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1997

document version

Early version, also known as pre-print

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citation for published version (APA)

Brouwer, E., & Kleinknecht, A. H. (1997). *Keynes-plus? Effective demand and changes in firmlevel R&D*. (Research Memorandum Vu Amsterdam; No. 1997-38). Economisch en Sociaal Instituut (ESI).

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KEYNES-PLUS?

Effective demand and changes in firm-level R&D.
An empirical note

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Research Memorandum 1997-38

August 1997



KEYNES-PLUS? Effective demand and changes in firm-level R&D.

An empirical note

by

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Abstract:

Analyzing changes over time in firm-level R&D efforts we find that demand growth in a firm's sector of principal activity has a positive influence on changes in a firm's R&D effort, config Schmookler's (1969) 'demand-pull' hypothesis. This finding points to an aspect of effective demand which has never been directly noticed by Keynes or the Keynesians. Such findings are important because of evidence in the literature that a firm's innovation activities are positively related to employment growth, export intensity and profits.

Acknowledgement:

The data used are from the Dutch part of the *Community Innovation Survey* (CIS), carried out when we were both Fellows of SEO, Foundation for Economic Research, *University of Amsterdam*. The survey was financed jointly by the Netherlands Ministry of Economic Affairs and by DG 13 of the European Commission. The research for the present paper has been supported by the **SPRINT/EIMS** program of the European Commission. While writing this paper, we received valuable hints from Bronwyn Hall and John Van Reenen. Moreover, we are indebted to Kees Burger, Enrico Deiaco and Jeremy **Howells** for detailed comments on an earlier version. The usual disclaimers apply.

1 Introduction

While stimulation of innovation ranks high on political agendas, there is still quite sparse knowledge about factors which induce changes in a firm's innovation effort. (Static) cross-sectional studies of R&D intensities are abundant, but little is known about determinants of changes in time of a firm's R&D intensity. Without doubt, the poor state of knowledge has something to do with lack of firm-level panel data on R&D. Such databases are often subject to tough secrecy protection. Moreover, there is a specific difficulty with R&D data: firm-level R&D efforts do not change very much over time and part of the observed variation may be due to noise (see e.g. Hall et al. 1986; Branstetter et al. 1995).

One reason which explains lack of variation over time relates to certain categories of scientists and engineers which are difficult to find in the **labour** market and they embody much of the technological knowledge relevant to the firm. When they are fired, this knowledge will be lost, or, even worse, it may be appropriated by a competitor. Quite important in this context is the role of so-called *tacit* knowledge which is historically accumulated by people through practical experience. Such knowledge has also been **characterised** as **uncodified**, unpublished and poorly documented knowledge which cannot be found in textbooks or in courses, but may be transferred by personal contact (Dosi 1988). Tacit knowledge is 'embodied' by employees which may be an explanation for **labour** hoarding.

In this paper we try to add something to the knowledge about determinants of changes in firm-level R&D intensities, drawing from the following two micro databases:

- the 1988 **SEO** national survey on R&D and innovation in Dutch manufacturing and services; and
- the 1992 Community Innovation Survey in the Netherlands.

Both surveys are representative of firms with 10 and more employees in all sectors of Dutch manufacturing and services. 2.083 firms responded to both surveys. That is, among the 4.352 firms which responded to the 1988 survey, 2.083 responded again in 1992. The difference is in part due to non-response in 1992; smaller parts are due to sampling variation and bankruptcies. Moreover, all firms were omitted from the sample which indicated in the 1992 questionnaire that, during the last three years, a major structural change had occurred which made their inter-temporal data incomparable (e.g. mergers, selling of parts of the firm etc.).

There are two possible objections to using such data. First, a comparison of R&D over a four-year period does not take into account the R&D by young firms which did not yet belong to the 1988 sample; second, as already mentioned, there is a high rate of firms which were in the 1988 sample but not in the 1992 sample. Since this raises concern about the possibility of a sample selection bias, we estimated a **Logit** model which compared properties of firms responding to both surveys to firms responding in 1988, but not in 1992. It turned out that there is hardly any systematic difference between the two with respect to factors such as R&D intensity, firm size, sector of principal activity, field of technology and so on. Moreover, a brief survey among non-responding firms in 1992 suggests that non-responding firm in 1992 do not systematically differ from respondents (see Brouwer & Kleinknecht 1994: 19-21). We therefore

estimate an Ordinary Least Squares (OLS) regression model, without a **Heckman** correction term.

Our estimate identifies factors which influence changes in a firm's R&D personnel (in full-time-equivalents) between 1988 and 1992, conditional upon having some R&D in these two years. The dependent variable includes intramural R&D and R&D contracted out (in man years), and consists of the log of R&D man years in 1992, minus the log of R&D man years in 1988. A log specification was used since this was the only version in which the dependent variable fulfilled the requirement of normal distribution. In all non-log versions (including changes in R&D intensities) the dependent variable was strongly non-normally distributed. Use of the log version implies that we have to leave out firms which have zero R&D in 1988 or in 1992 which reduces our observations to 441 firms. As a consequence, the interpretation of our findings is strictly confined to firms which have some R&D in both years. This implies that many firms which have only occasional R&D efforts are omitted from our analysis. This latter group consists mainly of small and medium-sized enterprises whose small-scale and often informal R&D efforts tend to be undercounted in official R&D surveys (Kleinknecht, Poot & Reijnen 1991).

Before coming to regression results we give some descriptive information. The sample consists of 86 service firms and 355 manufacturing firms. Among the latter, 239 fall into the category of high technological opportunity sectors and 116 belong to low technological opportunity sectors, the latter being identical to Pavitt's (1984) 'supplier-dominated sectors'. 34 firms participated in an EC R&D program during 1991 and/or 1992. 173 out of 441 firms have no formal R&D department, the R&D work being carried out by other departments, e.g. a sales or a production department.

Some means and standard deviations are given in table 1. The table shows that, in spite of a slight increase of average R&D man years per firm during the four years observation period (1988-92), the R&D intensity declined since R&D employment increased less than overall employment. This is another reason for taking, as a dependent variable, changes of the (log *of*) **absolute** numbers of R&D man years instead of taking R&D intensities (i.e. a firm's R&D man years divided by its total employment). The latter measure may be misleading, since R&D intensive firms tend to increase their overall employment more strongly than **non-innovators** (Brouwer et al. 1993).

Table 1 Means and standard deviations of some key variables

Variable	mean	Stand. dev.
average of firm level R&D intensities* in 1988	4,2	5,3
average of firm level R&D intensities* in 1992	3,7	4,4
R&D man years per firm in 1988	17	87
R&D man years per firm in 1992	19	106
firm size (number of employees) in 1988	377	1133.8

* definition of R&D intensity: R&D man years as a percentage of all employees in a **firm**

2 Hypotheses and Results

Our research was motivated by the wish to know more about effects of a firm's participation in R&D programs of the European Commission. Do these programs induce firms to undertake substantial extra R&D efforts or are firms doing what they wanted to do anyway, the subsidies mainly being used for cost reduction? In order to capture the influence of the EU programs we include in our model a dummy variable for firms which participated in 1991 and/or 1992 in such programs. For an assessment of the role of the EU-programs we need to control a number of other influential factors. A major difficulty in this respect is that many variables which play a role in (static) cross-sectional analyses of innovation are not so meaningful in a dynamic context. For example, measures of technological potential or of appropriability conditions in a sector have much explanatory power in cross-section R&D equations (see several contributions in Stoneman, ed. 1995; or Kleinknecht, ed. 1996). However, they may be less meaningful in an inter-temporal study since they do not change much in the short run. The same holds for related factors such as market share, firm size, location (regional spill-overs), ownership, and so on.

Nonetheless, some of these variables may still be of interest against the background that the last year of our observation period (1992) is a business cycle recession year. It is conceivable that firms will respond to the pressure of a recession differently, depending on whether they concentrate their R&D in more or less fecund technology fields (e.g. IT, biotechnology, new materials technology, medical technology etc.), whether they operate in a high or low technological opportunity sector, or whether R&D is organised in a separate R&D department rather than being integrated with other functions such as production or marketing. Therefore, a number of dummy variables is included in our estimate in order to capture the named properties. Moreover, we include a measure of firm size, assuming that smaller and larger firm may react differently to a recession.

Besides a dummy for participants in an R&D programme of the European Union, we include a measure for the growth of demand. The hypothesis that innovation depends on demand growth goes back to the seminal work by Schmookler (1966). Recent cross-section and time series analyses of innovation 'output' data give support to Schmookler's 'demand-pull'

hypothesis. For example, three chapters in Kleinknecht (ed., 1996) give evidence on ‘demand-pull’ based on cross-section analyses (using recent Community *Innovation Survey* data) in Switzerland, France and in the Netherlands. Evidence of ‘demand-pull’ in time series analyses of British innovation and patenting data has been provided by Geroski & Walters (1995). In the following we address the question whether ‘demand-pull’ effects are relevant not only for ‘output’ measures but also for R&D as an input measure. The results of our OLS regressions are summarised in Table 2.

Table 2 Factors which explain changes in logs of R&D man years (1988-1992). Summary of OLS regressions among 441 manufacturing and service firms in the Netherlands

exogenous variables:	coefficients:	t-values:
intercept	-0,47	-1,39
dummy for service firms (reference group: low technological opportunity firms in manufacturing)	0,83	3,25 ⁺⁺
dummy for high technological opportunity sectors within manufacturing*	0,18	2,12 ⁺⁺
dummy for firms participating in an EC R&D program in 1991 and/or 1992	0,38	1,93 ⁺
dummy for firms which have an R&D department	-0,23	-2,71 ⁺⁺
demand growth in a firm's sector of principal activity	0,68	2,74 ⁺⁺
firm size (log of numbers of workers)	-0,05	-1,54

* the distinction between high and low technological opportunity sectors is along the lines of Pavitt's (1984) taxonomy of sectors. We took Pavitt's categories of ‘specialized suppliers’, ‘science-based’ and ‘scale intensive’ industries in the category of high technological opportunity sectors. His category of ‘supplier-dominated’ sectors serves as the (low technological opportunity) reference group.

++ = significant at 95% level

+ = significant at 90% level

R-square: 0,05

In order to check the robustness of results, experiments were made with more narrowly defined sector dummies. We found that, besides the observed differences between high and low technological opportunity sectors, there is little evidence of differences between sectors. Moreover, when examining the possible impact of firm size, we experimented with non-linear specifications, finding no indications of this. In table 2, the coefficient of the log of firm size as a continuous variable is insignificant, indicating that there is no systematic difference in changes of R&D intensities between larger and smaller firms.

When looking at effects of participation in R&D programs of the European Commission, it should be noted that we have information about participants only for the second half of our observation period (1991-1992). The coefficient documented in table 2 just fails to be significant

at a 95 % level. In alternative specifications, it was always around a 95 % level. In fact, our model gives only a rough indication that participation in EC R&D programs is favourable to R&D efforts. Moreover, since many firms reduced their R&D activities during our observation period, the merit of the R&D programs may have been that they more or less committed firms to maintain their R&D efforts instead of reducing them in response to the recession. Unfortunately, nothing can be said about effects of subsidies since information about the amount of subsidies is lacking.

Growth of effective demand is measured by sales growth in a firm's sector of principal activity during 1990-92. The findings in table 2 are consistent with Schmookler's (1966) hypothesis that demand will stimulate innovation. Earlier tests of Schmookler's hypothesis gave weak evidence in favour of it. However, these tests were based on innovation data at sector level (see e.g. Scherer 1982, Walsh 1984, Kleinknecht and Verspagen 1990). One could still be concerned about the direction of causality. An indication that the dominant causal link runs from demand to innovation can be found in a time series analysis of British innovation data by Geroski & Walters (1995).

Such findings may be subject to one qualification. The evidence of demand-pull may be confined to indicators of major or minor innovations which occur in very high numbers. One of us has argued earlier, in a long-run historical context, that the demand-pull hypothesis does *not* apply to a much smaller number of really big innovations (e.g. 'basic innovations'). The latter can have earthshaking consequences, leading to the creation of entirely new branches of industry, and there is evidence that they follow a 'counter-Schmookler' pattern (Kleinknecht 1990, see also Walsh 1984 for evidence from chemical industry). While the many 'smaller' innovations (taking place *within* given 'technological paradigms'), may have a more direct impact on economic growth in the short en medium term, the few 'basic' innovations are relevant as indicators of long-run 'paradigm change' in the historical analysis of Kondratieff long waves in economic growth.

What matters for economic growth and policy in the short and medium term are the many innovations that occur within *existing* technological paradigms. Therefore, the findings on demand-pulled innovations can shed new light on the relevance of Keynesian demand theory. Fluctuations in aggregate demand will not only have effects on short-run production and employment as emphasised by Keynesians but may also enhance or hamper innovation. In principle, this does not yet need to be taken as a reason to advocate a policy of Keynesian 'fine-tuning' of effective demand. It does suggest, however, that, as part of effective innovation policies, effects on effective demand should always be an important criterion in the decision process about government policy measures. For example, strong budget cuts, such as those required for meeting the criteria of the Maastricht Treaty for EMU, are likely to be damaging to the innovation process in Europe. Another implication of the finding on 'demand-pull' is

¹ there has been a longer discussion in the literature about whether clusters of 'basic innovations' in historical time do exist and whether such clusters are indeed 'countercyclical' in a Kondratieff long wave perspective, starting with a criticism by Clark et al. (1981). For the most recent round of discussion see Solomou (1986) and Kleinknecht (1990) and the literature quoted there.

that the decline of R&D intensities during the 1988-92 period may in part be explained by the recession in the early 1990s and (expectations of) declining demand.

Our finding in table 2, that high technological opportunity sectors experienced a more favourable development of their R&D inputs is interesting in the context that the last year of our observation period is a business cycle recession year. Geroski et al. (1993) found that profits in innovating firms are more resistant to business cycle recessions. This may indicate that innovators in high technological opportunity fields have less problems with negative demand shocks or with respect to financing of R&D in a recession which may have something to do with market power related to innovation.

Besides the variables on participation in EU programs and on demand, we included other control variables. For example, we included dummies for firms which concentrated their R&D in certain technology fields (information technology, new materials technology, biotechnology, medical technology and environmental technology) finding little of an impact. In other words, during our observation period, these fields did not turn out to be particularly attractive fields of endeavour. Moreover, we found that firms which belong to service industries have a more favourable development of R&D intensities than manufacturing firms. The opposite holds for firms which organised their R&D in a formal R&D department. This suggests that firms which integrate their R&D efforts with other functions (e.g. marketing, production) have better resisted the pressure from the recession.

3 Summary and Conclusions

Our above results are subject to the qualification that there is not so much variation over time in a firm's R&D efforts, and part of the observed changes may be due to noise. It is therefore not surprising that the variance explained by our model is just 5 % .

Policy makers at the level of the European Commission will note the finding that participants in their R&D programs seem indeed to experience a more favourable development of their R&D inputs than non-participants. Interesting from a theoretical viewpoint is the evidence that demand growth plays a role for changing R&D efforts. This adds to the recent evidence that innovative output (that is, sales related to innovative products) depends on demand (see various contributions in Kleinknecht, ed. 1996). There remains the problem of the direction of causality which is hard to investigate with cross-section data. Moreover, R&D input data are much less volatile over the business cycle than are innovation output data which makes it difficult to investigate lead or lag relationships and causal links between R&D and other variables (see Hall et al. 1986). However, the time series analysis of British innovation output data by Geroski & Walters (1995) suggests that the (main) direction of causality seems indeed to run from demand to innovation as originally proposed by Schmookler (1966).

One can still discuss whether the true causal link has indeed to do with direct effects of demand (implying that demand growth reduces the expected pay-back period of R&D investment). An alternative interpretation has been suggested by Branstetter et al. (1995) and Hall (1992) who suggest that there is a problem of finance due to capital market imperfections. Of

course, favourable sales expectations and the ease of raising financial funds for an innovation project are intertwined. Whether the direct effect of favourable demand expectations or the indirectly positive effect of demand on financing possibilities is most important, would need to be investigated more closely in the future.

If demand growth plays (directly or indirectly) a significant role for (product) innovation performance, and given that innovation in turn has a positive impact on employment growth (e.g. Brouwer et al., 1993), on export performance (Hughes 1986, Brouwer & Kleinknecht (1993) and on company profits (Geroski et al. 1993), our results should be a challenge to macro-economists who are concerned about Keynesian demand effects. Seemingly, demand growth has additional effects which seem never to have been noticed by Keynes or the Keynesians. Of course, Keynesianism has been concerned about determinants of investment. Since R&D can be defined as one specific (largely intangible) category of investment, one could argue that our finding is thoroughly in tune with Keynesian theory and its policy implications. However, Keynesianism has never gone into depth with respect to determinants of (product) innovations and their repercussions on the economy. Therefore, from a broader economic theory viewpoint, the independent confirmation of the findings on **Schmooklerian 'demand-pull'** effects is perhaps the most suggestive result of our above exercise.

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