Outsourcing and Innovation: An empirical exploration of the dynamic relationship

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Abstract

We study the implications of vertical integration on innovation performance using firm-level data on Australian manufacturing. We use the data to distinguish between low-cost-oriented and innovation-oriented outsourcing. Outsourcing without innovation lowers costs at the expense of damaging the future chances of innovation, while innovation-oriented outsourcing leads to higher costs but increases the likelihood of future innovation. For firms that innovate and outsource, the probability of future innovation is 49 per cent compared to 8 per cent for those who outsource without innovating. Comparing across firms that innovate, simultaneously outsourcing increases the probability of future innovation by 5 per cent. Innovation-oriented outsourcing is accompanied by firms shifting expenditure to research and development. Our results offer strong support that outsourcing may be used not just as a cost-cutting strategy, but as part of comprehensive firm strategy to innovate and improve.

Keywords: Outsourcing, Innovation, R&D, Business Strategy.

JEL Codes: D22, L21, L24, L6.

1 Introduction

Outsourcing in mainstream economics is often modeled as a cost-reducing venture that helps firms reduce fixed costs by reducing the number of managers (Grossman & Helpman, 2002) or replace employees with cheaper contractors (Dube & Kaplan, 2010). Understandably, the least efficient firms are the ones most benefiting from this type of outsourcing. However, the range of firms observed in practice that opt for outsourcing is broader than can be explained by cost-oriented outsourcing. In this paper, we consider the relationship between outsourcing and innovation. It turns out that whether or not firms innovate at the same time as they outsource is crucial for understanding future firm performance in innovation, employment creation and wages.

By simultaneously examining innovation and outsourcing, we are able to identify in the data a clear distinction between low-cost-oriented outsourcing and innovation-oriented outsourcing. This distinction is also made by Bengtsson et al. (2009). They use a small, cross-sectional sample of Swedish engineering firms who outsource manufacturing and ask these firms about their reasons for outsourcing. In our case, we consider a much larger and broader panel sample of firms, and a much wider range of variables, from all manufacturing sectors. Although we do not have any information on why firms outsource, we see a clear effect on firm performance which emerges in the data and which is consistent with there being two types of outsourcing. For firms that outsource, those that simultaneously innovate are 41 per cent more likely to innovate in the next period relative to firms that outsource but without innovating.

For our study, we rely on firm-level data from Australian manufacturing. Our data is unique in that it is a panel of firm-level observations which include information about outsourcing and innovation activity across all sections of manufacturing. Furthermore, it provides us with details of expenditure on innovation-related activities enabling us to investigate the details of the innovation process for firms that innovate. Although we do not directly observe which jobs are outsourced, we use a time period during which the vast majority of outsourcing was to domestic suppliers for tasks that are not *offshorable* in the terminology of Blinder & Krueger (2009).[1] Furthermore, our data covers firms with at most 200 employees.

[1] Benson & Ieronimo (1996) survey 26 Australian manufacturing firms with an average of 2,000 employees

As Federico (2010) shows for Italy, the participation rate of firms with 10 to 200 employees in offshore outsourcing is about five per cent. Given that our time period is earlier (our data also include very small firms with less then 10 employees) and that Australia does not share a land border with any other country, we believe that offshore outsourcing is negligible in our data. By being able to rule out offshore outsourcing, we can separate out low-cost outsourcing from innovation-oriented outsourcing.

Our findings show two very different types of outsourcing. Outsourcing in the absence of innovation leads to lower wages, higher profits, but also a lower probability of future innovation. We brand these firms as seeking low-cost-oriented outsourcing. Yet, we find that when a firm introduces an innovation and outsources at around the same time, the likelihood of further innovation in the years that follow is about 5 per cent higher than firms which innovated but did not outsource. These firms also experience about a 6 per cent rise in their total wage bill relative to firms that introduce innovation with no simultaneous outsourcing. We interpret this wage rise as firms replacing their lower skilled workers, whose jobs are being sent out, with higher skilled professionals and researchers in a bid to increase research activity and innovate more frequently. It is this second group of firms that embodies innovation-oriented outsourcing.

To further understand innovation-oriented outsourcing, we also look at the breakdown of expenditure on innovation and observe how outsourcing shifts the focus to different activities related to innovation. Our data provides expenditure, specifically relating to innovation, on research and development (R&D), patenting, marketing, retooling of manufacturing and training of staff. Our empirical results show that firms engaged in innovation-oriented outsourcing experience an intensity shift to R&D during the year they innovate and the year after, further evidence that outsourcing is designed to free up resources for innovation.

Our findings support the predictions made by Acemoglu et al. (2003). They argue that vertical integration can eliminate transaction costs associated with conflict of interest and the holdup problem. However, it overburdens management, thus managers are compelled to focus on production more than innovation. Outsourcing, on the other hand, frees up management, and can be used to shift the emphasis to innovation. Our results can be interpreted as

in 1994 (the beginning of our sample period) and find that the main body of outsourced jobs by those firms are tasks such as maintenance, janitorial services and transportation that need physical presence.

support for this type of mechanism.

The rest of the paper is composed as follows: The next section reviews the relevant literature. Section 3 describes our data. Section 4.1 models the role of simultaneous innovation and outsourcing in the future performance of firms. Section 4.2 looks at the different elements of expenditure on innovation, such as research, patenting and training. We document how innovating and outsourcing firms focus on certain aspects of innovation. In Section 5, we discuss possible interpretation of our results and important caveats. We conclude in the last section.

2 Literature

Discussion of outsourcing in the economics literature is mostly in the context of cost reduction. Only a few papers have looked at innovation-oriented outsourcing and even these few works emphasize the impact of off-shoring on innovation and do not consider domestic outsourcing. The outsourcing which will be the focus of this paper is almost entirely domestic rather than off-shoring.

Glass & Saggi (2001) develop a model where outsourcing to a low wage country reduces costs of production and causes wages at home (especially those of researchers) to fall. Since production costs are lower (due to the off-shoring) and innovation is cheaper (due to lower wages at home), firms find incentives to invest more in innovation and come up with better and newer products more often. On the empirical side, Criscuolo et al. (2005) show that offshore outsourcing among UK firms has opened new and more diverse feedback lines to the firm, thus helping firms refine their current innovations and come up with newer products more frequently.

The approach of Acemoglu et al. (2003) is more relevant for our study. They argue that vertical integration overburdens management. In their model, firms focus on production instead of innovation because management resources are limited. Outsourcing frees up management from overseeing production, so that managers now find it optimal to focus on innovation. In their setting, outsourcing creates a holdup problem; the supplier will underprovide relative to the optimum under vertical integration. Under such circumstance, firms in a more productive country will select outsourcing/off-shoring, innovate more rapidly and

distance themselves from the developing world. Again, the focus here is on off-shoring as the vehicle for outsourcing, which is different than our focus.

Another line of research has focused on the outsourcing of innovation. The outsourcing of R&D and innovation is not the focus of this paper. Aghion & Tirole (1994), Quinn (2000) and Lai & Riezmann (2009) provide a starting point for readers interested in this line of research.

The paper by Bengtsson et al. (2009) is closest to our study in examining the distinction between low-cost-oriented outsourcing and innovation-oriented outsourcing. We adopt their terminology but our approach is a departure from theirs. We focus on the entire manufacturing sector as opposed to one industry; our sample is over 4,000 firm-years whereas theirs is less than 150; our data includes a much richer set of control variables including continuous measures of sales, employment and wages. We also have detailed data on expenditures related to innovation. They focus on subjective responses to questions about reasons for outsourcing which we do not have. Rather, we look at the relationship between outsourcing and other business activities. Finally, while their data is cross-sectional, we use a panel data set over 4 years which allows us to study a much richer set of dynamic relationships between outsourcing and firm performance. There are also some management case studies which have focused on the distinction between low-cost-oriented outsourcing and innovation-oriented outsourcing; see Bengtsson et al. (2009) for references.

Görg and Hanley (2011) show that outsourcing services makes firms more 'innovative' (in the sense of increasing their expenditure on research and development) and distinguish between international and domestic outsourcing. They show that international services outsourcing has a stronger effect on increasing research and development expenditure than domestic outsourcing. Our paper provides one possible explanation for their results. If the mix of low-cost-oriented and innovation-oriented outsourcing is different for international and domestic outsourcing, then our results indicate that it is not surprising to find a difference between the amount of innovation that results from these two types of outsourcing.

3 Data

The Business Longitudinal Survey (BLS) was conducted by the Australia Bureau of Statistics (ABS) during the fiscal years 1994–95 to 1997–98.[2] Four waves of data are available to researchers in a Confidentialised Unit Record File (CURF) in which several measures are taken to protect the confidentiality of individual firms, such as adding small amounts of noise to numerical values and suppressing extreme observations. The most important step taken is that all firms with more than 200 full-time employees are excluded from the CURF to render it more difficult for data users to identify individual firms. The results in this paper should thus strictly be considered as being only applicable to small and medium-size enterprises, but such businesses comprise 99% of all manufacturing firms in Australia.[3] The data are a unique source of detailed information on Australian firms from a wide array of industries such as manufacturing, mining, construction and services.[4]

The first wave in 1994–95 covers about 13,000 firms which are randomly selected from the Australian Business Register stratified by industry and business size. Sample weights were derived such that industry/size sample cells matched population totals (Will & Wilson, 2001). In the continuing (panel) phase of the survey about half of the 13,000 firms were followed. Firms from the first wave were stratified by innovation status, exporting status and growth. Those firms that were identified as innovators, exporters and those with high employment or sales growth were over-sampled for the panel. In all subsequent years (after the first year) a small sample of new firms was added to the survey (Breunig & Wong , 2008). In wave 2 and later, weights were re-calculated for each wave to account for the post wave 1 stratification and sample attrition. In all of our descriptive statistics and regressions reported below, we use the original weights, adjusted for non-response by the ABS, from 1994–1995 in order that our estimates may be interpreted as representative of the population of firms at that point in time.

The sample we use for analysis is restricted to the manufacturing sector (ANZSIC 2x). Some manufacturing firms are coded as ANZSIC 20 (unknown manufacturing). For these

[2]The fiscal year in Australia is from beginning July to end of June the following year, hence the use of two-year combinations.

[3]The ABS Business Counts (Cat.No.8165.0 at `http://www.abs.gov.au`) show that only about 1% of manufacturing firms in Australia have more than 200 employees.

[4]For full information on the population frame, sampling strategy, survey and available data items, see the Technical Manual, ABS Catalogue Number 8141.0.15.001 at `http://www.abs.gov.au`.

firms, we use the industry codes reported for the following years to identify the subdivision. In those cases where we could not find any identifying information, we assigned firms to Miscellaneous Manufacturing (ANZSIC 29). As a result, ANZSIC 29 is better described as an average manufacturing sector. Below, we consider the dynamic behavior of firms over a three-year time window and we therefore use the balanced panel of firms that are available in all four years of the survey. We only use firms that reported nonzero sales and employment in all years because we are unable to distinguish between continuing businesses that fail to respond and exiters. There is a substantial amount of exit in the data and our use of the balanced panel ignores this attrition. We discuss the effect of this on our results in Section 5 below.

In the first three years of the data, the BLS asks firms whether, in the last twelve months, they contracted out jobs that used to be performed by the firm's own employees ($OUTS$). We believe that this variable excludes new activities which are added through outsourcing. We further believe, subject to recall window problems, that this variable excludes jobs that were contracted out in previous years. Some confirmation of this is provided in Figure 1(a) – we observe that about 80% of firms reporting contracting out in one year do not report any contracting out the following year. The question about contracting out was not asked in 1997–98.

In addition, the BLS informs us about the number of employees, sales, value of exports, and the number of locations. Employment numbers are reported for the last pay period in the month of June every year, hence, we average over two consecutive years to find an annual calendar year estimate. The BLS also reports a few items relating to operational costs, such as the total wage bill, the cost of inputs, the cost of rentals and leasing of equipment, and other operational costs. For the empirical applications, the cost of production is set to the sum of expenditures on the purchases of inputs, rental and leasing expenses, and other operation costs. Our results suggest that the cost of contracted out jobs is captured in 'other operation costs'. Sales, wages, and costs are deflated to 1995 dollars using the ABS reported Consumer Price Index (CPI) values.[5] We construct a firm-level average wage by dividing the total wage bill by the number of employees.

Regarding innovation, the BLS provides a variety of detailed information. Firms indi-

[5]Cat.No.6401.0 at `http://www.abs.gov.au` provides CPI figures for Australia.

cated if they introduced a substantially new or improved product over the year or whether they developed or introduced any substantially changed processes (INV).[6] This variable is Boolean in nature. Firms also report their total expenditure on R&D (RD). In addition, if a firm had an innovation ($INV = 1$), then the firm reports itemized expenditures specific to the different aspects of the new product or process. These reported items, all of which are specific items relating to the new innovation, are expenditures on R&D, patenting and license acquisition, training of staff, retooling of manufacturing processes and marketing expenses. This level of detail for innovation expenses is available in every year except in 1995–96.

Table 1 reports the composition of manufacturing in the balanced panel and the level of contracting out activity. Table 2 reports the level of innovation activity by manufacturing subdivision. Both tables point to some cross-industry differences. The average number of innovations declines over time within our sample. One explanation for this may be that firms do not necessarily innovate (particularly products) in successive years, but rather benefit from the rents of innovation for some period of time before innovating again. As a result, the number of firms in our sample with an incentive to innovate gets smaller by the year.

Figure 1 looks at the fraction of firms in our sample that engage in contracting out and innovation activity. Part (a) presents the relationship between outsourcing in consecutive years. As mentioned above, this part seems to indicate that the outsourcing question is primarily capturing incremental outsourcing. Part (b) presents statistics on contemporaneous outsourcing and innovation activity. About 4 per cent of our sample report both innovation and contracting out in the same year. However, only about 13 per cent of all the firms that innovated also outsourced in the same year. Firms that innovate at one point in time are more likely to innovate the following period than firms which do not innovate. Perhaps more surprisingly, outsourcing is also positively correlated over time within firms.

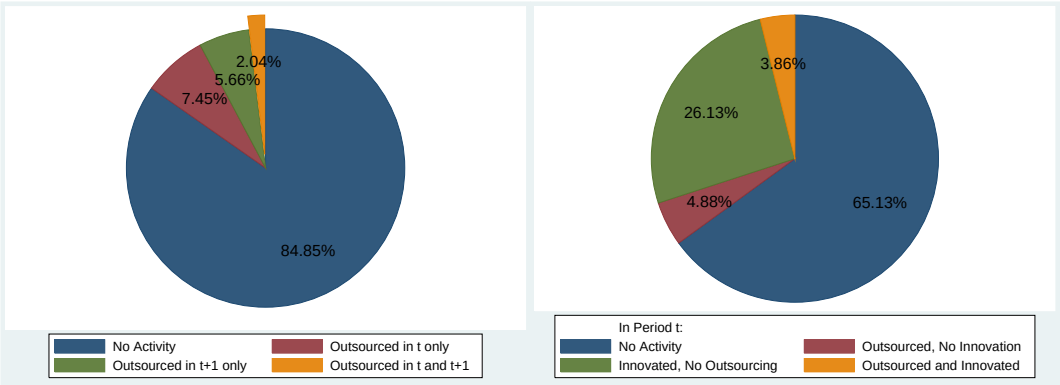
[6] The exact question is: Did this business: (i) develop any new products; or (ii) introduce any substantially changed products; or (iii) develop or introduce any new or substantially changed processes.

ANZSIC	Description	Number of Firms	Contracting Out		
			1994–95	1995–96	1996–97
21	Food, Beverages and Tobacco	150	8.7%	4.7%	7.3%
22	Textile, Clothing, Footwear and Leather	118	9.3%	9.3%	11.0%
23	Wood and Paper Products	75	8.0%	6.7%	6.7%
24	Printing, Publishing and Recorded Media	107	14.0%	12.2%	5.6%
25	Petroleum, Coal, and Chemical Products	176	5.7%	8.5%	6.3%
26	Non-metallic Mineral Products	68	7.4%	8.8%	4.4%
27	Metal Products	192	12.0%	4.7%	6.8%
28	Machinery and Equipment	369	13.8%	8.6%	6.8%
29	Miscellaneous Manufacturing	194	11.3%	10.3%	9.3%
2x	All Divisions	1,449	10.8%	8.1%	7.3%

Table 1: Contracting out activity by manufacturing sector in the analysis sample.

ANZSIC	Description	Number of Firms	Innovation		
			1994–95	1995–96	1996–97
21	Food, Beverages and Tobacco	150	38.7%	34.7%	20.0%
22	Textile, Clothing, Footwear and Leather	118	31.4%	23.7%	11.9%
23	Wood and Paper Products	76	13.3%	13.3%	8.0%
24	Printing, Publishing and Recorded Media	107	29.9%	21.5%	11.2%
25	Petroleum, Coal, and Chemical Products	177	48.9%	42.6%	32.4%
26	Non-metallic Mineral Products	68	38.2%	35.3%	20.6%
27	Metal Products	192	34.4%	24.5%	17.2%
28	Machinery and Equipment	371	45.3%	33.9%	25.5%
29	Miscellaneous Manufacturing	195	41.0%	30.4%	20.6%
2x	All Divisions	1,449	38.7%	30.6%	20.7%

Table 2: Innovation activity by manufacturing sector in the analysis sample.



(a) (b)

Figure 1: The composition of firms by outsourcing and innovation activities.
(a) The inter-temporal link between outsourcing activities, $t = 1994 - 95, 1995 - 96$.
(b) Simultaneous innovation and outsourcing, $t = 1994 - 95$ to $1996 - 97$.

4 Results

4.1 Outsourcing and Innovation

A first look at the data reveals that firms which outsource in one period are more likely to innovate in the following period. In our data, pooled across the four waves, 32 per cent of firms that outsource in one period innovate in the next period whereas only 23 per cent of those firms that do not outsource at time t report an innovation at time $t + 1$. This simple dichotomy is mis-leading however. If we look further at those firms which outsource in period t and divide them into firms which simultaneously innovate at time t and those that do not innovate at time t, we find that outsourcing combined with innovation is a strong predictor of future innovation whereas outsourcing in the absence of innovation is a strong *negative* predictor of future innovation. Of those firms that innovate and outsource in the same period, fully 49 per cent of them innovate in the following period, which is 5 per cent more than those firms that innovate but do not outsource (Figure 2). On the other hand, our descriptive graph shows that firms that *do not* outsource in period t are actually more likely to innovate at time $t + 1$ than those firms that outsource in the absence of innovation.

This basic empirical fact, which we document for the first time in a broad sample of manufacturing firms, forms the basis for the investigation that we undertake in this paper. Given that we have panel data which contains detailed information on outsourcing and innovation,

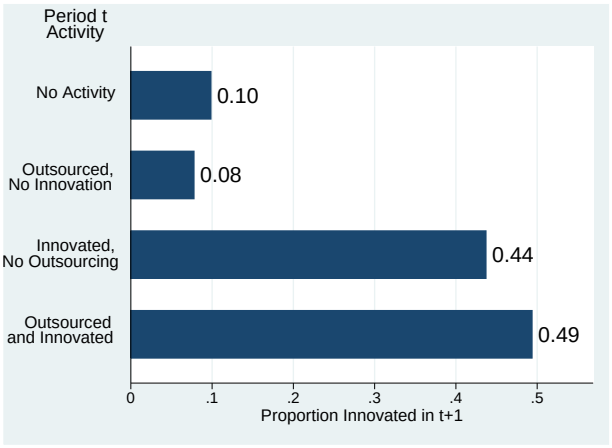


Figure 2: The percentage of firms that innovate in $t+1$ conditional on period t outsourcing and innovation activities, $t = 1994-95, 1995-96$.

we can examine the relationship between the two in a novel way. What is the relationship between past outsourcing and future innovation? What is the relationship between past and future innovation? How do past outsourcing and innovation interact with one another in their relationship with future innovation?

We begin our investigation with a model of the probability of a firm innovating which depends upon past innovation and outsourcing. The model allows for outsourcing and innovation in the two prior periods (as well as their interactions) to affect the probability of innovating. Given that firms can innovate in either period $t-1$ or t and that they can outsource in either period $t-1$ or t (including the possibility of outsourcing and/or innovating in both periods), this allows us to examine the probability of innovation for 16 different 'types' of firms where type is defined as the outsourcing/innovation path over the previous

two periods.[7] We estimate the following probit model:

$$
\begin{aligned}
Prob[INV_{j,t+1} = 1|t, t-1] = \\
\Phi\Big(& \alpha_0 + \alpha_1 INV_{j,t} + \alpha_2 INV_{j,t-1} + \alpha_3 INV_{j,t} \times INV_{j,t-1} \\
& + \alpha_4 OUTS_{j,t} + \alpha_5 OUTS_{j,t-1} + \alpha_6 OUTS_{j,t} \times OUTS_{j,t-1} \\
& + \alpha_7 OUTS_{j,t} \times INV_{j,t} + \alpha_8 OUTS_{j,t-1} \times INV_{j,t-1} \\
& + \alpha_9 OUTS_{j,t} \times INV_{j,t-1} + \alpha_{10} OUTS_{j,t-1} \times INV_{j,t} + Z_{j,t}\beta \Big),
\end{aligned}
\tag{1}
$$

in which $Z_{j,t}$ is a vector of observable controls for firm j in time t. The controls include the log of employment size (EMP), the log of average wages ($WAGES$), export and R&D intensities ($EXPINT$ and $RDINT$), and whether the firm is multi-location ($MULTI$).[8] Export (R&D) intensity is defined as the value of exports (research and development expenditure) divided by the value of sales using nominal values. The estimates also include controls for year, age of the business, and industry effects. The dummies that absorb the age effects are formed as bins of 0–1, 2–4, 5–9, 10–19, 20+. Table 3 shows simple statistics for the control variables. In particular, we note that more than half the firms in the data are not spending on R&D or exporting at all. Table 4 reports the correlation between key variables. As one would expect, most variables have a positive relationship with size, stated in employment or real sales, but the intensity of R&D drops with size.

We view equation (1) as primarily a descriptive device relating innovation at time $t+1$ to firm characteristics, and past innovation and outsourcing activity. Our sample size in the $t-$dimension is too short to realistically estimate a dynamic probit model which would include firm-level fixed effects such as that of Roberts & Tybout (1997). Therefore it would be misleading to interpret the coefficients from this model as 'causal' parameters, that is, the effect of innovation at time t on the probability of innovating at time $t+1$ holding all other factors constant. However, the model can still be used to look at the partial correlation amongst various combinations of innovation and outsourcing activity across time. Our main

[7] The length of the panel and the fact that outsourcing was not included in 1997–98 prevents us from looking at longer lags.

[8] A small number of firms report zero wages in some years, and most of them have only one or two personnel. We regard these jobs as self-employment, and to include those firms, we use $\log(1 + WAGES)$, in which $WAGES$ is the average real wage per employee.

Variable	Mean	Std.Dev.	1st Decile	Median	9th Decile
EMP	15.2	25.3	2.0	6.0	36.0
$SALES$(\$000)	2525.7	7297.1	97.1	572.5	5400.0
$WAGES$(\$000)	24.8	15.4	4.7	24.4	42.8
$COST$(\$000)	488.0	1005.9	13.0	156.0	1156.0
$RDINT$	0.021	0.386	0	0	0.012
$EXPINT$	0.045	0.189	0	0	0.105

Table 3: Simple statistics for key control variables. Pooled sample of 1,449 firms averaged over 1994–1997 from the balanced panel of the BLS.

	EMP	$SALES$	$WAGES$	$PURCHAS$	$RDINT$
$SALES$	0.758				
$WAGES$	0.288	0.310			
$PURCHAS$	0.723	0.984	0.294		
$RDINT$	-0.017	-0.013	-0.025	-0.012	
$EXPINT$	0.125	0.140	0.105	0.154	0.127

Table 4: Correlation coefficients for key variables. Pooled sample of 1,449 firms averaged over 1994–1997 from the balanced panel of the BLS.

purpose is to highlight these patterns which have been generally ignored in the literature. This descriptive approach, and the fact that our model is not a fully-specified structural, provides our justification for weighting the regressions.

In addition, in examining the propensity to innovate, we also look at a few other performance measures including change in wages and change in employment. We compute change in performance in log terms, or

$$\Delta X_{t+1} = \log(X_{t+1}) - \log(X_t), \tag{2}$$

in which X is the quantity of interest, for instance, sales or employment.

We then estimate a flexible equation relating past innovation and outsourcing to current

performance changes as

$$\begin{aligned}\Delta X_{t+1} = & \\ & \alpha_0 + \alpha_1 INV_{j,t} + \alpha_2 INV_{j,t-1} + \alpha_3 INV_{j,t} \times INV_{j,t-1} \\ & + \alpha_4 OUTS_{j,t} + \alpha_5 OUTS_{j,t-1} + \alpha_6 OUTS_{j,t} \times OUTS_{j,t-1} \\ & + \alpha_7 OUTS_{j,t} \times INV_{j,t} + \alpha_8 OUTS_{j,t-1} \times INV_{j,t-1} \\ & + \alpha_9 OUTS_{j,t} \times INV_{j,t-1} + \alpha_{10} OUTS_{j,t-1} \times INV_{j,t} + Z_{j,t}\beta + \epsilon_{j,t+1},\end{aligned} \tag{3}$$

where the control variables, $Z_{j,t}$, are the same as those used in equation (1) above.

Table 5 summarizes the estimation results from equations (1) and (3).[9] The rows in the table are sorted by the predicted probability of innovating from the estimates of equation (1). So for example, the row labeled 15 is generated by using the estimated coefficients, setting the dummy variables for innovation and outsourcing at both time periods equal to one and setting the (vector) value of $Z_{j,t}$ equal to the whole sample average. The 'marginal effects', conditional on various starting points, can be calculated from the differences in probabilities across rows.

First we note that outsourcing at time $t-1$ has little effect on innovation at time $t+1$ once we consider outsourcing behavior at time t and innovation at both times $t-1$ and t. A very clear pattern emerges when we look at these last three items. Firms that outsource at time t and do not innovate at either time $t-1$ or at time t are the least likely to innovate at time $t+1$ (the rows labeled 1 and 2 in Table 5). Firms that innovate at both time periods and outsource at time t are the most likely to innovate at time $t+1$ (the last two labeled rows of Table 5). The remaining intermediate groups are almost perfectly sorted on these three variables in the following order, by increasing probability to innovate at time $t+1$:

- Firms that do not outsource at time t and do not innovate at time $t-1$ nor at time t (rows 3 and 4)
- Firms that outsource at time t and innovate at time $t-1$ but do not innovate at time t (rows 5 and 6)
- Firms that innovate at time $t-1$ but neither innovate nor outsource at time t (rows 7

[9] The coefficient estimates which produce this table are available upon request from the authors.

Row Label	Outsource $t-1$	Outsource t	Innovate $t-1$	Innovate t	Number of Firm–years	Probability of Innovating in $t+1$	% Change in Wage t to $t+1$	% Change in Employment t to $t+1$
1		•			71	4.0%	-2.3%	-8.8%
2	•	•			26	4.8%	1.4%	2.3%
3					1,440	6.5%	4.1%	-0.1%
4	•				98	8.8%	-6.1%	2.9%
5	•	•	•		7	8.9%	-5.4%	0.1%
6		•	•		27	11.8%	-2.6%	-3.2%
7	•		•		54	13.1%	-2.6%	-3.2%
8			•		432	15.0%	14.3%	2.7%
9				•	218	19.7%	2.1%	-0.5%
	Sample Size and Predicted Mean				2,898	22.2%	3.5%	-0.9%
10		•		•	21	25.4%	11.4%	-3.9%
11	•			•	12	26.6%	-3.3%	4.6%
12	•	•		•	8	30.7%	20.0%	9.3%
13	•		•	•	52	41.5%	-2.4%	-0.8%
14			•	•	369	42.5%	9.6%	1.8%
15	•	•	•	•	18	49.7%	10.4%	6.6%
16		•	•	•	45	53.2%	8.5%	1.2%
	# Firm-years				2,898			

Table 5: The predicted values of the dependent by the type of outsourcing and innovation activities in t and $t-1$. Bullets indicate that the action took place at the given time. The results are sorted from the lowest probability of innovation to the highest. $t = 1995-96, 1996-97$.

and 8)

- Firms that innovate at time t but not at time $t-1$ (rows 9 through 12)
- Firms that innovate both at time $t-1$ and time t but do not outsource at time t (rows 13 and 14)

Other things that are clear from the table are that 'super-innovators' who innovate in both previous periods are the most likely to innovate at time $t+1$. Innovation dominates in determining future innovation and innovation only at time t results in higher probability of innovation at time $t+1$ than innovation only at time $t-1$. Outsourcing is less important than innovation in explaining future innovation, but the overall pattern is clear: outsourcing at time t in partnership with innovation at time t is related positively to future innovation whereas outsourcing at time t without innovating at time t is related negatively to future innovation.

When we look at column 7, which estimates equation (3) for wages, we see two clear patterns. Firms that outsource at time t without innovating report lower wages (or in one case, small positive wage growth below the mean wage growth in the data). Firms that outsource at time t and simultaneously innovate, report higher wages in $t+1$, ranging from 8.5% to 20% higher, well above average wage growth in the sample. This is consistent with a story about there being two very different types of outsourcing. Low-cost-oriented outsourcing which is not accompanied by innovation and which is undertaken to reduce costs results in lower wages. Innovation-oriented outsourcing outsources low cost jobs and replaces them with higher cost jobs that are focused on further innovation or on making the most of the innovation which has occurred. This results in a higher wage bill.

Looking at changes in employment in column 8, the results are slightly more varied. Simultaneously outsourcing and innovating at time t appears to lead to higher employment, though the increase is smaller than the increase in wages, consistent with a story of replacing lower-paid outsourced workers with higher-paid workers who can pursue innovation. The largest decreases in employment come from firms that outsource in time t with no innovation at time t. There does seem to be some role for outsourcing at time $t-1$ for this variable, as those firms that outsourced at time $t-1$ generally seem to have higher change in employment

at time $t+1$ irrespective of outsourcing and innovation at other time periods. While this latter results holds for most categories, it does not hold for all and the effects are numerically small.

If we only look at contemporaneous effects, there is a clear ordering in the predicted probability of future innovation, from least to most likely:

- Outsourcing at time t
- Neither outsourcing nor innovating at time t
- Innovating at time t
- Innovating and outsourcing at time t

Since these contemporaneous effects are stronger than the lagged effects, we also estimate a restricted model of the probability of innovation at time $t+1$ as

$$Prob[INV_{j,t+1} = 1|t] = \Phi\Big(\alpha_0 + \alpha_1 INV_{j,t} + \alpha_2 OUTS_{j,t} + \alpha_3 OUTS_{j,t} \times INV_{j,t} + Z_{j,t}\beta\Big), \tag{4}$$

where control variables are still defined as for equation (1). Equations for changes in wages and employment are estimated as in equation (3) but without terms involving time period $t-1$. For a more detailed look at the effects of simultaneous innovation and outsourcing on firm performance, we additionally estimate this reduced form of equation (3) for changes in sales and operational costs as independent variables. A further advantage of this approach of only using one lag is that it allows us to estimate over a larger sample and to investigate whether the same patterns emerge.

Results from equation (4) are summarized in Table 6. First, we observe the inter-temporal link between innovation activities, so that firms that innovated at time t are much more likely to come up with an innovation in $t+1$. The estimated effect of average wages is especially interesting since it shows that firms paying higher wages per employee, perhaps to professional and skilled workers, are more likely to innovate.

The results show that firms that outsource at time t but do not innovate at the same time are saving on wages, increasing their sales, and decreasing their employment. This pattern

Variable	Dependent Variables				
	INV_{t+1}	$\Delta Sales_{t+1}$	ΔEMP_{t+1}	$\Delta WAGE_{t+1}$	$\Delta COST_{t+1}$
Controls					
$\log(EMP_t)$	0.042***	-0.003*	-0.030***	0.010***	-0.000
	(0.002)	(0.002)	(0.001)	(0.002)	(0.002)
$\log(1+WAGES_t)$	0.015***	-0.014***	0.031***	-0.213***	0.012***
	(0.002)	(0.002)	(0.001)	(0.006)	(0.003)
$EXPINT_t$	0.065***	0.262***	-0.007	0.089***	0.011
	(0.006)	(0.028)	(0.005)	(0.009)	(0.009)
$RDINT_t$	-0.019***	0.115***	-0.020***	0.016***	0.131***
	(0.004)	(0.002)	(0.003)	(0.001)	(0.003)
$MULTI_t$	-0.023***	0.017***	-0.017***	0.003	-0.004
	(0.004)	(0.004)	(0.003)	(0.006)	(0.005)
$OUTS_t$	-0.036***	0.036***	-0.016**	-0.046***	0.055***
	(0.007)	(0.006)	(0.005)	(0.008)	(0.007)
INV_t	0.276***	0.054***	0.026***	0.016**	0.045***
	(0.005)	(0.004)	(0.002)	(0.005)	(0.005)
$OUTS_tINV_t$	0.076***	-0.032**	-0.002	0.104***	-0.006
	(0.014)	(0.011)	(0.008)	(0.013)	(0.014)
R^2		0.074	0.058	0.093	0.034
Log-Likelihood	-22340.6	-22546.3	4144.5	-36027.5	-37900.1
# Firm–years			4,347		

Table 6: The marginal effects of innovation and contracting out on firms' future performance. The numbers in parenthesis are robust standard errors. Year, age, and industry dummies are also included but not reported. ***, **, and * denote 1%, 5%, and 10% significance levels. $t = 1994-95$ to $1996-97$.

Outsource t	Innovate t	Number of Firm–years	Probability of Innovating in $t+1$	% Change in Wage t to $t+1$	% Change in Employment t to $t+1$
		1,136	7.2%	0.1%	0.1%
•		2,831	10.0%	4.7%	1.8%
Sample Size and Predicted Mean		4,347	24.8%	2.9%	0.7%
	•	212	37.4%	6.3%	4.4%
•	•	168	41.8%	12.1%	2.6%
# Firm–years			4,347		

Table 7: The predicted values of the dependent by the type of outsourcing and innovation activities in t. Bullets indicate that the action took place at the given time. The results are sorted from the lowest probability of innovation to the highest. Using years $t = 1994 - 95$ to $1996 - 97$.

is consistent with low-cost-oriented outsourcing. The same firms also experience an increase in operational costs, which we explain as the value of the contracted out service being added to the operational costs. Low-cost-oriented outsourcing, however, is damaging the future chances of innovation, hence, this practice turns out to be a short-sighted strategy which increases profits now at the cost of hurting the long-term competitiveness of the firm.

On the other hand, for those firms that both innovate and outsource at time t, we find lower sales at time $t+1$ relative to time t. These firms are also paying higher wages per employee. This is consistent with firms incurring higher costs and sacrificing (short-term) future sales to improve their future innovation capability and to position themselves for long-term success.

The main patterns described earlier in the four bullet points are also clearly visible in Table 7 of predicted values. Again, low-cost-oriented outsourcing shows very different implications for firm innovation, wages and employment than innovation-oriented outsourcing.

4.2 Outsourcing and the Type of Innovation Activity

To improve our understanding of innovation-oriented outsourcing, we examine how expenditure components of innovation activity are affected by outsourcing. In our data, firms indicating that they have made an innovation are asked specifically about expenditure for innovation. This expenditure is categorized in five mutually exclusive ways: research and de-

	Fraction	Mean	Std.Dev.	1st Decile	Median	9th Decile
1	R&D	0.480	0.366	0	0.500	1
2	Training	0.068	0.172	0	0	0.177
3	Patenting	0.018	0.090	0	0	0.022
4	Retooling	0.291	0.329	0	0.167	0.893
5	Marketing	0.143	0.236	0	0.006	0.667
	$RDINT$	0.132	1.025	0	0.012	0.142
	# Firm-years			844		

Table 8: The fraction of expenditure pertaining to the different elements of innovation. The last row is about the R&D intensity in firms. The sample is the pooled sample of firm-years form the balanced panel of the BLS conditional on firm-year having had an innovation.

velopment (R&D), training, patenting/licensing, retooling and marketing. We also consider how innovation-oriented outsourcing relates to overall firm R&D expenditure by considering the R&D intensity variable, $RDINT$, defined in Section 4.1 above. We calculate $W_{ij,t}$ as the fraction of expenditure on component $E_{ij,t}$ out of total innovation-related expenditure

$$W_{ij,t} = \frac{E_{ij,t}}{\sum_{i=1}^{5} E_{ij,t}}, \quad i = 1, \ldots, 5. \tag{5}$$

Table 8 reports the sample statistics for the fraction of expenditures on the different elements of innovation conditional for those firm-years where a firm reports an innovation and non-zero expenditure on innovation. Importantly, the prevalence of zeros in the table shows that many firms only focus on certain aspects of innovation activity. In particular, research and development, retooling and marketing seem to be regarded by Australian firms as the more relevant factors for the success of an innovation. In the second-last row of the table, we also present summary information about R&D intensity for this subset of firms.

These expenditure fractions are each bounded between zero and one (inclusive) and sum to one. In order to model these expenditure shares we need to constrain the model such that predicted values sum to one and marginal effects sum to zero: an increase in one share of expenditure due to some factor has to be offset by an equal drop in one or more of the other shares due to the same factor. Papke & Wooldridge (1996) offer a solution to the problem of estimating a fractional left-hand side variable in a univariate context by assuming that the dependent variable is a probit or logit transformation of a latent linear model representing

an agent's intensity of engagement in the activity. In our context, the unobserved intensity that a firm engages in each of the innovation activities is modeled as

$$W^*_{ij,t} = \alpha_{i,0} + \alpha_{i,1} OUTS_{j,t} + Z_{j,t}\beta_i + \epsilon_{ij,t}, \qquad i = 1, \ldots, 5, \tag{6}$$

in which $Z_{j,t}$ is the same set of control variables that was in use in equation (1). Since we are restricted to firms that have innovated at time t (those are the only firms reporting expenditure shares), our model is conditional on innovating. To bind all five equations together in one single estimation model, we use Mullahy (2010)'s extension of the fractional response model of Papke & Wooldridge (1996). In this approach, each share is modeled as a logit function of all the latent variables, resulting in the following quasi-likelihood function:

$$\mathcal{L} = \prod_{j,t=1}^{N_{INV}} \prod_{i=1}^{5} \left(\frac{\exp\left(W^*_{ij,t}\right)}{\sum_{i'=1}^{5} \exp\left(W^*_{i'j,t}\right)} \right)^{W_{ij,t}}, \tag{7}$$

where N_{INV} is the total number of firm–years in our sample reporting innovation. Since $W_{5j,t} = 1 - \sum_{i=1}^{4} W_{ij,t}$, it is necessary for the identifiability of our model to assume that $\alpha_5 = 0$ and $\beta_5 = 0$ (i.e., we treat the fifth expenditure share as a 'reference' share). Maximizing the log of this quasi-likelihood function then generates the estimates for the other coefficients within each type of expenditure, especially those of $\alpha_{1,1}$ to $\alpha_{4,1}$. The marginal effects can be calculated as the average partial effects using the method suggested by Mullahy (2010, Appendix 1), which is independent of the choice of reference share and automatically constrains the marginal effects to sum to zero. The use of only innovating firms introduces some selection, and we will discuss this issue in Section 5 below.

Table 9 reports the estimated marginal effects. The most interesting result is that firms that innovate and outsource at the same time (row $OUTS$) seem to be focused primarily on research and development expenditure. Outsourcing appears to be helping these firms to allocate a larger share of their spending towards research and development. One can interpret this finding in the light of the paper by Acemoglu et al. (2003) that firms undertake this re-focusing of activity when the burden of having to manage peripheral jobs not related to research activities is reduced by contracting them out.

It is also interesting to know whether past outsourcing and innovation affects current

Variable	R&D	TRAIN	PATENT	RETOOL	MARKET
$Log(EMP_t)$	0.036***	-0.014***	-0.005***	-0.018***	0.001
	(0.005)	(0.001)	(0.001)	(0.004)	(0.002)
$Log(1+WAGES_t)$	-0.048***	0.007***	0.007***	0.030***	0.004
	(0.007)	(0.001)	(0.001)	(0.006)	(0.003)
$EXPINT_t$	0.179***	-0.096***	-0.004	-0.092***	0.012***
	(0.018)	(0.008)	(0.003)	(0.019)	(0.005)
$RDINT_t$	1.422***	-0.164***	-0.031***	-0.764***	-0.463***
	(0.109)	(0.015)	(0.011)	(0.091)	(0.030)
$MULTI_t$	-0.014	0.032***	-0.002	-0.012	-0.004
	(0.012)	(0.005)	(0.001)	(0.010)	(0.006)
$OUTS_t$	0.057***	-0.031***	-0.007***	-0.028***	0.009
	(0.012)	(0.002)	(0.001)	(0.010)	(0.006)
Log-Likelihood	-9272.8	-9272.8	-9272.8	-9272.8	-9272.8
# Firm-years			831		

Table 9: The influence of outsourcing and innovation on different expenditure components of innovation. Conditional on the firm having innovation in t. Table entries are marginal effects; numbers in parenthesis are robust standard errors. ***, **, and * denote 1%, 5%, and 10% significance levels. $t = 1994-95, 1996-97$.

period expenditure patterns in any particular way. To explore this question, we introduce the following latent specifications

$$W^*_{ij,t} = \alpha_{i,0} + \alpha_{i,1} INV_{j,t-1} + \alpha_{i,2} OUTS_{j,t-1} + \alpha_{i,3} INV_{j,t-1} \times OUTS_{j,t-1} + Z_{j,t}\beta_i + \epsilon_{ij,t}, \quad i = 1, \ldots, 5. \tag{8}$$

The method we apply for estimation is again our adaptation (requiring the marginal effects to sum to zero) of that proposed by Papke & Wooldridge (1996). Table 10 reports marginal effects from this model. Note that the sample of firm-years used to generate the results in Tables 9 and 10 do not fully overlap because information about innovation expenditures is missing in 1995–96.

We find results that are quite consistent with those of Table 9. Firms that outsource and innovate one period ago and continue to innovate at time t are shifting expenditure to research and development, patenting and marketing.[10] Firms that outsourced last period

[10] To understand the behavior of these firms the marginal effects from the last three rows of Table 10 need to be summed together.

Variable	R&D	TRAIN	PATENT	RETOOL	MARKET
$Log(EMP_t)$	0.050***	-0.000***	0.002	-0.046***	-0.005***
	(0.005)	(0.000)	(0.002)	(0.005)	(0.001)
$Log(1+WAGES_t)$	0.012*	0.000	-0.000	-0.010*	-0.002
	(0.007)	(0.000)	(0.002)	(0.005)	(0.001)
$EXPINT_t$	0.162***	-0.008***	-0.105***	-0.044**	-0.004
	(0.029)	(0.002)	(0.023)	(0.018)	(0.003)
$RDINT_t$	1.562***	-0.039***	0.009	-1.123***	-0.409***
	(0.059)	(0.009)	(0.043)	(0.034)	(0.039)
$MULTI_t$	-0.026**	0.000	0.004	0.020**	0.002
	(0.010)	(0.000)	(0.004)	(0.009)	(0.002)
$OUTS_{t-1}$	-0.101***	-0.001**	0.018**	0.066**	0.018**
	(0.034)	(0.000)	(0.009)	(0.031)	(0.008)
INV_{t-1}	0.003	-0.000***	-0.010**	0.002	0.005***
	(0.008)	(0.000)	(0.005)	(0.007)	(0.001)
$OUTS_{t-1}INV_{t-1}$	0.122***	0.002	-0.007	-0.107***	-0.010***
	(0.016)	(0.001)	(0.006)	(0.013)	(0.004)
Log-Likelihood	-5844.2	-5844.2	-5844.2	-5844.2	-5844.2
# Firm-years			570		

Table 10: The influence of lagged outsourcing and lagged innovation on different expenditure components of innovation. Conditional on the firm having innovation in t. Table entries are marginal effects; numbers in parenthesis are robust standard errors. ***, **, and * denote 1%, 5%, and 10% significance levels. $t = 1996-97, 1997-98$.

(but which did not innovate) and innovate at time t are switching away from research and development towards patenting, re-tooling and marketing. Likewise firms that only innovated last period and this period, but did not outsource, are switching expenditure to marketing, perhaps focusing on selling a new or improved product.

Most importantly, from Tables 9 and 10 we learn that firms which simultaneously innovated and outsourced in the previous period behave differently in their expenditure allocations than firms which innovated without outsourcing. The former focus more on research and development whereas the latter seem to focus more on marketing.

5 Interpretation and Caveats

As we indicate above, our findings about the relationship between innovation and outsourcing are documenting the patterns found in the data. Taking a random firm that outsources but does not innovate at time t and 'forcing' them to innovate may not lead to a dramatic difference in innovation performance at time $t+1$. In this sense our paper does not provide guidelines for how firms should behave but rather provides insights to researchers trying to understand the dynamic relationship between innovation and outsourcing. The point of our paper is that firms outsource for a variety of reasons and considering innovation behavior simultaneously with outsourcing behavior demonstrates some large differences in innovation outcomes for firms which outsource and simultaneously innovate and those who outsource without innovating.

It could be that combining innovation and outsourcing produces innovation at time t. It could also be that these three outcomes are all determined by some other factors that are not observed. Outsourcing at time t could provide additional resources for innovation at time $t+1$ and be causal in this sense. It's also possible that outsourcing is simply the product of the decision to innovate in the future and is thus jointly determined and not causal. Estimating a model in which these hypotheses can be tested would require a richer data set and should be an important object of future research.

We use the balanced panel, so firms which exit are dropped from our sample. More than half of firms in the first wave are not in the last wave, so keeping the balanced panel introduces a large amount of selection. Exit may be correlated with outsourcing and innovation and this may affect our results. Innovation is highly correlated with staying in the sample. Amongst firms that don't innovate, 58 per cent of them leave the sample in the next period. Of those firms that do innovate at time t, only 4 per cent leave the sample. This big difference is not surprising. Firms are unlikely to undertake major innovation if they are about to shut down. In fact, this large differential reassures us that the innovation question we use is probably capturing major innovations. Firms which outsource are also more likely to appear in the sample next period, but the difference is not as great. 48 per cent of firms who do not outsource at time t leave the sample at time $t+1$ compared with only 29 per cent of firms who do outsource at time t. Again, it is reassuring that outsourcing has measurable effects

on firm survival.

Our conclusion that outsourcing and innovation together at time t are associated with a higher probability of innovating at time $t+1$ is based upon a sample of firms that we observe at both time t and $t+1$ and needs to be interpreted in this light. Outsourcing alone at time t is associated with a much smaller probability of innovating at time $t+1$. If we treat those firms that exit as being non-innovators, then our results are even stronger than what is presented above. As the gap in exit is much larger between innovators and non-innovators than it is between those who outsource and those who don't, if we were to estimate our correlations on the unbalanced panel we would find an even more dramatic combined effect of outsourcing and innovating.

In subsection 4.2 we estimate a model of expenditure only for those firms who innovate. The results need to be interpreted as expenditure patterns *conditional* on innovating. They should not be interpreted as necessarily indicating how firms who are attempting/intending to innovate distribute expenditure amongst these categories. Crepon et al. (2007) estimate a model where they control for determinants of innovation to correct for selection in the expenditure equation. Innovation is fairly rare in our data and we were unable to find convincing exclusion restrictions to identify such a selection model. We do note that the expenditure categories we model are asked of firms as expenditure specifically related to the innovation which they have reported. Thus our model is not one of general research and development expenditure where selection might be more of a problem.

6 Conclusion

Outsourcing can be targeted at saving costs, reducing wages or downsizing. Alternatively, outsourcing could be used to free up resources to shift a firm's focus from one activity to another or to pursue activities such as innovation or research and development. In the latter case, there is less concern in saving total costs and more concern in improving the firm's research and innovation environment. Consequently, a firm which outsources janitorial jobs, for example, might be observed to have a higher wage bill after outsourcing if these jobs have been replaced with higher-paid professional and research staff or if performance incentives for existing staff to engage in more innovative endeavors are increased.

This paper presents a range of results that uncover a distinction in the data between outsourcing to reduce cost and outsourcing to boost innovation. Based on these results, we interpret outsourcing by innovative firms as an attempt to reduce the scope of peripheral jobs undertaken in-house in order to shift managerial resources to oversee innovation. Moreover, we observe a shift to more intensive research and development on the part of these innovation-oriented outsourcing firms consistent with this story. A similar conclusion is reached by looking at the higher overall wage bill that innovation-oriented outsourcing firms have. In line with the theoretical predictions of Acemoglu et al. (2003), these firms experience an accelerating rate of innovation and may perhaps be able to distance themselves from the horde.

We find that firms which outsource without innovating are the worst of all performers in terms of future innovation probability. This may be consistent with low-cost-oriented outsourcing being a sign of trouble for the firm. It may be a strategy to keep the firm alive rather than to improve firm performance.

One implication of our results is that we may need richer data to help move beyond the rather uni-dimensional view of outsourcing as being a cost-reducing strategy. We would argue that business surveys should ask more detailed questions about outsourcing including which jobs were outsourced and why outsourcing was undertaken.

Finally, our key empirical observation that the best performers in terms of future innovation are those that combine innovation with outsourcing whereas the worst performers are those who outsource without innovating has an important implication for future economic research. Researchers who treat all outsourcing firms as homogeneous, either in theoretical or empirical research, risk missing important features of economic behavior and the data it generates. We would argue for a richer view of outsourcing and a clear distinction between outsourcing to cut costs and outsourcing as one aspect of the strategy of an innovative firm trying to stay ahead of the pack.

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