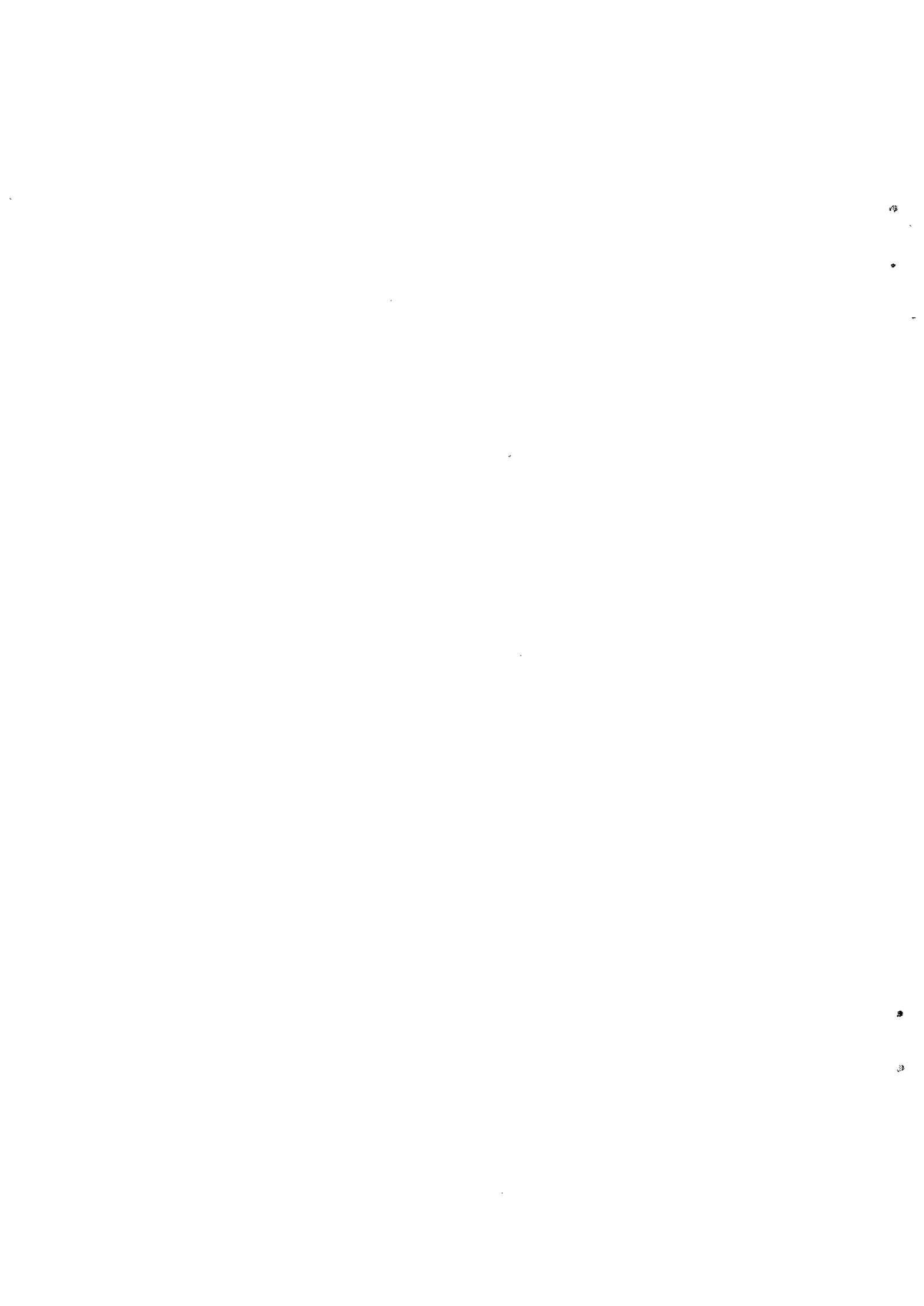
Monopoly profits from innovation and wage differentials. A micro-econometric investigation

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Monopoly profits from innovation and wage differentials.
A micro-econometric investigation

by

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Abstract:
Using the OSA enterprise database for the Netherlands, we analyze the impact of technological innovation on profits and average wages at company level. We find that firms with a high product-R&D intensity (as opposed to process innovators) indeed realize above-normal profits. This can be explained by entry barriers that are caused by historically accumulated (often 'tacit') product knowledge. Product innovations are therefore often harder to imitate than process innovations, the latter often being based on the acquisition of equipment. Moreover, we find support for the hypothesis that, to prevent the leaking of knowledge, innovative firms pay above average wages which reduce the probability that workers will leave the firm.

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0   Introduction

In a neo-Schumpeterian context, it may be argued that knowledge required for the development of innovations is not merely publicly available knowledge; it may also include certain types of technological knowledge which are difficult to buy on a market or to obtain in other ways. Such knowledge comprises so-called 'tacit' knowledge which is historically accumulated through practical experience. Tacit knowledge has also been described as uncodified, unpublished, tied to certain persons and possessing certain idiosyncratic elements (Dosi 1988: 1120-71).

Tacit knowledge may be particularly important in activities such as mechanical engineering where knowledge about the past performance of machines or instruments (e.g. typical handling mistakes by users) is essential in the design of new and superior vintages. To the extent that such knowledge is historically accumulated in the firm, it tends to confine the range of innovative options available: the type of (competitive) product a firm can develop and produce today is to a certain degree determined by what it developed and produced in the past. Historically-accumulated technological knowledge may therefore act as an entry barrier into markets. If a firm has a unique knowledge base, it can develop products that are difficult (and time-consuming) to imitate by competitors. The range of capable imitators is in any case likely to be confined to a relatively few firms that have accumulated the appropriate knowledge. In addition, the innovating firm may enjoy certain 'first mover' advantages such as a lead on the learning curve, or the possibility to register patents. This all suggests that knowledge-intensive firms may enjoy some monopoly power and reap monopoly rents.

One implication of all this is that firms have an interest in reducing the labour market mobility of their stuff: if the latter possess strategically important (tacit) knowledge, they should

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be encouraged not to leave the firm. An incentive can be given by sharing monopoly rents with them: an obvious method is to pay above-normal wages.

These hypotheses appear intuitively plausible. If realistic, they have some obvious implications for our understanding of innovation, profits and wage differentials. To the best of our knowledge, however, little of this relationship has yet been investigated at the firm level. Using OSA's unique national enterprise data base, the hypotheses can be tested with data at the firm level, covering all sectors of the national economy of the Netherlands. The hypothesis that product innovators make above average profits will be tested in section 1, using panel data from 1.200 firms which participated in two rounds of the OSA survey (1988 and 1990). The data allow 1990 profits to be explained with the use of independent variables relating to 1988. In section 2, simple cross sections are used, explaining wage differentials in 1988 and 1990 separately. We analyze factors that influence the average wage paid by an enterprise. In both sections particular attention is given to the possible impact of factors related to the innovative performance of firms.

1 Innovative performance and profits at the firm level

In the following, a firm's R&D intensity in 1988 (i.e. R&D man years as a percentage of a firm's total labour force) is used as an indicator of unique knowledge which may become a source of monopoly power. In addition to R&D, the OSA database covers profits (before tax) and sales in 1990. Starting from 1286 firms that returned a questionnaire in both rounds of the survey and after deleting firms with missing observations and implausible values, data on profits and sales from 570 firms are retained. Among these we find relatively high profits (as a percentage of sales): on average 12,9%. For about half of the 570 firms, profits as a percentage of sales are between -0,01 and 4,37 percent. This relatively high level may in part be explained by the fact that data were measured during a prosperous phase of the business cycle. However, there is also the more general problem that financial data are often badly reported in postal surveys and that non-response can be selective; i.e. firms with favourable records may be more likely to participate in both rounds of the survey. In order to correct for possibly selective non-response, a Heckman correction term will be included in our profit equation.

The results of our regression estimates are summarized in Table 1/1 in which insignificant variables are not included. Among such variables were a number of dummies for sectors, implying that, at a 95% significance level, there are no notable differences in profit rates among sectors. This finding also implies that a few sectors characterized by the presence of very large multinational firms (possessing market power) do not differ from others. Other potentially relevant variables having no impact on profits rates are: the growth rate of a firm's labour productivity (1988-90), a firm's age (if included as a continuous variable), and investment per employee in 1990. The Heckman correction term is not included in Table 1/1, given that its coefficient of minus 22.6 (t-value: 1,91) just fails to be significant at a

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95% level. The negative coefficient of the Heckman term indicates that firms with less favourable financial records may be less likely to participate in the two rounds of the survey.

It is interesting to note from Table 1/1 that intramural product-related R&D has a strongly positive influence on profits. According to our model, an increase of a firm's product-R&D intensity (i.e. man years of intramural R&D dedicated to the development of new products or services as a percentage of total employment) by one percentage point corresponds with an increase of profits (as a percentage of sales) by 0,9 percentage points. As opposed to intramural R&D, the contracting-out of R&D seems to have a negative impact on profits. In Table 1/1, the dummy for firms contracting-out R&D is significantly negative, implying that pre-tax profits as a percentage of sales are 5.87% lower than in firms that do not contract-out R&D. In an alternative regression equation (not documented in Table 1/1), instead of a dummy for contracting-out R&D, we included a firm's R&D intensity with respect to process-R&D contracted-out (i.e. process-R&D man years contracted-out as a percentage of the firm's total labour force) finding also a negative impact on profits: an increase of the external process R&D-intensity by one percentage point leads to a reduction of profits as a percentage of sales by 1,09 percentage points (t-value: 2,77).

Table 1/1:   Factors that influence 1990 profits as a percentage of sales (only factors significant at 95% level).
Summary of multiple regressions

independent variables*:	coefficients:	t-values:
constant term	12,27	7,52
intramural product-R&D intensity**	0,90	5,84
dummy for firms contracting-out R&D	-5,87	-3,10
dummy: firm has an advanced position in mechanization and automatization	-4,53	-2,26
dummy: firm believes that its markets will grow (rapidly) in the future	4,21	2,11
dummy: firm is 20-40 years old	6,03	2,85

Notes:
- number of observations: 570 firms;
- R-square: 0.11;
*   independent variables refer to the year 1988;
**   Definition: intramural R&D man years related to product development in 1988 as a percentage of total employment in the same year. Product-R&D in 1988 was obtained by applying a firm's subdivision of R&D into product- and process-related R&D in 1990 to a firm's (total) R&D in 1988.

Further experiments revealed that the impact of intramural process-related R&D on profits is insignificantly positive, and that product-R&D contracted-out has an insignificantly negative coefficient. This explains why total R&D (including: product- and process-R&D, intramural R&D and contracted-out R&D) has only a weakly significant positive influence on profits (coefficient: 0.12, t-value: 1,62).

These findings are interesting when confronted with the hypothesis of David Teece (1988). Teece argues that R&D projects of key importance to a firm's strategy tend not to be contracted-out: firms do not want to become dependent on third parties with respect to their crucial assets. Important reasons for this attitude are (1) that the firm's partners may develop some monopoly power; (2) that knowledge may more easily leak out (moral hazard); and (3)

that problems concerning the appropriation of R&D spill-overs and serendipity effects may arise. Hence, contracted-out R&D tends to be confined to less important R&D activities (e.g. routine material testing).

Against this background, our finding that the profits of firms contracting-out R&D are lower can be interpreted in two ways. Either the R&D contracted-out by those firms covers (in accordance with Teece's hypothesis) little unique knowledge that could become a source of monopoly rents, or such firms have not learnt the lesson from Teece's hypothesis.

In addition to R&D, the OSA survey asked for qualitative information on the importance of process technology to the firm. The relevant question was whether the firm had an 'advanced position with respect to mechanization and automatization'. Table 1/1 shows remarkably that firms that (believe they) have such an advanced position have significantly lower profits as a percentage of sales (-4,53%). Moreover, firms that responded that 'an important new technology has been introduced during the past two years' have no significantly higher profit rate. It is interesting to add here that the growth rate of labour productivity (i.e. the change in sales per employee during the period 1988-1990) also does not have a significant impact on profits.

The different impact of product and process innovation on profits may be explained as follows. Product-related R&D may indeed lead to the accumulation of relatively unique knowledge in the firm. Such knowledge (in particular 'tacit' knowledge) may be hard to imitate, and the number of competent imitators is likely to be limited. Moreover, patent protection may enhance a product innovator's monopoly power. On the other hand, an advanced position with respect to mechanization and automatization often requires less indigenous effort by

the firm. Such a position can be obtained, to an important degree, by buying the relevant equipment - which can also be done by firms with relatively little technological competence. As a consequence, a pioneers' monopoly rent can be competed-away by imitators much more quickly than in the case of product innovation. In addition, pioneering firms that buy the most recent vintage of mechanization and automatization equipment may have more severe problems with technological uncertainty and perhaps buy equipment with various types of (infancy) 'bugs', thus causing additional costs.

Besides the above-named variables, firms that have been in existence for 20 to 40 years seem to be the most successful in terms of profits. As has been mentioned above, 'firm age' (as a continuous variable) was insignificant, which could imply that there are some non-linearities in the relationship between firm age and profitability. Our finding that firms that consider that their market will grow (rapidly) in the future are more profitable, is not really surprising.

Our conclusion from the above is that the data support the hypothesis that product innovators realize above-average profits, while process innovators do not. In the latter case, imitation works more quickly. Although we only use profit data from one year, it may be argued that the above-average profits of product innovators are likely to be more durable, given that they are based on historically-accumulated product knowledge.

2   Innovative performance and average wage levels

In the introduction it is argued that product innovators may protect their monopoly rents by sharing (part of) those rents with their employees, thus reducing the probability that employees would leave the firm, taking with them strategically important knowledge. In the following, OSA cross-section data are used in order to analyze factors that account for differences in average wages paid by firms. In doing so, we take advantage of the analysis of wage differentials on the OSA data by Teulings et al. (1992). In principle, the same independent variables that they tested are included. It should be noted, however, that although they analyzed the impact of numerous variables, Teulings et al. did _not_ include indicators of technological innovation.

Data on average wages paid by individual firms are available from both rounds of the OSA survey (1988, 1990). Explanatory variables available for the two years are slightly different. For example, the 1990 survey includes questions about the division of R&D into product- and process-related R&D, while the 1988 data cover only total R&D. The 1990 data provide information about the size of the responding establishment (e.g. a branch plant) which may be part of a larger unit, while the 1988 data cover the size of the enterprise as a whole. Furthermore, the latter show a measure of trade unionization, while the 1990 data do not. Such variances allow for the specification of slightly different regression models which may give hints about the robustness of outcomes.

Our estimates for 1990 are summarized in Table 2/1 and are quite similar to those of Teulings et al. (1992). For example, an increase by one percentage point of the share of employees taking part in external training courses leads to a wage increase of 0,11%. As might be expected, education levels and the age of workers also have an impact on wages.

Sexual discrimination is indicataed by our finding that, ceteris paribus, an increase by one percentage point of the share of male workers results in a wage increase of 0,24%. If a high percentage of workers left the firm during the previous year, average wages are lower. The direction of causality may be debated: did people leave voluntarily or were they fired?

Table 2/1a   Variables influencing the log of average wages paid by a firm in 1990.
              Summary of regressions

independent variables:	coefficients:	t-values:
constant term	7,61	99,90
percentage share of male workers	0,24	9,00
percentage of workers taking part in		
external manpower training courses	0,11	2,39
percentage of workers in the age groups:		
- less than 20 years	-0,37	-3,32
- 20-29 years	0,05	0,66
- 30-39 years	0,24	2,93
- 40-49 years	0,24	2,46
percentage of workers with:		
- lower education	-0,00	-0,09
- medium education	0,14	3,92
- higher education	0,53	13,68
(intramural) R&D-intensity	0,15	1,68
perc. of workers leaving the firm	-0,20	-3.07

Notes:
-    R-square: 0,45
-    943 observations
-    all variables refer to the year 1990

Table 2/1b   Variables that have no systematic influence on wage levels

-    percentages of workers following internal manpower training courses in 1990;
-    percentages of workers newly hired in 1990;
-    log of the number of workers in the establishment;
-    dummy for firms indicating that they had introduced a new process technology during the past two years;
-    dummy for firms claiming an 'advanced position in the field of mechanization and automatization'.

Important in the context of this paper is the finding that, after control for such variables, product- and process-related intramural R&D both have a positive influence on wages. If a firm's total intramural R&D intensity increases by one percentage point, wage levels increase by 0,15%.

Dividing intramural R&D into product- and process-related R&D and adding both variables in turn to our equation, we find that they both have a significantly positive influence on wages: coefficients are 0,25 (t-value: 2,16) for internal product-R&D intensity and 0,72 (t-value: 2,93) for internal process-R&D intensity. If the two variables are included together in the equation, internal product-related R&D becomes insignificant due to multicollinearity (the R-square between the two is 0,30). Some multicollinearity between R&D intensity and educational levels may also be expected. If intramural product- and process-R&D intensity are included in the equation and educational variables are omitted, the result is a significant coefficient for both intramural product- (coefficient: 0,51, t-value: 3,80) and process-R&D intensity (0,96, t-value: 3,37). However, this model is not such a good predictor of average wage levels, the R-square being 0,29. Seemingly, educational levels are more important than R&D for wages.

The most remarkable result is that a positive impact on wages is achieved by both product- and process-related R&D, the latter being even more important than the former. In this context, it should be noted that two qualitative process innovation variables have no systematic impact on wages: (1) firms that indicated that they had introduced a novel process technology during 1988-90, and (2) firms claiming that they held an 'advanced position in the field of mechanization and automatization' do not pay systematically higher (or lower) wages.

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The discrepancy between process-related R&D and the two qualitative variables can be explained as follows. Process-related R&D requires a substantial investment in knowledge by the firm itself. To the extent that this knowledge is 'embodied' in the heads of people, the firm has an interest in minimizing the risk of their leaving by paying higher wages. The need to prevent the leaking of (tacit) knowledge may be less urgent in the case of an 'introduction of a new process technology' or for an 'advanced position in the field of mechanization and automatization', as this may often be based on the acquisition of new equipment and less on the firm's development efforts.

Our finding that process-related R&D has no impact on profits but does have a positive impact on wages is a little harder to explain. One explanation may be that process-R&D often serves to meet tougher environmental standards. As the principal aim is to improve the environment, such R&D need not have a systematic impact on productivity or profitability. Nevertheless, it requires highly skilled labour with specialist knowledge. A different but not necessarily competing explanation is that firms that concentrate on process technology have made the strategic choice to produce fairly simple standard products that can be produced at low cost due to modern process technology. Such products may often compete with similar products from low wage countries, which may explain the relatively low profits.

Finally, Table 2/2 summarizes our estimates of wage level determinants for the year 1988. In spite of some differences in the specification of our regression equation (due to data availability), quite similar results are found with respect to educational levels and age classes. Among the variables added in 1988 (and not available in 1990) the following are worth mentioning. Trade unionization (i.e. percentages of trade union members in the firm) has a significantly positive impact on wages. This also holds for the growth of employment at the

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firm level. Moreover, as in the equation for 1990 (Table 2/1), firm size has little systematic impact on wages. In the 1988 cross-section, firm size (i.e. numbers of employees) was approached in two ways: the size of the entire firm (i.e. the principal establishment) and the size of the establishment or branch plant (being part of a larger unit). In both years, the size of the establishment (as part of a larger unit) proves insignificant. However, in 1988 the size of the (total) firm (not available in the 1990 data) is (weakly) significant at 89%. Again, R&D intensity has a positive impact on wages, although it should be noted that it is significant only at a 90% level.

Table 2/2   Variables that influenced the log of average wages paid by a firm in 1988.
            Summary of regressions

independent variables:	coefficients:	t-values:
constant term	7,54	108,94
percentage of male workers	0,16	6,81
percentage of workers participating in:		
- external training courses	0,05	1,25
- internal training courses	-0,05	-1,71
percentage of workers who changed to		
a different department or function	-0,16	-2,01
percentage of workers in age groups:		
- under than 20 years	-0,14	-1,35
- 20-29 years	-0,01	-0,15
- 30-39 years	0,23	3,33
- 40-49 years	0,21	2,38
percentage of workers with:		
- lower education	0,08	2,48
- medium education	0,16	4,79
- higher education	0,54	15,05
intramural R&D intensity	0,24	1,79
percentage of workers leaving the firm	0,03	0,55
percentage of trade union members	0,04	1,87
job growth in the firm during 1986-88	0,11	3,37
firm size (log of number of workers)	0,004	1,60

Notes:
-    R-square: 0,40;
-    954 observations; some firms with an R&D intensity of >30% have been deleted as
     outlyers;
-    all variables refer to 1988;
-    some t-values may be exceptionally high as the method of 'pairwise' (instead of
     'listwise') deletion was used in dealing with missing values.

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