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Article Title: Does being R&D intensive still discourage outsourcing?: Evidence from Dutch manufacturing

Year of publication: 2005

Link to published article:

<http://dx.doi.org/10.1016/j.respol.2005.03.007>

Publisher statement: Mol, M. J. (2005). Does being R&D intensive still discourage outsourcing?: Evidence from Dutch manufacturing. *Research Policy*, Vol. 34(4), pp. 571-582

**Does being R&D intensive still discourage outsourcing? Evidence
from Dutch manufacturing**

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¹ The author would like to thank Statistics Netherlands (Centraal Bureau voor de Statistiek) for kindly allowing him to access the data employed in this study. He would also like to express his gratitude to Zella King for comments on an earlier version.

Abstract:

Being R&D intensive has traditionally been seen as an impediment to outsourcing. This study confirms that empirically this was the case for a set of manufacturing industries in the Netherlands in the early 1990s but also shows that R&D intensity became a positive predictor for changes in outsourcing levels over the 1990s, suggesting firms in R&D intensive industries have increasingly started to rely on partnership relations with outside suppliers. This confirms the need to move the analysis from scale, opportunism and appropriation concerns to a relational perspective when studying outsourcing in R&D intensive industries.

Keywords:

Outsourcing, R&D intensity, supply chain strategy, manufacturing industry

Does being R&D intensive still discourage outsourcing? Evidence from Dutch manufacturing

1. Introduction

Firms no longer are what they used to be, appears to have become the communis opinio among practitioners and academics alike when it comes to the newly emerging vertical structures of high-tech firms. More extensive outsourcing of activities, including activities in the manufacturing and product development realms, has led to more nimble and leaner firms, so the argument often starts (Domberger, 1998; Quinn, 2000). To compensate for the loss of internal technological capabilities, however, firms increasingly rely on partnering relations with outside suppliers that can act as an effective substitute to the internal generation of knowledge and innovation (Dyer and Nobeoka, 2000; Dyer and Singh, 1998; Hagedoorn, 1993; Kinder, 2003; Nooteboom, 1999; Quinn, 2000). Yet, through all the anecdotal evidence on leading manufacturing firms supporting these statements, it is unclear whether such changes in outsourcing policy have indeed taken on broader significance to the extent that R&D intensive industries have been engaged in large-scale outsourcing efforts.

It has long been argued that a high R&D intensity should lead to lower levels of outsourcing (Harrigan, 1985; Stigler, 1951; Williamson, 1985). In R&D intensive industries scale advantages are usually sufficient to allow for more vertical integration (Harrigan, 1985; Stigler, 1951). Furthermore innovative activities may be harder to appropriate if they are not performed inside the firm (Teece, 1986; Pisano, 1990). And there can be an increased risk of opportunism under these conditions, especially

where the R&D concerned is of a proprietary rather than a generic nature (Williamson, 1985). Yet an alternative, relational view has arisen, which predicts outsourcing levels should be on the rise in the context of R&D intensive firms, since there is increasing inter-sector technological specialization and buyer-supplier relations have become more effective vehicles for exchanging technological know-how (Dyer and Nobeoka, 2000; Dyer and Singh, 1998; Kinder, 2003; Quinn, 2000). It has been suggested that in the face of severe technological change (Afuah, 2001) or if heterogeneity among firms is a substantial driver of the competitive process (Barney, 1999) vertical integration can instill rigidity into technological trajectories. Furthermore the widening range of technologies needed to produce products like aircraft engines forces firms to look to outside suppliers for an increasing part of their innovative needs (Brusoni, Prencipe and Pavitt, 2001). Thus there is now no conceptual agreement on the relation between R&D intensity and outsourcing.

This article attempts to tackle this controversy in the outsourcing and technology literatures by empirically unraveling the relationship between R&D intensity and outsourcing. Its central contention is that R&D intensity is no longer a negative predictor of outsourcing because firms in high-tech industries increasingly use cooperative relations with outside suppliers to obtain technology in areas that they know of but are not themselves specialized in. By investigating outsourcing both as a state variable, in terms of how much a firm relies on external suppliers for producing its goods, and as a flow variable, in terms of changes in that external reliance, static and dynamic effects are captured. The two rival theoretical explanations are contrasted. An empirical test of 52 manufacturing industries in the Netherlands provides support for the traditional argument initially but also shows how the relational has gained impetus over the 1990s and is now more valid, implying R&D

intensive industries were originally more vertically integrated but have outsourced a substantial amount of activities and are now less integrated than other industries. This casts substantial doubt over the tenability of the conventional argument and suggests the relational view (Dyer and Singh, 1998) is more appropriate.

The second section of the article discusses the current stock of knowledge on outsourcing in the management and applied economics literature, focusing in particular on how R&D is believed to influence make-or-buy decisions. It also puts forward two hypotheses. Section three discusses developments in outsourcing in the Netherlands over the 1990s and presents the empirical data underlying this study. In the fourth section these data are used to test the hypotheses through regression models. The conclusions, in section five, center on the theoretical implications, in terms of our understanding of when (not) to outsource and on the policy implications, particularly how the changing nature and extent of outsourcing forces managers and policy makers to rethink existing practices.

2. Outsourcing and its predictors

The make-or-buy or outsourcing decision has been the subject of substantial analysis in economics and management. While this is neither the place nor is there enough space to fully review this area here, it is useful to recapture some of the main arguments and findings. In particular various attempts have been made to construct contingency models that help explain under which conditions outsourcing is a beneficial solution. Transaction cost economics clearly is one such model that predicts (Williamson, 1981, 1985) outsourcing occurs under conditions of low asset specificity, low uncertainty and a low frequency of transactions. When transactions

employ highly specific assets markets fail due to pressures for opportunism, forcing firms to internalize transactions (Walker and Weber, 1984). Similarly if a certain asset is required frequently, the transaction cost disadvantages of the market will increase and internalization occurs. Uncertainty, for instance in the form of volume or profit margin fluctuations, will induce the same effect, since contracts with suppliers will be imperfect, making external contracting less attractive. This effect of uncertainty is strongest in the simultaneous presence of asset specificity (Williamson, 1985). Williamson (1981) originally also argued that technological uncertainty, like volume uncertainty, would lead to vertical integration. Yet this has not been consistently confirmed in empirical research (Walker and Weber, 1984). More recently, Williamson's stance on this has changed somewhat in that technological uncertainty is no longer seen as a significant predictor of outsourcing (Williamson, 1996). But technological uncertainty is not quite the same as R&D intensity, the focus of this article, as will be discussed shortly. There is of course also a literature linking different types of innovation to organizational forms (e.g. Henderson and Clark, 1990; Brusoni et al, 2001) but that is not within the scope of this article.

Measurement and information approaches (Milgrom and Roberts, 1987) point at monitoring problems and information differentials between buyer and supplier as explanations of outsourcing. If a supplier's behavior cannot be appropriately monitored, this will stimulate vertical integration. Likewise the existence of substantial information differences, when the supplier knows things the buyer does not know, will induce vertical integration. Another type of explanation of outsourcing focuses more on analysis of the capabilities of the firm. The knowledge-based (Grant, 1996; Kogut and Zander, 1992) and resource-based (Barney, 1999; Quinn, 2000) explanations of outsourcing suggest that a firm will outsource those activities in

which it is not particularly specialized or that are ‘non-core’ because the firm is less capable of performing those activities. So rather than invoking a market failure explanation, this suggests firms may fail in certain respects. When there is such ‘firm failure’ outsourcing will come into play. Applying real options theory Leiblein and Miller (2003) argue that whether to outsource an activity or not can also be a consequence of the likelihood of that activity becoming a platform for future growth. In addition some scholars have pointed at the influence of the institutional environment on outsourcing. Toulan (2001) related increases in outsourcing to liberalization of the economy because liberalization provides more freely operating markets. This closely follows the institutional voids argument of Khanna and Palepu (2000), who argue that internalization of activities can be a consequence of the lack of properly functioning institutions in a country. Relational rent (Dyer and Singh, 1998) and trust (Zaheer, McEvily and Perrone, 1998) arguments suggest that establishing long-term, trusting, and idiosyncratic relations with certain suppliers can provide above average returns, which may also act as an incentive to outsource these activities. Very briefly these are some of the main arguments in the outsourcing area.

2.1 Innovation and R&D

For the purposes of this article, however, it makes sense to discuss in some more detail the relation between R&D intensity and outsourcing. R&D intensity is normally defined as research and development expenditures divided by sales and is a strong correlate for the innovative output of the firm (Colombo and Garrone, 1996; Greve, 2003). At this point it is necessary to elaborate upon the difference between technological uncertainty, which is one of the variables originally included in transaction cost economics-based explanations of outsourcing (Williamson, 1981),

and R&D intensity. Empirically there is probably a positive correlation between R&D intensity and technological uncertainty, since disruptive technological change is more likely to substantially impact firms' business models in technologically intense industries and because R&D expenditures generate new technologies and therefore technological upheaval in the industry. But this correlation is nowhere near perfect. Many industries that are not technologically intensive, in the sense of substantial R&D investments, have faced much disruptive technological change in the internet era. This holds true both for retailers like Barnes & Noble in its battle with Amazon and for many office environments, including for instance business schools. Furthermore R&D intensity can be measured at a distinct moment in time while technological uncertainty by definition refers to future technological flows that cannot be predicted well nor actually measured with as much accuracy. In conclusion R&D intensity will primarily be interpreted here as an input measure for innovative activity. Thus while I do not suggest R&D is the same as innovation I do maintain that R&D is performed in order to generate innovations, particularly of the technological type. While the existing literature has put forward some anecdotal evidence and conceptual discussions that relate innovation to outsourcing (Kinder, 2003; Williamson, 1985; Quinn, 2000), no large-scale empirical test appears to exist.

The wider literature on technological change provides some additional clues that can help us understand the R&D-outsourcing relationship. Dosi (1997) has for instance noted that technological change is a process driven by both factors inside the firm and outside sources of knowledge like suppliers, who usually provide knowledge complementary to that of the outsourcing firm, in areas where it may not be well-versed, an argument akin to that of Dyer and Singh (1998). Malerba and Orsenigo (1993) have argued in line with TCE that in industries with highly complex products

appropriability will be low and tacit knowledge will be abundant and therefore vertical integration will usually be the preferred solution. Using Pavitt's classification of industries, Malerba and Orsenigo (1996) further stated that scale-based industries are also strongly vertically integrated. Patel and Pavitt (1997) showed that many firms, particularly large multinationals, hold competences across a wide range of technologies. In later work Pavitt and colleagues (Brusoni et al., 2001) used this notion to suggest that firms know more than they make, implying that components and materials that could potentially be made by the firm are in fact outsourced, a useful extension of the resource-based argument discussed earlier. Cantwell and Santangelo (1999) found that while much of R&D spending is highly localized in the parent company, there are some instances of sourcing abroad. These appear dictated either by supply-side factors, with certain knowledge only being available in one or a few foreign clusters, or by the ability of large multinational firms to develop a global knowledge exploration network inside and around the firm. Thus the technological change literature, while not being very specific on how innovation, and R&D intensity in particular, ought to influence outsourcing levels, has developed useful notions on the implications of the type of product and industry for sourcing behavior. I will now build two contrasting hypotheses to link R&D investment levels to outsourcing levels. The first builds upon conventional insights, mostly drawn from economics, and the second brings in more recent findings from the management literature.

2.2. The conventional argument on innovation and outsourcing

Conventional industrial organization (IO) accounts of vertical integration (Stigler, 1951) tend to stress how it is used as a means to enhance the scale of operations and bargaining power. Technologically intensive industries normally favor

a large operating scale because R&D investments are mostly fixed costs that can be recuperated more easily at high revenue levels. The marginal costs of production are relatively low in technologically intensive industries. Thus a technologically intensive industry can be expected to be dominated by one or a few firms that employ substantial amounts of backward vertical integration to maximize the scale of operations. More recent observers in the IO tradition (Harrigan, 1985; Porter, 1980) seem to concur that where R&D matters, vertical integration is preferred over outsourcing.

In transaction cost economics Williamson's (1985: 141-144) discussion on the role of innovation in vertical integration decisions brings to light several arguments favoring integration under conditions of substantial innovation but also includes some discussion concerning hybrid agreements as a solution. The key advantage of integration is that it promotes cooperation between stages. On the other hand it will compromise the high-powered incentives available in markets because costs and benefits will tend to be shared between the purchasing and supply stages in an integrated setting (Williamson, 1985). Additionally there may be instances of higher-level intrusion or accounting manipulation that can further distract from such incentives. The latter, however, will exist to a larger degree in markets where opportunistic behavior is more common. Williamson (1985) concludes that where innovation is of a proprietary rather than a generic type it will lead to integration or at the very least partial ownership (hybrid forms), particularly when combined with a need for specific assets. He further suggests that non-specific assets will normally only lead to generic innovation. Thus there appears to be a positive correlation between proprietary innovations and specific assets. This further suggests that if R&D is undertaken in-house it must be aimed at producing some type of proprietary

innovation for the firm and should generally be associated with vertical integration according to Williamson. Teece (1986) has added that when the R&D intensity of a sector is high, it will be more prone to integrate activities into the firm rather than to outsource them in order to protect intellectual property rights. Pisano (1990) similarly argued that appropriation problems around knowledge, like that obtained from R&D, lead to vertical integration, as did Malerba and Orsenigo (1993).

Monteverde (1995) discussed the application of transaction cost economics in the exchange of technical engineering knowledge. He investigated empirically how unstructured technical dialog, one form of human asset specificity, affects outsourcing decisions. Because organizations can internally develop a specific dialect for exchanging unstructured and tacit knowledge, they are much more efficient at transferring this type of knowledge. Therefore the costs of transacting are substantially lower inside the organization and vertical integration is the preferred solution. Note that the latter observation, that organizations can be more efficient carriers of knowledge than markets, takes Monteverde's work closer to the knowledge-based explanation of Kogut and Zander (1992), which argues governance forms are less a result of market failure than one of organizational superiority in certain types of transactions.

In sum this conventional view suggests that innovation is created more efficiently inside firms than through markets. Outsourcing is not a means to innovate because outside suppliers lack incentives to innovate for the buying firm. Where they do innovate, it will be hard for the buying firm to appropriate the rents of innovations (Teece, 1986) as the supplier will seek to use it for a wide range of clients. Thus dedicated innovation is particularly hard to achieve under an outsourcing regime. All of this suggests that when R&D is an important part of an industry's value chain,

firms in that industry will integrate more activities and outsource fewer, which best summarizes this view on R&D and outsourcing.

Hypothesis 1: The R&D intensity of an industry is a negative predictor of its extent of outsourcing.

2.3. A relational view of innovation and outsourcing

To provide an explanation for the recent changes in the supply chain strategies of firms discussed in the introduction a different conceptual perspective is in order. For if R&D intensity and outsourcing are as incompatible as suggested above, how can we explain the rises in outsourcing in R&D intensive environments that have been reported (Leiblein and Miller, 2003; Quinn, 2000)? This other perspective, which is here coined a relational view (Dyer and Singh, 1998), argues that much of a firm's innovation now occurs in conjunction with outside suppliers rather than inside the firm. Because developments in non-core technology areas have become very rapid, it is no longer feasible to keep up with all of these technologies in as much detail as needed (Brusoni et al, 2001; Quinn, 2000). Therefore outside technology sources are in many instances the only option for firms that wish to keep up-to-date (Hagedoorn, 1993). Barney (1999) has suggested that firms need not necessarily own all relevant capabilities, as long as they have sufficient access to them. Such access may well be obtained through relations with outside suppliers.

Brusoni et al (2001) have noted that among manufacturing firms knowledge is now becoming more extensive than needed for the activities performed inside the firm. In other words, firms must know more than they make in order to be able to integrate the inputs of various specialist outside suppliers. The more uneven rates of

technological change in underlying components and the more often the interdependencies between components change, the more slack knowledge the buying firm needs to maintain (Brusoni et al, 2001). Nishiguchi (1994) has argued that the use of outside suppliers creates the option to access a much larger productive network and knowledge pool. This network provides much-needed flexibility to cope with changes in demand and helps to lower time-to-market substantially. Afuah (2001) further suggested that over the life cycle of a technology firms are best off by gradually increasing their extent of outsourcing. Only when a radical, competence destroying, technological change occurs does it make sense to revert to vertical integration into this new technology (Afuah, 2001).

In the context of innovation, Langlois and Robertson (1992) have developed the notion that it is feasible to develop initial innovation through outsourcing in a decentralized network, especially if substantial network externalities are present. If outsourcing is to make sense in the context of R&D intensive businesses though, relations with suppliers ought to replicate some of the characteristics of firms. For if relations are of a strict arm's length type, there is no incentive for external suppliers to undertake innovative activities on behalf of the buying firm. Dyer and Singh (1998) have developed a relational view of rent attainment, which argues that inter-organizational relations, including buyer-supplier relations, can provide benefits similar to hierarchies without the production cost disadvantages associated with hierarchies. Dyer and Nobeoka (2000) detail through their case study of Toyota how new technology is developed through dedicated buyer-supplier relations. This new model of interorganizational relations as a means to innovation is superseding traditional in-house development so it is argued (Dyer and Singh, 1998; Kinder 2003;

Quinn, 2000). This trend ought to be reflected in the outsourcing levels of R&D intensive industries, which should rise as a consequence.

Hypothesis 2: The R&D intensity of an industry is a positive predictor of changes in its extent of outsourcing.

3. Outsourcing in Dutch manufacturing

Similar to elsewhere outsourcing and increasingly cooperative relations have in the 1990s been identified as a key trend in the Netherlands (De Wit, Mol & Van Drunen, 1998; Nooteboom, 1998). Firms in the Netherlands have increased their reliance on external suppliers dating back even to the late 1970s but from the early 1990s onwards a particularly large shift towards outsourcing occurred (De Wit et al, 1998). Where firms previously outsourced secondary and support activities, like catering, temporary labor, and other facilities management activities, they now also outsourced manufacturing activities. There was increasing technological specialization between industries. The production of printed circuit boards (PCBs) for instance, which was formerly operated as a small-scale, made-to-order internal activity, was now subcontracted to specialized PCB suppliers. Rapid technological developments in electronics, mechatronics, and related fields made much of the existing internal knowledge on PCBs and other electronic components obsolete and raised the production costs because of rising equipment needs. Therefore in many cases non-specialized firms had little choice but to outsource.

The nature of the underlying supplier relations had to be altered because the newly outsourced activities required more intensive coordination given their

sensitivity to overall product outcomes (Nooteboom, 1998). The implementation of these changes was sometimes problematic and buyers and suppliers both needed to adjust to the changed circumstances. Wynstra and Weggeman (2001) provide some evidence that manufacturing firms in the Netherlands have increasingly engaged in cooperation with suppliers to produce product innovation. Finally outsourcing also took on a more prominent role in the Dutch discourse on management and among policy makers. Management consultancy firms published on the topic, government institutions became interested in its consequences for local employment and growth, academics increasingly wrote about it and all kinds of employers' associations, training agencies and conference firms organized activities on outsourcing.

3.1. Empirical measures

The empirical tests, which will be discussed shortly, are based on 3-digit level census data of Statistics Netherlands (*Centraal Bureau voor de Statistiek*) on 52 industries. The 3-digit industry level is specific enough to include a clearly defined product, like pharmaceuticals or machine tools, but not so specific as to render the number of companies in the industry too small for reliable analysis. The industry classification used is the European NACE system, similar to SIC in the United States, and all industries included are in manufacturing, ranging from complex assembly to simple processing industries. The industry level variables are formed by aggregation of business unit level data gathered directly from manufacturing firms. The latter are collected on an annual basis and include questions on total sales, external sourcing, profitability, R&D expenditures, total exports, and the number of firms, including an indication of the nationality of the parent firm. The dependent variable of **OUTSOURCING** is constructed by dividing total external sourcing in the industry in

1994 by total sales in the industry in 1994. Therefore it measures to what extent the industry relies on external suppliers for the creation of products across all its activities, including manufacturing, design and services. This OUTSOURCING measure represents the vertical structure of the firm. The accompanying flow variable, of OUTSOURCING CHANGE is calculated as the difference between outsourcing in 1998 and outsourcing in 1994. R&D INTENSITY, the predictor variable, is measured as the industry's 1993 total R&D expenditures over its 1993 total sales. In these data R&D levels are fairly constant across years (inter-year correlations range from 0.75 upwards). Recent research in the transaction costs strand (Gilley and Rasheed, 2000; Leiblein, Reuer and Dalsace, 2003) has continued its focus on how a set of predictors at a given time influences outsourcing choices at that time. Yet time differences will often exist between the presence of R&D intensity and the implementation of outsourcing and a one-year time lag between all independent variables and the dependent variable, from 1993 to 1994, was introduced to reflect this. In addition any claim to causality is much strengthened if the independent variable is measured prior to the dependent variable.

Five control variables are employed in addition to the R&D intensity variable. The AVERAGE SIZE variable is the average size of firms in the industry in 1993, measured by the average turnover per firm. Larger firms often take on a different role in the supply chain, by primarily becoming an assembler and not a producer, and may therefore outsource more. The extent of presence of FOREIGN FIRMS is measured by dividing the number of foreign subsidiaries over the total number of firms. It is conceivable foreign firms have developed a different outsourcing pattern because they are less familiar with local suppliers. There is an effect that is known as the 'liability of foreignness' in international management research (Kostova and Zaheer, 1998).

Because foreign firms are less familiar with their host environments they will have more difficulties than local firms in partnering with local suppliers. Given the higher search and evaluation costs for foreign firms, outsourcing is normally a less viable option for them. In addition foreign firms have often established themselves in their host environment on the basis of some superior set of internal capabilities that may help them offset the liability of foreignness (Dunning, 1993). Having such a superior set of internal capabilities, for instance human resources, also makes it less likely that foreign firms will outsource activities since they will want to fully exploit these internal strengths. PRODUCTIVITY is calculated as 1993 total sales divided by the 1993 total number of employees. In order to become more productive firms in an industry probably need to focus on a smaller set of tasks, which they can do by outsourcing more. Productivity as measured here, however, relates positively to outsourcing because outsourcing normally reduces the number of employees while sales remain constant. Productivity is therefore one of the drivers of outsourcing decisions and a positive association must be expected. EXPORT INTENSITY is the 1993 total amount of exports over 1993 total sales. Since the ability to export products is an indicator of company strength, more export intensive industries possess more internal capabilities and may therefore outsource less. Similar to foreignness, a high export intensity reflects the competitive strength of an industry. The more internal strengths firms in an industry possess, the less likely they are to outsource. In general, competition between firms stimulates outsourcing (Cachon and Harker, 2001). More export intensive industries will be faced with a more competitive environment and will therefore seek to outsource more. UNCERTAINTY in the industry is measured by the variance in the industry's annual return on sales measures over the 1993-1998 period. The uncertainty-outsourcing relationship was discussed at length above.

Ordinary least squares (OLS) regression is used to test the hypothesized relationships because the variables are such that it is an efficient and reliable estimator.

4. Empirical results and discussion

Table 1 below briefly captures the means, standard deviations, and correlations of the key variables. It is worth noting that the average outsourcing level stood at 52.3% of sales in 1994 and increased by 3.5% between 1994 and 1998, which is a fairly substantial increase. Also note that while the average R&D intensity is not particularly high among these industries, about 0.5% of sales, there is substantial variance in R&D levels in the sample. Finally observe that there is a negative correlation between the outsourcing and outsourcing change variables, implying a catching-up effect. Industries that initially outsourced less have now seen substantial increases.

Insert table 1 around here

Table 2 investigates the effect of 1993 R&D intensity and a set of control variables on the industry average level of outsourcing in 1994. It confirms hypothesis 1: R&D intensive industries initially displayed a lower level of outsourcing. Thus the conventional perspective, which holds that under conditions of high innovation expenditures there are scale, appropriation, and opportunism concerns that make outsourcing a less preferred option, did hold true initially.

Insert table 2 around here

Table 2 also provides some interesting findings on the control variables employed. The presence of foreign firms is a slightly negative predictor for outsourcing levels, which confirms the liability of foreignness argument presented before. As expected the productivity of firms, measured as per-employee turnover, is positively related to outsourcing. As noted above this is both a strongly intuitive and a mathematically determined relation, since firms that produce large volumes with a limited number of employees will typically also need to outsource many activities to achieve such productivity. In fact, the causality probably runs in two directions: outsourcing increases productivity and a desire to increase productivity may be at the heart of outsourcing decisions. The average size of firms in the sector is not a significant predictor of outsourcing, although the sign is positive. Perhaps the indirect form of measurement, using average size of firms in an industry to link that to industry outsourcing, disguises size effects though. A study of the size of firms and their outsourcing levels could clarify this further. The positive impact of the export intensity variable points to the role that having to compete more ferociously, in international markets, can play in forcing firms to outsource. Uncertainty is shown to be a strongly negative predictor of outsourcing levels, confirming the TCE logic. In the presence of substantial uncertainty it is harder to write complete contracts.

In table 3 the results of the regression analysis on changes in the outsourcing level between 1994 and 1998 are displayed. There is a strongly positive relation

between R&D intensity in 1993 and subsequent changes in the level of outsourcing. Thus the second hypothesis is confirmed in that R&D intensity acted as a positive predictor for changes in outsourcing¹. This confirms what many authors have suggested about the changing nature of outsourcing, though the evidence presented here is not based on perception data or anecdotal or small-scale evidence. Especially in technologically volatile environments where R&D is a key priority, firms have increased their reliance on external suppliers. They could do this because of the changed nature of underlying technologies and relations with suppliers. The need to understand and utilize multiple technologies that cannot all be maintained in-house forces firms to outsource more activities than before. Changes in communication technologies and the increasing openness of economies increase the rent potential of relations with external suppliers, many of them foreign, and permit firms to set up closer relations with suppliers than hitherto possible.

Insert table 3 around here

There are two other significant findings in table 3. Foreign firms have not increased their extent of outsourcing as much as have local firms, consistent with the logic outlined above. Foreign firms will have a lower degree of penetration among local

¹ In fact, a rerun of the analysis presented in table 2 for 1997 R&D intensity and 1998 outsourcing revealed that the initially significantly negative relationship between R&D intensity and outsourcing turned into a positive one in 1998, albeit not a significantly positive one. This raises several interesting questions. First, how has this relationship developed since 1998? It is conceivable that R&D intensity has now actually become a positive predictor of outsourcing. Second, what processes allow firms that have heavily invested into R&D to outsource many of their activities nonetheless? Third, what remains of the predictive value of the traditional perspective outlined above in such a much altered business environment?

suppliers and will use their internal capabilities as much as possible. Uncertainty is a positive predictor of changes in outsourcing levels. This could be construed to imply that the predictive power of TCE has been decreasing over time, since more uncertainty is no longer associated with more vertical integration. As stated before though uncertainty is seen to explain integration particularly effectively in the joint presence of asset specificity. Since no asset specificity test was included, it is not possible to reach any final conclusion on this point.

4.1 Research limitations and extensions

In terms of limitations, the number of sampled industries (52) is fairly low which is potentially troublesome in the context of running regressions, where some 40 observations are often seen as a bare minimum and 5 to 10 observations are needed per variable to create models with sufficient statistical power. Yet there are several reasons to believe the number of observations is not problematic here. First, the industry data themselves are aggregates of firm level data, involving thousands of firms. Thus any aberrations at the firm level are wielded out through the aggregation process and the resulting industry level data are very reliable. Second, the model statistics of both models are solid. The F-tests are fairly high and adjusted R^2 figures are also quite satisfactory. Third, more industries become available when omitting the focal R&D variable from the regressions, i.e. there are quite a few missing values for R&D expenditure in the database. Missing values appear mostly in industries with particularly small numbers of firms where industry level R&D data could be traced back to individual firms. When rerunning the models for a wider set of some 84 industries, the other variables in the model maintain their signs and mostly become

more significant. Therefore it appears fair to conclude that the results are fairly robust in spite of the small number of observations.

Another data-related problem is the use of R&D intensity as a proxy for innovative behavior. While it is suggested that R&D intensity is indeed a close correlate of innovation (Greve, 2003), this is not a perfect correlation as noted earlier. Indeed R&D intensity could perhaps also be interpreted as one possible measure of technological uncertainty, in which case the key point of this article would really be that firms have started to outsource more, and particularly do so in the face of high technological uncertainty. Regardless of these issues, however, R&D intensity itself is worthy of study (Colombo and Garrone, 1996; Greve, 2003) and the nature of its relation to outsourcing decisions is informative for strategic decision-making.

One variable missing from the equations was asset specificity, for which no valid empirical measures were available in the present study. Including asset specificity might have provided additional explanatory power. On the other hand, asset specificity is likely also positively correlated with R&D intensity as argued before. Furthermore it is hard to say what would constitute a proper measure of asset specificity across a wide range of transactions at the business unit level, which is how both outsourcing and R&D intensity were measured here. Another limitation is that the R&D intensity of industries is only one indicator of an industry's innovative output. And it is not a perfect measure for innovative output either. Thus it could be informative to test how other innovation measures, like the number of patents granted, are related to the outsourcing behavior of firms. Similarly the empirical context used here, the Dutch manufacturing sector, may produce results specific to that sector's development. Although there are no obvious indications that outsourcing in the Netherlands is very different from outsourcing in other OECD countries, there could

certainly be differences in timing or degree. A replication elsewhere would be useful. Where available firm level data could shed a different and more detailed light on the outsourcing-innovation relation than these industry level data, for instance by investigating possible interactions with asset specificity, capabilities or firm size. Such a trade-off of breadth for depth could generate additional insights. Similarly there is merit in applying other outsourcing measures, for instance by linking the probability that a specific component will be outsourced given its R&D intensity. The results on outsourcing as a firm level concept provided here, however, are not only a useful starting point for such further studies but also interesting in their own right.

5. Conclusions

A major controversy in the area of outsourcing and innovation is whether R&D intensity discourages outsourcing or is compatible with it. This article is the only recent test of this relationship with large-scale empirical data. It demonstrated, in the empirical context of the Dutch manufacturing sector, that while R&D may historically have been a negative predictor of outsourcing there was a clear reversal over the 1990s. The relational view of outsourcing and innovation, which maintains that buyer-supplier relations can be an effective substitute for internal development, thus appears to have gained impetus in practice. Alternatively the more humble, and probably more correct, perspective is that the relational view appears to be an appropriate portrait of empirical reality as it has been developing. Product life cycles are becoming shorter and there has been a shift in priorities away from appropriating in-house innovations towards developing the ability to rapidly launch new products. This kind of ability is often better developed in a buyer-supplier network setting

where a more flexible, wider, and larger joint research capacity can be obtained than inside a single firm. In terms of the outsourcing literature this article has demonstrated that predictors of outsourcing are not necessarily stable over time and that theoretical positions may therefore not remain valid indefinitely. In terms of the technological change literature, the key point would be that alternative production arrangements of innovative products, involving outside suppliers, have become a feasible supplement to vertical integration.

Brusoni et al (2001: 599) stated that: “firms invest in broadening their knowledge bases while narrowing down their manufacturing bases”. The evidence presented here seems to suggest that the latter aspect, of narrowing down the manufacturing base, is moving at a much faster pace than the former, the broadening of the knowledge base. Industries in this sample did not significantly raise their R&D investments but did increase their dependence on outside suppliers. Further anecdotal evidence suggests many Dutch firms have rapidly and thoroughly disengaged from activities like the production of printed circuit boards but maintain some basic knowledge of such activities. Therefore firms do generally know more than they make (Brusoni et al, 2001) and the gap between knowing and making may be on the rise but this is mostly due to the fact they are starting to make less than they know and not necessarily because their knowledge base widens rapidly. To test this further it could be fruitful to find out whether R&D investments in specific subfields are generally maintained over longer time periods, even when firms have disengaged from the underlying activities. This would require data on R&D spending patterns and specific outsourcing patterns, which could perhaps only be obtained when studying one or a few cases. It also points to one of the problems associated with outsourcing, which is how to maintain sufficient knowledge inside the firm to be able to jointly develop new

knowledge with a supplier and at the same time assess the supplier's performance. Since many instances of outsourcing involve moving people to suppliers much knowledge can be lost with the transition. Outsourcing can become a source of serious bargaining and learning problems in the long run.

Firms increasingly outsource activities that are crucial to the competitive advantage of the firm. In itself this type of outsourcing can be beneficial, if rents can be obtained from the relation. Where such rents are deeply ingrained in the relation itself, there are few problems of spillovers. But there is a big question mark over how to appropriate such rents in the case of new technology. Technology that is developed in conjunction with a supplier may have multiple alternative uses for the supplier but none for the buying firm. Technological knowledge is often replicated fairly easily within the same supplier firm. Under such circumstances there are serious dangers of knowledge leaks to competitors and appropriate governance responses must be found unless the value of knowledge stocks in an industry depreciates so fast that this knowledge has limited value for competitors by the time it reaches them (Nooteboom, 1999). Where knowledge leaks occur a need for creating different contracting solutions arises in which buyers and suppliers are both provided with incentives to innovate and can obtain joint ownership. From a public policy perspective this creates pressures for legal protection of joint intellectual property.

Another key public policy implication of increased outsourcing is how it affects underlying technology activities and employment. If R&D intensive industries can outsource many more manufacturing and design activities, as now appears to be the case, this implies these activities become increasingly footloose. The recent rise of global sourcing structures is therefore not limited to activities where cost of labor is the key consideration but also appears to start including more innovative activities

(Mol, Pauwels, Matthyssens, and Quintens, 2003). For practicing managers global sourcing poses different challenges, for instance in terms of how to deal with suppliers in institutional and cultural environments different from that of the buyer.

There are few longitudinal accounts of how outsourcing and R&D intensity are related in current literature and none of recent origin. Yet, quite a bit is known about technological collaboration between buyer and supplier and what influences outsourcing levels at a given point in time. What is needed then, is a more intricate understanding of how the R&D-outsourcing relation evolves over time. Some specific research questions can be suggested. Under what conditions is a high R&D intensity compatible with much outsourcing? Will outsourcing levels be maintained in the face of discontinuous technological change (Afuah, 2001)? Answers to these questions would be very valuable outcomes of future research.

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Tables

	Mean	S.D.	1	2	3	4	5	6	7	8
1. R&D intensity	.4538	.7530	1	-.239	.543**	.279*	-.036	.205	.141	-.123
2. Outsourcing	52.29	14.00		1	-.375**	-.106	.463**	.199	.337**	-.306**
3. Outsourcing change	3.460	6.487			1	-.069	-.165	-.151	-.196	-.054
4. Foreign firms	32.82	23.60				1	.304**	.281*	.474**	.062
5. Productivity	334.3	315.6					1	.200	.684**	-.165
6. Export intensity	35.64	17.27						1	.447**	.105
7. Average size	10.42	1.131							1	.004
8. Uncertainty	2.868	3.676								1

Table 1: means, standard deviations and correlations among variables. ** Significant at the 1% level; * significant at the 5% level. $N = 84$, except for row 1 where $N = 52$.

Variable	Unstand. β	Standard error	t-value	significance
Constant	0.459	0.191	2.399	0.021
Foreign firms	-0.133	0.071	-1.872	0.068
R&D intensity	-0.051	0.019	-2.680	0.010
Productivity	0.000	0.000	2.814	0.007
Export intensity	0.002	0.001	2.245	0.030
Average size	0.004	0.021	0.194	0.847
Uncertainty	-0.017	0.004	-4.537	0.000
F-value: 10.185 (.000)		R^2 : .576	Adjusted R^2 : .519	

Table 2: OLS regression on 1994 industry level of outsourcing. $N = 52$.

Variable	Unstand. β	Standard error	t-value	significance
Constant	-0.075	0.103	-0.731	0.469
Foreign firms	-0.066	0.038	-1.729	0.091
R&D intensity	0.055	0.010	5.356	0.000
Productivity	-0.000	0.000	-1.753	0.086
Export intensity	-0.000	0.000	-0.992	0.326
Average size	0.014	0.012	1.219	0.229
Uncertainty	0.005	0.002	2.482	0.017
F-value: 6.861 (.000)		R^2 : .478	Adjusted R^2 : .408	

Table 3: OLS Regression on industry level outsourcing change between 1994 and 1998. $N = 52$.