Received: 11 March 2022 | Revised: 27 May 2022 | Accepted: 4 July 2022
DOI: 10.1002/mde.3683

RESEARCH ARTICLE

WILEY

Lifting the hood of supply and demand for trademarks of start-ups: Partial observability estimates

Bernadette Power[1] | **Gavin C. Reid**[2,3]

[1]School of Economics, University College Cork, Cork, Ireland

[2]Centre for Business Research, Cambridge Judge Business School, University of Cambridge, Cambridge, UK

[3]School of Economics and Finance, University of St. Andrews, St. Salvator's College, St. Andrews, Fife, UK

Correspondence
Bernadette Power, School of Economics, University College Cork, Cork, Ireland.
Email: b.power@ucc.ie

This paper estimates simultaneously the supply and the demand determinants of the trademark adoption decision made by start-ups. We use a partial observability econometric model, as non-adoption is unobserved. Estimation is by maximum likelihood using the partial observability bivariate probit (POBP) model for an unbalanced longitudinal panel of surviving US start-ups (2004–2011). Our model is shown to provide a good explanation of supply and demand determinants of trademark adoption. For example, size, incorporation and expenditure on R&D are important on the supply side; and copyrights, licensing out and being in a high knowledge information sector are important on the demand side.

JEL CLASSIFICATION
D01, D22, K11, L21, L26

1 | INTRODUCTION

The goal of this paper is to identify which supply and demand determinants exert the most influence over the adoption decision, by owner managers of start-ups, of trademarks (cf. Blackett, 1998; De Carvalho, 2019). Trademarks are signs, like a word or an image, that uniquely identify a company's product (Athreye & Fassio, 2020). They allow the possessor to protect this representation of the product. We undertake our supply and demand analysis of trademarks using an emerging econometric technique, the partial observability bi-probit model (POBP) (Greene, 2018, Ch. 17; Poirier, 2014). For decision-making within start-ups, it offers an appealing solution to the intrinsic problem of partial observability of owner managers' actions. This arises because the only decision one observes is the owner manager registering a trademark, while the other decision *not to register* goes unobserved.

Recently, trademarks have been recognised as being an increasingly important type of intellectual property (IP), both in terms of volume, having grown exponentially in the last 80 years (at a rate of over 8% growth) (Ribeiro et al., 2022), and in terms of function. As regards the latter, for example, trademarks are being associated with Kirznerian entrepreneurship (see Lyalkov et al., 2020) and are recognised as becoming ‘unplugged’ (Kozinski, 1993), in the sense of being much more than just an identifier of a product, but rather a part of the product per se. They are therefore ready targets for further research.

In the economic context of trademarks and product variety, the most relevant standard economic model for our start-up firms is arguably monopolistic competition, originally formulated by Chamberlin (1933) and Robinson (1933), and since then more recently adopted by scholars of small business, like Andersen et al. (1993), Cowling and Nadeem (2020), and Ughetto et al. (2019). Since its genesis, theory in this area has advanced greatly in sophistication, yet contemporary analysis of monopolistic competition (cf. Dhingra & Marrow, 2019; Parenti et al., 2017) still retains its fundamentals, namely, differentiated products; the uniqueness of product (q) provision by each firm; and falling marginal revenue (MR) at the optimum where it is equal to marginal cost (MC), the familiar MR = MC. Alternatively, one can look at this optimum differently using modern theoretical analysis along industrial organizational lines. This would say that, for a marginal utility defined as u(q), its elasticity, $u'(q)q \div u(q)$, will be equal to the price–cost margin. As ever, in equilibrium, the cut-off for firms being active in the market is determined by a zero-profit condition. This kind of theoretical perspective, in its modern form, is the backdrop to our analysis. It follows the similar use of monopolistic competition by Ughetto et al. (2019), in their study of venture capital and business angel finance provision to small businesses, in their case from a regional and evolutionary perspective.

2 | BACKGROUND

IP is important to small and medium-sized enterprises (SMEs) (De Rassenfosse, 2012; Parr & Smith, 2004; Power & Reid, 2021b, 2021c). It creates rights of control and exploitation over 'creations of the mind' of potential commercial value, which have been generated within a firm. Our paper investigates IP use among start-ups in the United States, with a specific focus on the adoption of trademarks (De Carvalho, 2019). For the start-up, a strategic imperative is often to exploit rapidly new-to-the-market knowledge, (Block et al., 2015). This may involve the adoption of a specific IP type, of which trademarks (Blackett, 1998; Economides, 1988) are an increasingly important, and economical, form of IP protection, especially for entrepreneurial start-ups (Lyalkov et al., 2020).

Creating and exploiting such IP was once the province of large technology-intensive firms, but that time is past. For example, cf. Oduro (2019), who finds that open innovation practices are commonplace for low-tech SMEs in emerging markets. Today, IP is increasingly relevant to SMEs, especially in its trademark form, which is now the most used IP and is regarded as an important signaller of innovative capacity, (Ribeiro et al., 2022). Such trademarks have evolved distinctive features; cf. Lunney (2018) who identifies two tiers in trademark systems, in which both parties can afford to litigate in the upper tier, but only one party can in the lower tier. It has been argued by Athreye and Fassio (2020) that while trademarks share the same characteristics of exclusivity as patents, trademarks protect a quite different kind of market failure (viz. the information asymmetry between buyer and seller), allowing the protection of both incremental and service innovations.

While our paper does not emphasise the evolutionary dimension to our findings, it is there, and brief consideration of it is helpful to the interpretation of our procedures and findings. This dimension refers to the importance of IP in facilitating growth. This can take advantage of going down the long-run average cost curve (LAC) as discussed by Ughetto et al. (2019), with resulting improvement in performance. This argument has been elaborated by Reid and Smith (2008). They show, theoretically and empirically, how the envelope of innovative performance for high-tech start-ups has two turning points. The first turning point can probably be achieved by many small firms over time, at a significantly higher scale of operation than at start-up, exploiting the LAC advantage, whereas the second turning point can probably only be achieved at a much higher scales, by those few firms who are capable of taking advantage of increasing returns to scale, of Schumpeterian dimensions (Reid and Smith, 2008, figure 4, p. 40). The latter would typically occur by mergers or takeovers, resulting in returns which, in principle, are unbounded, being limited theoretically by the total market's extent, but with market shares ultimately being limited, in practice, as much by regulation as by market forces.

3 | IP AND TRADEMARKS

Property rights are heavily protected: broadly by the Fifth Amendment; and, more narrowly, by the protocols of various statutory bodies, like the United States Patents and Trademarks Office (USPTO)[1] and the United States Copyright Office. While patents and copyrights issued by these bodies have tended to have the most academic attention, more modest IP types, like trademarks, have become more important in recent years, because they are effective, flexible and relatively cheap (Flikkema et al., 2014; Lyalkov et al., 2020). This has made trademarks very attractive to SMEs seeking IP protection (Ribeiro et al., 2022).

Figure 1 shows time series for trademark filings (dotted line) and registrations (solid line) using USPTO data from 2008 to 2020. From this graphical evidence, two important points are observed: (i) the steady uplift in trademarks and (ii) the narrowing gap between filings and registrations of trademarks. Further analysis by Ribeiro et al. (2022, figure 1, p. 492) suggests a long-run secular increase in the intensity of trademarking, in that, once firms have started trademarking, they tend to trademark more subsequently. In the relatively short time interval that our data cover, 2005–2011, it is difficult to confirm more intense trademarking over time. What we can say about the evolution of our start-ups over our data period is as follows. Of the 1612 firms which survived throughout this interval, the proportion of those firms who trademarked year by year is relatively stable and averaged about 12%. There is a slight tendency towards greater use of trademarks in their earlier years.

Trademarks protect brands rather than radical inventions (Blackett, 1998). They signal product quality and help consumers to differentiate between the products of a company and their rivals (Besen & Raskind, 1991; Landes & Posner, 1987): Indeed, to economists, their purpose is largely to resolve such information asymmetries (Greenhalgh & Rogers, 2010). The prominence of trademarks is evident in the vast number of trademark applications. It is the most widely used form of IP, having enjoyed an annual exponential growth of about 8% since the 1930s (Ribeiro et al., 2022). SMEs are more likely to engage in trademarking than large firms (Greenhalgh & Rogers, 2010; Rogers et al., 2007). They differentiate products in niche markets, making branding more important (see Block et al., 2015). It is also less costly and less complex to register trademarks, compared to other IP types. Arguably, they signal quality to venture capital funders and foster partnerships and strategic alliances (Block et al., 2015; Motohashi, 2008). There is much expert evidence to conclude that the effect of trademarks on firm performance, in all its dimensions, is positive (cf. Greenhalgh & Rogers, 2012; Sandner & Block, 2011). Supporting this view, several studies like Srinivasan

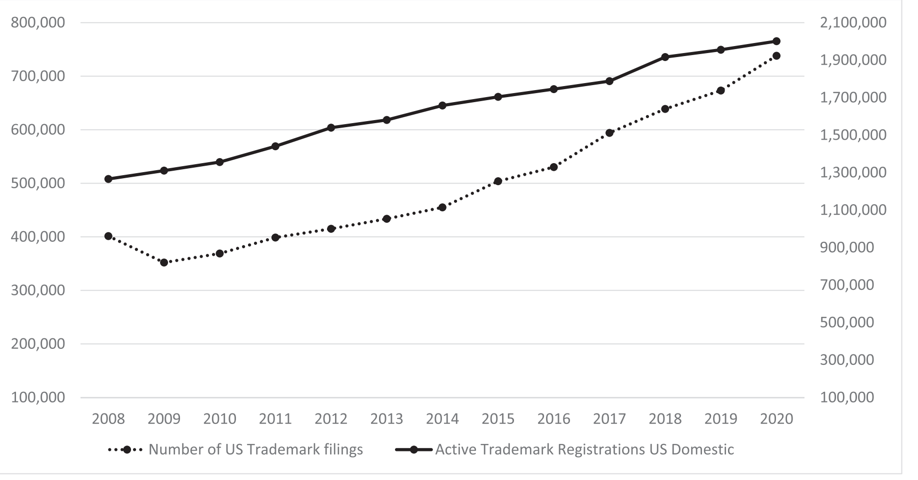

FIGURE 1 US trademarks. *Source:* US Patents and Trademarks Office (https://www.uspto.gov/dashboard/trademarks/)

et al. (2008), Jensen et al. (2008) and Helmers and Rogers (2010) find that SME's trademarks also reduce their exit rate.

4 | MODEL AND ESTIMATION

We explain here our model of trademarking, from both the supply and demand sides. In outline, the model posits maximisation of a concave entrepreneurial ordinal utility function, (Power & Reid, 2021b, 2021c; Reid, 1987), with a decision format that involves, first, optimization of the awareness (A) of potential means of securing IP (cf. Thomä & Bizer, 2013) and, second, optimization of the evaluation (E) of the best IP to adopt (cf. Dimara & Skuras, 2003; Van den Bulte & Lilien, 2001). Here, the variables A and E are treated as binary (1, 0), with 1 representing (a) achieving awareness of the feasible IP options and 0 representing (b) deciding specifically on the adoption of trademarks. A is considered prior to E, which represents the conditional decision mode ($E = 1| A = 1$). Technically, the problem of partial observability is that A and E cannot be observed separately, but only their product $A \times E = Y$. Despite partial observability, the following compound probability is necessarily true: $P(Y = 1|Y_{-1} = 0) = P(E = 1|A = 1, Y_{-1} = 0) \times P(A = 1|Y_{-1} = 0)$, where the -1 subscript relates to variable values in the previous time period (i.e. $t - 1$, if t represents the current period). From this, using the notation ($Y_1 \equiv S$) for supply and ($Y_2 \equiv D$) for demand, we can write the compound probability of *adopting* a trademark as P (IP Type = 1) = P(D = 1) × P(S = 1|D = 1) and the probability of *not adopting* a trademark as P (IP Type = 0) = P (D = 0) + P(D = 1) × P(S = 0|D = 1). Assuming that the determinants of S and D are linear in form and that a unit standard normal cumulative density function $\Phi(.)$ characterizes the error structure, we can derive maximum likelihood estimators for the following supply and demand functions in Equations 1 and 2, respectively:

$$\text{Supply Model}: Y_1 \equiv S = \boldsymbol{X}_1\boldsymbol{\beta}_1 + \boldsymbol{X}_2\boldsymbol{\beta}_2 + \mu \qquad (1)$$

$$\text{Supply Model}: Y_2 \equiv D = \boldsymbol{X}_1\boldsymbol{\beta}_1 + \boldsymbol{X}_3\boldsymbol{\beta}_3 + \varepsilon, \qquad (2)$$

where μ and ε are uncorrelated error terms. Here, the $\boldsymbol{\beta}_i$ are estimable parameters, and the regressors $\boldsymbol{X}_i$ ($i = 1, 2, 3$) are vectors of data. A full account of the definitions of regressors $\boldsymbol{X}_i$ is provided in Table A2 in the Supplementary Appendix. The $\boldsymbol{X}_2$ variables of Equation (1) explain the supply of trademarks and reflect the resource-based theory of the firm (Barney, 1996; Galbreath, 2005). The $\boldsymbol{X}_3$ variables of Equation (2) explain the demand for trademarks and reflect the inclusive stakeholder theory of business interests (Mitchell et al., 2015; Wheeler & Sillanpa, 1998). The common $\boldsymbol{X}_1$ in Equations (1) and (2) explain both the supply of and demand for trademarks.

For the purposes of econometric 'identification', it is important that some variables contained in $\boldsymbol{X}_2$ are not also included in $\boldsymbol{X}_3$ (see Greene, 2018; Maddala, 1983; Poirier, 1980). We used STATA® software for estimating the S and D functions, by POBP, on Kauffman survey data (Farhat et al., 2018; Robb & Reedy, 2011) (see Section 5) using Gauss–Hermite quadrature (Beltagi, 2001; Rabe-Hesketh et al., 2005). This process typically converged in four to five iterations. Sample selection bias corrections (Greene, 2018, Ch. 19; Vella, 1998) were applied to all our estimates using start-up closure data (see Table A3, Supplementary Appendix). We also applied robustness checks (Greene, 2018, part IV) to our estimates, considering every alternative combination of variables that could be applied to our supply and demand equations (see Table A4, Supplementary Appendix). This required around one hundred rounds of re-estimation. None of these checks suggested changes to the specification of our model, nor did they alter our conclusions.

5 | DATA

The data used in our paper were obtained from the Kauffman Foundation of Kansas City, MO (see Robb & Reedy, 2011). They support the longitudinal Kauffman Firm Survey of US start-ups (see DesRoches et al., 2013; Power & Reid, 2021a). This dataset applies to

TABLE 1 Key statistics

Variables (x)	All	Trademarks	
		Yes	No
	Mean *(standard deviation)*	Mean *(standard deviation)*	Mean *(standard deviation)*
1. Size (FT + PT)—headcount of all full-time and part-time employees	2.94 *(6.15)*	5.06 *(8.24)*	2.55 *(5.47)*
2. Product—business sells a product (1, 0)	0.49 *(0.50)*	0.69 *(0.46)*	0.45 *(0.50)*
3. Copyrights—count of firm's copyrights	1.49 *(0.50)*	4.19 *(17.98)*	1.04 *(10.87)*
4. Patents—count of firm's patents	0.17 *(1.99)*	0.84 *(4.68)*	0.07 *(1.12)*
5. Licensing in (1, 0)	0.08 *(0.37)*	0.15 *(0.35)*	0.04 *(0.20)*
6. Licensing out (1, 0)	0.03 *(0.19)*	0.09 *(0.29)*	0.01 *(0.09)*
7. Incorporated (1, 0)	0.65 *(0.48)*	0.80 *(0.40)*	0.62 *(0.49)*
8. Expenditure on R&D (1, 0)	0.19 *(0.39)*	0.40 *(0.49)*	0.15 *(0.36)*
9. Competitive advantage (1, 0)	0.59 *(0.49)*	0.79 *(0.41)*	0.58 *(0.50)*
10. Equity—investment angels (1, 0)	0.03 *(0.17)*	0.08 *(0.27)*	0.02 *(0.14)*
11. Equity—venture capitalists (1, 0)	0.02 *(0.13)*	0.03 *(0.17)*	0.004 *(0.06)*
12. Construction (1, 0)	0.08 *(0.27)*	0.03 *(0.16)*	0.09 *(0.28)*
13. Knowledge IS—knowledge-intensive services (1, 0)	0.38 *(0.59)*	0.38 *(0.49)*	0.38 *(0.49)*

the period 2004–2012, and its evidence was collected by the mixed use of self-administered web surveying and computer-assisted telephone interviewing (CATI). When the survey rounds began in 2004, 4928 start-ups were included. These initial firms were subsequently tracked annually until 2012. Table A1 in the Supplementary Appendix shows how successive rounds were completed right through to 2012.

Our sample had a high response rate (43%), based on weighted sampling (Ballou et al., 2008). All NAICS sectors from 11 to 92 were represented in our sample. As expected, sample attrition (e.g. due to exits, refusals, etc.) was very evident, implying our data were in the form of an unbalanced panel. Due to sample attrition and various restrictions on our variables (e.g. exit, non-response etc.), for our estimated models (see Section 6), we had a reduced sample size of $N = 13{,}427$ start-ups. Such samples are known to be good representations of the population of US start-ups at the times of data acquisition (see Farhat et al., 2018).

For a comprehensive statistical picture of our sample of start-ups, key variables, and their definitions, refer to the detailed Table A2, in the Supplementary Appendix. Alternatively, for a quick aperçu of the data, consider Table 1 in the main text. Most of the key explanatory variables (x) for the econometric estimation are shown there. Where necessary, from these two tables (Table 1 and Table A2), interpolated values can be derived, for example, such calculations show that the average start-up in our sample carries just $950 debt (interpolated) and receives only $576 equity (interpolated).

Table 1 and in detail Table A2 show that, on average, our start-ups are typically solely owned, incorporated micro-firms (with a headcount of three) (see Table 1, Lines 1 and 7). They carry little debt or equity (<$5 k) and mainly sell services (rather than goods) out of rented property, which readily allows them to be conceived as monopolistic competitors (Chamberlin, 1933; Reid, 1993). About a fifth (19%) of them incur research and development (R&D) expenditure (Table 1, Line 8). In orders of magnitude (from the largest to the least) the extent of adoption of IP types are copyrights, trademarks and patents (cf. Meiners & Staaf, 1990; Power & Reid, 2021a). Licensing in and licensing out (Table 1, Lines 5 and 6) are comparatively infrequent (<10%), with the former (8%) being over twice the latter (3%). Most (59%) of the start-ups think they have a relative competitive advantage (Table 1, Line 9) over rivals. In terms of outside equity, formal arrangements are rare (<1%), but business angels (3%) and venture capital (2%) (Table 1, Lines 10 and 11) do have a presence (cf. Reid & Smith, 2008).

From the key statistics of Table 1, we can also infer much about the differences between trademarking start-ups ($y = 1$) (Column 3) and non-trademarking start-ups ($y = 0$) (Column 4). Specifically, they are larger, have a broader product range and use more IP types (and more intensively), ranging from copyrighting to licensing (in and out). Further, they undertake more R&D spend, regard themselves as having relatively more competitive advantage over rivals and have more access to angel and venture capital funding.

Not shown in Table 1 but available in Table A2 in the Supplementary Appendix are the following illuminating statistics. Trademark adoption (14%) is much higher than patent adoption (4%) (cf. De Vries et al., 2017; Power & Reid, 2021a). The modal sector for these start-ups is in knowledge-intensive services (38%), and the modal 'customer' (46%) is another business. Thus, business to business (B2B), as noted by Merrilees et al. (2011), is the predominant trade of these start-ups.

TABLE 2 Trademarks: supply/demand POBP and simple probit estimates

Variables	(I) Supply side	(II) Demand-side	(III) Simple probit
1. Size	0.0295*** (0.0111)	−0.0097 (0.0075)	0.0120*** (0.0032)
2. Debt	0.0209 (0.0160)	−0.0064 (0.0155)	0.0106* (0.0063)
3. Team of owners	−0.1700 (0.1210)	0.2070* (0.1160)	0.0260 (0.0489)
4. Total equity of owners	0.0266 (0.0165)	−0.0038 (0.0164)	0.0324*** (0.0066)
5. Service	0.0379 (0.2020)	−0.4050* (0.2280)	−0.3850*** (0.0654)
6. Product	0.0327 (0.1410)	0.1300 (0.1370)	0.2640*** (0.0482)
7. High tech	0.0507 (0.1360)	−0.0301 (0.1440)	0.0368 (0.0708)
8. Copyrights	−0.0041*** (0.0015)	1.4290*** (0.2070)	0.0035** (0.0016)
9. Patents	−0.0106 (0.0119)	0.2880 (0.2840)	0.0504** (0.0227)
10. Licensing in	0.261** (0.0713)	-	0.2920*** (0.0638)
11. Licensing out	-	5.7580*** (0.1640)	1.1150*** (0.1180)
12. Purchased	−0.0632 (0.0840)	-	−0.0928 (0.0889)
13. Incorporated	0.2380*** (0.0973)	-	0.2810*** (0.0912)
14. PhD	0.0312 (0.0891)	-	0.0598 (0.0647)
15. Expenditure on R&D	0.2490*** (0.0620)	-	0.3420*** (0.0452)
16. Competitive advantage	0.2840*** (0.0721)	-	0.3860*** (0.0459)
17. Percentage of sales to other businesses	-	−0.0009 (0.0006)	−0.0001 (0.0006)
18. Percentage of sales to government	-	−0.0026** (0.0013)	−0.0026** (0.0012)
19. Equity investment by business angels	-	0.2540* (0.1300)	0.3280*** (0.0880)
20. Equity investment by businesses (CVC)	-	0.0123 (0.1150)	0.0760 (0.1130)
21. Equity investment by government	-	0.4140* (0.2350)	0.3020 (0.2230)
22. Equity investment by venture capitalists	-	0.4930* (0.2540)	0.7210*** (0.1790)
23. Non-bank business loans	-	0.0432 (0.1140)	0.0472 (0.1270)
24. Government business loans	-	0.0452 (0.1610)	−0.0530 (0.1610)
25. Business loans from other businesses	-	0.1260 (0.2200)	−0.0815 (0.2700)
26. Construction	−0.2360 (0.4810)	−0.1330 (0.3950)	−0.4930*** (0.1080)
27. Wholesale retail	−0.2400 (0.2800)	0.2410 (0.2450)	0.0268 (0.0890)
28. Low knowledge IS	−0.2140 (0.3240)	0.2120 (0.2740)	0.0132 (0.0855)
29. Knowledge IS	−0.5470** (0.2350)	0.5580*** (0.1920)	0.0890 (0.0739)
30. Other	−0.6580 (0.4960)	0.5390 (0.5660)	−0.1480 (0.2040)
31. Mills ratio	−1.3410 (1.5730)	1.5840 (1.7110)	−0.1010 (0.4800)
32. Constant	−0.1347 (0.3812)	−0.2488 (0.3166)	−1.863*** (0.1840)
33. Observations	13,427		13,427
34. Wald χ^2 (66 df)	4936.11***		759.67***

Note: Robust standard errors in parentheses.
**p* < 0.1. ***p* < 0.05. ****p* < 0.01.

6 | RESULTS

Here, we present in Table 2 (Columns I and II) the POBP supply and demand estimates of trademark adoption. The results from these are expounded in Sections 6.1 and 6.2. Alongside these (see Table 2, Column III, for comparative purposes) are the familiar simple probit estimates. Their comparative implications are expounded briefly in Section 6.3. We note first that the overall fit of the POBP model of Table 2 is good, as indicated by the Wald χ^2 statistic (which is highly significant, at $p < 0.01$). Further, there are numerous highly significant coefficients on both the supply side (e.g. *Size*, *Competitive advantage*) and demand side (e.g. *Copyrights*, *Licensing out*). Our interpretation of these results is now set out, in Sections 6.1 to 6.3, as follows.

6.1 | Supply side for trademarks

Focusing on the supply-side determinants of the registration of trademarks (Table 2, Column I), we note the following. The start-up *Size* coefficient, on the supply side, is positive (+0.030) and highly significant ($p < 0.01$) (Table 2, Column I, Line 1), indicating that scale is an important driver behind the registration of trademarks. This finding is aligned with those of numerous other studies (e.g. Arundel & Kabla, 1998; Cohen et al., 2000). This is also concordant with the findings that the better-resourced, and the larger, the firm is, the more likely it is to register its IP; cf. Hanel (2006), Huang and Cheng (2015) and Hall et al. (2014). We note too that this is exclusively a supply-side influence under POBP estimation, as there is an insignificant coefficient for the *Size* variable on the demand side (Table 2, Column II, Line 1). As a micro-firm grows, becoming *Incorporated* (Table 2, Column I, Line 13) becomes more desirable (cf. Daskalakis et al., 2013), which is confirmed by a positive (+0.238) and highly significant coefficient ($p < 0.01$) for this incorporation variable on the supply side. *Expenditure on R&D* and *Competitive advantage* (Table 2, Column I, Lines 15 and 16, respectively) are also key positive (+0.249, +0.284, respectively) drivers on the supply-side of trademark registration, supporting the works of Guo-Fitoussi et al. (2019) and Leiponen and Byma (2009), who find that firms that spend on R&D have a 30% higher likelihood of registering trademarks. In defending their IP in this way, they are enhancing their products' marketplace attraction (e.g. by differentiating their product more), which then becomes a source of competitive advantage, as it enables the start-up to 'nibble' at the edges of rivals' markets. *Copyrights* on the supply side (Table 2, Column I, Line 8) have a negative (−0.004) and highly significant ($p < 0.01$) impact on the supply of trademarks, providing evidence of strong IP substitutive effects. This finding supports those of Amara et al. (2008). By contrast, *Licensing in* on the supply side (Table 2, Column I, Line 10) has a positive coefficient (+0.261) and is significant ($p < 0.05$) in its impact. This provides further evidence of a complementary effect across formal IP types, as noted in Lee et al. (2017) and Gallié and Legros (2012). On the supply side for trademarks (Table 2), there are few sectoral effects, apart from knowledge-intensive services (*Knowledge IS*) (Table 2, Column I, Line 29) for which there is a negative (−0.547) and significant ($p < 0.05$) coefficient.

The above suggests the strength of the supply side of our model. It is well represented by our econometric results and data analysis. It provides a strong and unambiguous guide to the determinants of trademark adoption on the supply side. As such, it supports strongly other empirical work on trademarks, as opposed to other IP types, which finds them to be a cheaper, and more effective, than available alternatives for start-ups (cf. Lee et al., 2017).

6.2 | Demand side for trademarks

We turn now to the demand-side estimates of our POBP model (Table 2, Column II). As one would expect, the demand-side effects tend to be different from the supply-side effects (e.g. in sign and in significance). This displays one of the merits of our supply/demand estimation technique. For example, *Size*, *Copyrights* and *Knowledge IS* have coefficients with different (indeed reverse) signs, when making comparisons across the demand side and the supply side (see Table 2, cf. Columns I and II, Lines 1, 8 and 29). This is a clear indication of how our modelling successfully differentiates between the supply side and demand side. Further, on significance, we see that while *Size* is highly significant on the supply side, it is insignificant on the demand side (Table 2, Line 1, Columns II and II). This ties in with what is predicted by organizational theories of the firm (Reid, 1987, Ch. 9), where the stakeholders on the supply side include the owner-manager of the start-up, who are keen to grow on the firm (e.g. to exploit economics of scale).

On the demand side, a major concern of stakeholders, like venture capitalists, and other business lenders, like business angels, is the rate of return and profitability. This can often be achieved by exploiting increasing returns, in monopolistically competitive firms, taking advantage of falling LAC, so financial backers may well favour expansion being part of the entrepreneur's business plan. Indeed, it is notable that the ownership team variable (Table 2, Line 3) is significant and positive on the demand side (while insignificant on the supply side), emphasising how important to each start-up is their ownership team, in achieving a link between demand and supply when contemplating IP adoption like trademarking. If this link incentivises the entrepreneur to drive forward the size of the start-up, seeking potential advantage through going along the downward-sloping LAC, benefits from higher price–cost margins can thereby be exploited. But this must be done with precision, as costs can also rise disproportionally with growth (e.g. because of an enlarged skilled workforce, inflating the wage bill and more R&D spend), especially if it is rapid.

Reflecting further on our reasoning above, in recognising differences between supply-side and demand-side influences, we observe, for example, that *Copyrights* have different signs on their coefficients in the supply side (−0.004) and demand side (+1.43) (Table 2, Columns I and II, Line 8) and yet are each highly significant ($p < 0.01$). This confirms a synergistic relationship that is observed between adopting copyrights and trademarks. Studies such as Greenhalgh et al. (2003), Loundes and Rogers (2003) and Amara et al. (2008) and Power and Reid (2021a) explore such substitution and complementary interactions between IP types.

Continuing our demand-side analysis, we see that *Patents* are not key drivers of trademarks (Table 2, Columns I and II, Line 9). This is not surprising given the start-up status of our sampled firms, which typically need several development years to create patentable products (cf. Reid & Smith, 2008). However, for a different type of IP like *Licensing out*, it has a positive impact (+5.76) on the demand for trademarks and is highly significant ($p < 0.01$), which corresponds to findings by the likes of Parr and Smith (2004) and Bei (2019). Under the demand side, the correspondence of copyrights and licensing out being positive and highly significant bears further consideration. Some start-ups are very IP conscious and can trade in markets where multiple IP types are important to the 'hybrid goods' they produce. Consider, for example, automobile supply components that cross over from physical elements (with metal engineering aspects which are patentable), then electronic and software elements that are worthy of both patents or copyrights, and then, finally, to aesthetic elements that may have both design and trademark IP aspects. Flexibility of strategy allows such start-ups to license out several elements of its IP, including copyrights, which would apply to software contained within automotive components. Such strategies are typical of high-performing start-ups (Power & Reid, 2021a).

Parties within the stakeholders on the demand side, like banks, business angels and venture capitalists, would tend to view *Licensing out* favourably. This is because, as an IP type, it is relatively cheap to adopt, in terms of transactions costs, as well as being efficacious too, for example, in terms of its potential for early contribution to the performance of the start-up (Almeida, 2021; Oduro, 2019). Finally, we see that being in a high *Knowledge IS* sector has a coefficient that is positive (+0.558) and highly significant ($p < 0.01$) (see Table 2, Column II, Line 29), which conclusion is supported by the recent work by Belderbos et al. (2020), who suggest that sectors with information intensity attract a relatively stronger investment flow, which often can be associated with the greater adoption of trademarks.

6.3 | Simple probit on trademarks

Finally, for comparison, especially for those more familiar with simple probit estimation, rather than POBP estimation, we consider the results in Table 2, Column III. While not unpicking supply-side and demand-side effects, they are still of value as a kind of 'reduced form' version of the supply and demand model of Table 2, Columns I and II. Generally, the probit does identify significance in a similar way to the supply side and demand side, but obviously the signs can (and should) differ across supply and demand, as they each encapsulate different micro-effects. We see that the simple probit picks up more significant coefficients overall than the POBP. This includes a few coefficients in areas that do not show much significance on either the supply side or the demand side, like *Product*, *Patents*, and various types of outside equity, like *Investment Angels* and *Venture Capitalists*, which all have positive and highly significant coefficients (see Table 2, Column III, Lines 6, 9, 19 and 22, respectively), supporting the abundant fieldwork evidence on the prominence of these forms of equity provision to start-ups, as in the likes of Reid (1996, 1998) and Reid and Smith (2008). In this sense, there is still value in the simple probit results, as they provide some guidance on the *net* effects of supply and demand. We note, for example, the coefficient for the *Construction* sector has a negative coefficient (−0.493), which is highly significant ($p < 0.01$) in the simple probit (see Table 2, Column III, Line 26). Certainly, this *Construction* variable is negative in both the supply (−0.2360) and demand (−0.1330) estimates (see Table 2, Columns I and II, Line 26) but not significant, but the net effect (in the simple probit) is significant, suggesting construction and trademarks do not gel. The reason for this may be that the construction sector exhibits a complex and intricate IP setting, in which trade secrets abound and copyrights (which we do not model as a dependent variable) are the main 'workhorse' in IP terms. However, they often struggle to give effective protection to architectural work, technical drawings, elevations, building information modelling (BIM) and much more, in the construction sector (see Adibar et al., 2020). To reinforce this argument, we note in Table A5 in the Supplementary Appendix (Column III, Line 26) that the elasticity effect of the *Construction* variable on trademarks is statistically insignificant and small (−1.5%). More on elasticities and marginal effects follows.

7 | DISCUSSION OF RESULTS

Here, we summarise and illustrate our key findings, with an eye on what is important in a policy sense. To this end, in Table 3, we present key determinants (denoted simply as an x from the relevant data matrix $\boldsymbol{X}$) of trademark adoption, in the sense of having statistically significant elasticities ($\eta = ey/ex$) and marginal effects ($\partial y/\partial x$). These figures were computed under the joint probability (P) restriction:

$$y = P\,(Trademark\ Supply = 1, Trademark\ Demand = 1).$$

In Table 3, only the variables that had statistically significant *marginal* (Column 2), or *elasticity* (Column 3) values have been retained. The full set of estimates underpinning Table 3 can be found in Table A5 in the Supplementary Appendix. The variables in the reduced presentation of results of Table 3 are of interest for three reasons: first, statistical significance; second, the magnitudes and signs of the associated marginal effects ($\partial y/\partial x$); and third (especially) the absolute magnitudes of their elasticities $\eta = (\partial y/\partial x) \div (y^*/x^*)$, where y^* and x^* denote mean values of the variables y and x, which are used to compute the elasticities. The elasticity value (η) is preferred for interpretation because (unlike the marginal effect) it is a unit-free measure. As econometricians Wonnacott and Wonnacott (1970) once so wisely said, we

TABLE 3 Significant marginal effects and elasticities

Variable (x)	Marginal ∂y/∂x	Elasticity η = ey/ex
1. Size	0.0112*** (0.0041)	0.0791*** (0.0289)
2. Total equity of owners	0.0103* (0.0059)	0.0400* (0.0234)
3. Copyrights	0.0569* (0.0303)	0.1485* (0.0773)
4. Licensing in	0.0991*** (0.0267)	0.0118*** (0.0035)
5. Incorporated	0.0942** (0.0388)	0.1562** (0.0666)
6. Expenditure on R&D	0.0958*** (0.0000)	0.0352*** (0.00956)
7. Competitive advantage	0.1116*** (0.0287)	0.1244*** (0.0348)
8. Knowledge IS	−0.1929** (0.0846)	−0.1329** (0.0598)

Notes: (1) Computed using POBP estimation, subject to the joint probability (P) constraint: y = P (Trademarks Supply = 1, Trademarks Demand = 1). Table A5, note (b), explains the calculation of elasticities in Table 3.

$^*p < 0.1$. $^{**}p < 0.05$. $^{***}p < 0.01$.

should not have interest in 'statistically significant mole-hills'. Therefore, we focus on large (in the absolute value sense of $|\eta|$) and highly statistically significant ($p < 0.01$) elasticities to avoid this. So, what we discover are empirical guidelines on what is important, in the policy sense of offering leverage over: *the decision by owner-managers of start-ups to adopt trademarks*.

We note that the *Size* variable (Table 3, Line 1) ($\partial y/\partial x$) is highly significant, as is its elasticity (η). While its marginal value may seem low at 1% (exact value +0.0112), its elasticity (which is unit-free) is relatively high at 8% (exact value +0.0791). For trademarks, compared to patents, for example, one would in any case expect the former to have lesser magnitudes. That is because patent adoption typically involves a deeper IP investment than trademark adoption. For example, compared to trademarks, patents require greater human and financial resources, which characteristically are only possible at a greater scale of operation. At the very least, the nominal costs of trademarking with the USPTO will be of the order of just $225–$600 per trademark, as contrasted to $900 for do-it-yourself patenting, and much more (e.g. $5,000–10,000) if you use patent lawyers. In each case, the full costs (viz. both for adopting and maintaining the protection IP, as well as meeting the developments costs of generating the IP in the first place) will be much larger. Here, our 8% elasticity does suggest that, for the average start-up in our sample, aiming to 'grow on' the business (e.g. by increasing its headcount), it is an eminently sensible way of proceeding, likely to lead to an increase in the adoption of trademarks. For example, a 20% increase in size would lead to an 1.6% increase in the proclivity to trademark adoption, by the average start-up.

Total equity of owners (Table 3, Line 2) and *Copyrights* (Table 3, Line 3) are just ($p < 0.1$) significant, as regards both marginal effects and elasticities. The elasticity for *Total equity* is not large (4%); but that for *Copyrights* is much larger (15% approximately; more accurately 0.1485). This implies that a 20% increase in copyrights in the average start-up, *ceteris paribus*, should lead to something like a 3% (more accurately 2.97%) increase in its trademark adoption. This is consistent with the known tendence for copyrights and trademarks to be complements (cf. Lee et al., 2017; Ribeiro et al., 2022), rather than substitutes in SME's IP portfolios, (Bei, 2019; Block et al., 2015; De Rassenfosse, 2012). A similar remark can be made of *Licensing in* (cf. Motohashi, 2008; Parr & Smith, 2004), which is highly significant ($p < 0.01$) (see Table 3, Line 4), for both marginal and elasticity measures. This variable has the same complementary IP attributes as *Copyrights*, but smaller quantitative impact, for example, compare 10% for the *Licensing in* elasticity (Table 3, Line 4), as opposed to 15% for the *Copyrights* elasticity (Table 3, Line 3).

Being *Incorporated* (Table 3, Line 5) and incurring *Expenditure on R&D* (Table 3, Line 6) have positive and significant impacts on the probability of trademark adoption, but the R&D variable's elasticity is small (3.5%). The *Incorporated* variable has a positive and highly significant elasticity of 16%. This is the largest elasticity in Table 3. Incorporation is an act of commitment to a business, and with it come several legal obligations that can foster a more capable and alert superintendence of the firm, though incorporation can be a double-edged sword in other aspects (Freedman, 2003). Protection of IP can be a positive motive for incorporation, though others, like efficiency, may be of equivocal merit. While incorporation and the adoption of trademarks may seem to go 'hand in glove', like many economic phenomena, this may not be only because of what the start-up does, but rather—to a degree—to the environment in which it functions: that is, to its 'start-up community'. This is referred to as the quality of the 'entrepreneurial ecosystem' within which start-ups function (cf. Audretsch et al., 2019; Feld & Hathaway, 2022). Whatever the causation, Western economies have led the way in extolling the benefits of incorporation. By imitation, these advantages have been sought elsewhere, and realized to a considerable degree, most notably in China (cf. Li & Yueh, 2011).

By contrast, the *Competitive advantage* variable (Table 3, Line 7) (cf. Andersen et al., 1993) displays a lesser impact on trademarking, with an elasticity of 12% (more precisely +0.1244). Elsewhere in Table 3, one sees few significant variables, barring *Knowledge IS* (Table 3, Line 8) a sectoral variable for high knowledge-intensity business. This sector merits more detailed research examination (cf. Amara et al., 2008). It is significant ($p < 0.05$) and negative and has the highest marginal effect (−0.1929) of all the variables in the model and also has one of the highest elasticities (−0.1329).

8 | CONCLUSION

We have found that it is advantageous to unpick the sources of the supply of and demand for trademarks (cf. Block et al., 2015). In brief, we find that the key determinants of the supply of trademarks are size, copyrights (cf. Adibar et al., 2020), incorporation (cf. Freedman, 2003), R&D spend (cf. Sandner & Block, 2011) and competitive advantage (cf. Andersen et al., 1993), with all of these being positive influences, apart from copyrights. As is the nature of supply, these determinants are all things that are within the control, to a great extent, of the owner-manager of a start-up, their staff and/or internal advisors (cf. Barney, 1996; Galbreath, 2005) for the relevant perspective of the resource-based theory of the firm.

On the demand side, we find that the key determinants of trademarks are copyrights, licensing out (cf. Bei, 2019) and being in a high knowledge-intensive sector. These determinants are largely the province of IP lawyers (cf. Blackett, 1998; De Carvalho, 2019) and other firms, banks, venture capitalists, private equity and business angels (cf. Reid, 1998; Reid & Smith, 2008), all of whom are in the market for providing technical advice before investing, and (perhaps most important) small business incubator advisors (cf. Feld & Hathaway, 2022)—who influence start-ups on matters likes how to protect their IP (cf. Thomä & Bizer, 2013), how to finance their business growth (cf. Reid, 1996) and which industrial sectors to favour for location. Collectively, the above-noted stimulate the demand for IP protection like trademarking.

On the supply side, we see the key determinants of trademarking are, in order of magnitude of elasticity η (from greatest to smallest), competitive advantage (+ 0.1244), size (+ 0.0791) and R&D spend

(+ 0.0352) (cf. Sandner & Block, 2011) and licensing in (cf. Parr & Smith, 2004) (+ 0.0118) (see Table 3, Lines 7, 1, 6 and 4). However, incorporation (see Table 3, Line 5), though of lesser statistical significance (5% rather than 1%), has the highest elasticity of them all (+0.1562). While both the marginal effects ($\partial y/\partial x$) and elasticities (η) above are significant, the elasticities, being a better indicator of impact on trademarking (being measurement-free), are more important, especially in terms of policy. We note that all these determinants are under the control of the entrepreneur and are supply-side effects. Of course, when supply meets demand, there is a mediation of supply with demand, for example, through both the explicit and implicit contracting by the start-up on the supply side with the backers of the business on the demand side (Reid, 1993).

These key determinants discussed above are all positive effects on the supply side. It is worth noting, as a nuance, that the largest elasticity on the supply side ($\eta = 0.1562$, 16% approx.) is for the incorporation variable (see Line 5, Table 3) (Freedman, 2003). This is a strong institutional effect and should be seen as an important part of explaining what determines trademarking. It could be rationalised in several ways. For example, it is important to professional status on the supply side and to incubator advice on the demand side (cf. Wheeler & Sillanpa, 1998).

In terms of policy effectiveness, we have highlighted just four key determinants of trademarking. To recap, they were size, licensing in, expenditure on R&D and competitive advantage. These were expressed as elasticities (see Table 3). These four had the highest leverage, of all highly significant determinants, on the decision within start-ups to adopt trademark. As we have seen, in terms of structural modelling, both supply and demand are important, but the preponderance of influence comes through the supply side, which has more determinants that are significant and quantitatively important, compared to the demand side. Our conclusion can be expressed simply by saying that the start-up firm per se and its owner-manager are the key influences on the trademark adoption decision.

Contained within this paper, several further research puzzles have emerged, going beyond what we first set out to investigate, namely, how to disentangle the demand and supply determinants of trademarks. Unfortunately, there is not enough space to pursue them all here. As regards future work suggested by our research, two are particularly interesting. First, there appear to be interactions between IP types for these start-ups, with some being substitutes and some being complements, and these interactions in start-ups are under-researched. Second, there are potentially interesting new 'innovation stories' to be told, prompted by our evidence on the high importance of R&D spend and competitive advantage for these start-ups and their potentially close relationship between copyrights and licensing out.

ACKNOWLEDGEMENTS

We gratefully acknowledge the excellent research assistance provided on this project by Krisztina Pákozdy. Open access funding provided by IReL.

DATA AVAILABILITY STATEMENT

The datasets generated during and/or analysed during the current study are available from the Kauffman Foundation.

ORCID

Bernadette Power https://orcid.org/0000-0003-0565-6108
Gavin C. Reid https://orcid.org/0000-0002-9446-9760

ENDNOTE

[1] See https://www.uspto.gov and https://www.copyright.gov.

REFERENCES

Adibar, A., Costin, A., & Issa, R. R. A. (2020). Design copyright in architecture, engineering, and construction industry: Review of history, pitfalls, and lessons learned. *Journal of Legal Affairs and Dispute Resolution in Engineering and Construction*, *12*(3), 04520032. https://doi.org/10.1061/%28ASCE%29LA.1943-4170.0000421

Almeida, F. (2021). Open-innovation practices: Diversity in Portuguese SMEs. *Journal of Open Innovation: Technology, Market and Complexity*, *7*(3), 169. https://doi.org/10.3390/joitmc7030169

Amara, N., Landry, R., & Traoré, N. (2008). Managing the protection of innovations in knowledge-intensive business services. *Research Policy*, *37*(9), 1530–1547. https://doi.org/10.1016/j.respol.2008.07.001

Andersen, M. E., Jacobsen, L. R., & Reid, G. C. (1993). *Profiles in small business: A competitive strategy approach*. Routledge.

Arundel, A., & Kabla, I. (1998). What percentage of innovations are patented? Empirical estimates for European firms. *Research Policy*, *27*(2), 127–141. https://doi.org/10.1016/S0048-7333(98)00033-X

Athreye, S., & Fassio, C. (2020). Why do innovators not apply for trademarks? The role of information asymmetries and collaborative innovation. *Industry and Innovation*, *27*(1–2), 134–154. https://doi.org/10.1080/13662716.2019.1616533

Audretsch, D. B., Cunningham, J. A., Kuratko, D. F., Lehmann, E. E., & Menter, M. (2019). Entrepreneurial ecosystems: Economic, technological, and societal impacts. *The Journal of Technology Transfer*, *44*, 313–325. https://doi.org/10.1007/s10961-018-9690-4

Ballou, J., Barton, T., DesRoches, D., Potter, F., Reedy, E. J., Robb, A., Shane, S., & Zhao, Z. (2008). The Kauffman firm survey: Results from the baseline and first follow-up surveys. Available at: https://ssrn.com/abstract=1098173 (accessed 14 July 2020).

Barney, J. B. (1996). The resource-based theory of the firm. *Organization Science*, *7*(5), 469. https://www.jstor.org/stable/2635284. https://doi.org/10.1287/orsc.7.5.469

Bei, X. (2019). Trademarks, specialized complementary assets, and the external sourcing of innovation. *Research Policy*, *48*(9), 103709. https://doi.org/10.1016/j.respol.2018.11.003

Belderbos, R., Lokshin, B., Boone, C., & Jacob, J. (2020). Top management team international diversity and the performance of international R&D. *Global Strategy Journal*, *12*, 108–133. https://doi.org/10.1002/gsj.1395

Beltagi, B. H. (2001). *Econometric analysis of panel data*. Wiley.

Besen, S. M., & Raskind, L. J. (1991). An introduction to the law and economics of intellectual property. *Journal of Economic Perspectives*, *5*(1), 3–27. https://doi.org/10.1257/jep.5.1.3

Blackett, T. (1998). *Trademarks*. Macmillan. https://doi.org/10.1007/978-1-349-14719-9

Block, J. H., Fisch, C. O., Hahn, A., & Sandner, P. G. (2015). Why do SMEs file trademarks? Insights from firms in innovative industries. *Research Policy*, *44*(10), 1915–1930. https://doi.org/10.1016/j.respol.2015.06.007

Chamberlin, E. H. (1933). *The theory of monopolistic competition: A re-orientation of the theory of value*. Harvard University Press.

Cohen, W. M., Nelson, R. R., & Walsh, J. P. (2000). Protecting their intellectual assets: Appropriability conditions and why U.S. manufacturing firms patent (or not). NBER, Working paper No. 7552. https://www.nber.org/papers/w7552

Cowling, M., & Nadeem, S. P. (2020). Entrepreneurial firms: With whom do they compete, and where? *Review of Industrial Organization*, *57*(3), 559–577. https://doi.org/10.1007/s11151-020-09782-y

Daskalakis, N., Jarvis, R., & Schizas, E. (2013). Financing practices and preferences for micro and small firms. *Journal of Small Business and Enterprise Development*, *20*(1), 80–101. https://doi.org/10.1108/14626001311298420

De Carvalho, N. P. (2019). *The TRIPS regime of trademarks and designs* (4th ed.). Kluwer International BV.

De Rassenfosse, G. (2012). How SMEs exploit their intellectual property assets: Evidence from survey data. *Small Business Economics*, *39*(2), 437–452. https://doi.org/10.1007/s11187-010-9313-4

De Vries, G., Pennings, E., Block, J. H., & Fisch, C. (2017). Trademark or patent? The effects of market concentration, customer type and venture capital financing on start-ups initial IP applications. *Industry and Innovation*, *24*(4), 325–345. https://doi.org/10.1080/13662716.2016.1231607

DesRoches, D., Potter, F., Santos, B., Sengmavong, A., & Zheng, Y. (2013). Kauffman firm survey (KFS) seventh follow up methodology report. http://ssrn.com/abstract=2027044, https://doi.org/10.2139/ssrn.2286725

Dhingra, S., & Marrow, J. (2019). Monopolistic competition and optimum product diversity. *Journal of Political Economy*, *127*(1), 196–231. https://doi.org/10.1086/700732

Dimara, E., & Skuras, D. (2003). Adoption of agricultural innovation as a two-stage partial observability process. *Agricultural Economics*, *28*(3), 187–196. https://doi.org/10.1016/S0169-5150(03)00003-3

Economides, N. S. (1988). The economics of trademarks. *Trademark Reporter*, *78*, 523.

Farhat, J., Matusik, S., Robb, A., & Robinson, D. T. (2018). New directions in entrepreneurship research with the Kauffman firm survey. *Small Business Economics*, *50*(3), 521–532. https://doi.org/10.1007/s11187-017-9905-3

Feld, B., & Hathaway, I. (2022). *The start-up community way: Evolving an entrepreneurial ecosystem*. Wiley.

Flikkema, M., De Man, A.-P., & Castaldi, C. (2014). Are trademark counts a valid indicator of innovation? Results of an in-depth study of new Benelux trademarks filed by SMEs. *Industry and Innovation*, *21*(4), 310–331. https://doi.org/10.1080/13662716.2014.934547

Freedman, J. (2003). Limited liability: Large company theory and small firms. *The Modern Law Review*, *63*(3), 317–354. PMID: http://www.jstor.org/stable/1097173

Galbreath, J. (2005). Which resources matter the most to firm success? An exploratory study of resource-based theory. *Technovation*, *25*(9), 979–987. https://doi.org/10.1016/j.technovation.2004.02.008

Gallié, E.-P., & Legros, D. (2012). French firms strategies for protecting their intellectual property. *Research Policy*, *41*(4), 780–794. https://doi.org/10.1016/j.respol.2011.12.008

Greene, W. H. (2018). *Econometric analysis* (8th ed.). Pearson.

Greenhalgh C., Longland M., & Bosworth D. (2003). Trends and distribution of intellectual property: UK and European patents and UK trade and service marks 1986–2000. Working Paper. https://webarchive.nationalarchives.gov.uk/20140603115018/http:/www.ipo.gov.uk/ipresearch-trends.pdf

Greenhalgh, C., & Rogers, M. (2010). *Innovation, intellectual property and economic growth*. Princeton University Press. https://doi.org/10.1515/9781400832231

Greenhalgh, C., & Rogers, M. (2012). Trademarks and performance in services and manufacturing firms: Evidence of Schumpeterian competition through innovation. *The Australian Economic Review*, *45*(1), 50–76. https://doi.org/10.1111/j.1467-8462.2011.00665.x

Guo-Fitoussi, L., Bounfour, A., & Rekik, S. (2019). Intellectual property rights, complementarity and the firms economic performance. *International Journal of Intellectual Property Management*, *9*(2), 136–165. https://doi.org/10.1504/IJIPM.2019.100213

Hall, B., Helmers, C., Rogers, M., & Sena, V. (2014). The choice between formal and informal intellectual property: A review. *Journal of Economic Literature*, *52*(2), 375–423. https://doi.org/10.1257/jel.52.2.375

Hanel, P. (2006). Intellectual property rights business management practices: A survey of the literature. *Technovation*, *26*(8), 895–931. https://doi.org/10.1016/j.technovation.2005.12.001

Helmers, C., & Rogers, M. (2010). Innovation and the survival of new firms in the UK. *Review of Industrial Organization*, *36*(3), 227–248. https://doi.org/10.1007/s11151-010-9247-7

Huang, K.-F., & Cheng, T.-C. (2015). Determinants of firms patenting or not patenting behaviors. *Journal of Engineering and Technology Management*, *36(C)*, 52–77. https://doi.org/10.1016/j.jengtecman.2015.05.003

Jensen, P. H., Webster, E., & Buddelmeyer, H. (2008). Innovation, technological conditions and new firm survival. *The Economic Record*, *84*(267), 434–448. https://doi.org/10.1111/j.1475-4932.2008.00509.x

Kozinski, A. (1993). Trademarks unplugged. *New York University Law Review*, *68*(4), 960–978.

Landes, W. M., & Posner, R. A. (1987). Trademark law: An economic perspective. *Journal of Law and Economics*, *30*, 265–309. https://doi.org/10.1086/467138

Lee, J. M., Joo, S. H., & Kim, Y. (2017). The complementary effect of intellectual property protection mechanisms on product innovation performance. *R&D Management*, *48*(3), 320–330. https://doi.org/10.1111/radm.12296

Leiponen, A., & Byma, J. (2009). If you cannot block, you better run: Small firms, cooperative innovation, and appropriation strategies. *Research Policy*, *38*(9), 1478–1488. https://doi.org/10.1016/j.respol.2009.06.003

Li, X. M., & Yueh, L. Y. (2011). Does incorporation improve firm performance? *Oxford Bulletin of Economics and Statistics*, *73*(6), 753–770. https://doi.org/10.1111/j.1468-0084.2011.00674.x

Loundes, J., & Rogers, M. (2003). The rise of trademarking in Australia in the 1990s. *Melbourne Institute Working Paper Series wp2003n08*. Melbourne Institute of Applied Economic and Social Research, The University of Melbourne.

Lunney, G. (2018). Two-tiered trademarks. *Houston Law Review*, *56*, 295–332. PMID: https://scholarship.law.tamu.edu/facscholar/1348

Lyalkov, S., Carmona, M., Congregado, E., Millán, A., & Millán, J. M. (2020). Trademarks and their association with Kirznerian entrepreneurs. *Industry and Innovation*, *27*(1–2), 155–183. https://doi.org/10.1080/13662716.2019.1586523

Maddala, G. S. (1983). *Limited-dependent and qualitative variables in econometrics*. Cambridge University Press. https://doi.org/10.1017/CBO9780511810176

Meiners, R. E., & Staaf, R. J. (1990). Patents, copyrights, and trademarks: Property or monopoly. *Harvard Journal of Law and Public Policy*, *13*(3), 911–947.

Merrilees, B., Rundle-Thiele, S., & Lye, A. (2011). Marketing capabilities: Antecedents and implications for B2B SME performance. *Industrial Marketing Management*, *40*(3), 368–375. https://doi.org/10.1016/j.indmarman.2010.08.005

Mitchell, R. K., Van Buren, H. J. III, Greenwood, M., & Freeman, R. E. (2015). Stakeholder inclusion and accounting for stakeholders. *Journal of Management Studies*, *52*(7), 851–877. https://doi.org/10.1111/joms.12151

Motohashi, K. (2008). Licensing or not licensing? An empirical analysis of the strategic use of patents by Japanese firms. *Research Policy*, *37*(9), 1548–1555. https://doi.org/10.1016/j.respol.2007.12.014

Oduro, S. (2019). Examining open innovations practices in low-tech SMEs: Insights from an emerging market. *Journal of Science and Technology Policy*, *10*(3), 509–532. https://doi.org/10.1108/JSTPM-03-2019-0036

Parenti, M., Ushchev, P., & Thisse. (2017). Towards a theory of monopolistic competition. *Journal of Economic Theory*, *167*(1), 86–115. https://doi.org/10.1016/j.jet.2016.10.005

Parr, R. L., & Smith, G. V. (2004). *Intellectual property: Licensing and joint venture profit strategies* (3rd ed.). Wiley.

Poirier, D. J. (1980). Partial observability in bivariate probit models. *Journal of Econometrics*, *12*(2), 209–217. https://doi.org/10.1016/0304-4076(80)90007-X

Poirier, D. J. (2014). Identification in multivariate partial observability probit. *International Journal of Mathematical Modelling and Numerical Optimisation*, *5*(1/2), 45–63. https://doi.org/10.1504/IJMMNO.2014.059945

Power, B., & Reid, G. C. (2021a). The impact of intellectual property types on the performance of business start-ups in the United States. *International Small Business Journal*, *39*(4), 312–400. https://doi.org/10.1080/13504851.2021.1980190

Power, B., & Reid, G. C. (2021b). Adopting industrial designs: Further IP protection for USstart-ups? *Applied Economics Letters*. https://doi.org/10.1080/13504851.2021.1980190

Power, B., & Reid, G. C. (2021c). An innovation adoption model of licensing-in for US start-ups. *Economics and Business Letters*, *10*(4), 369–382. https://doi.org/10.17811/ebl.10.4.2021.369-382

Rabe-Hesketh, S., Skrondal, A., & Pickles, A. (2005). Maximum likelihood estimation of limited and discrete dependent variables models with nested random effects. *Journal of Econometrics*, *128*(2), 301–323. https://doi.org/10.1016/j.jeconom.2004.08.017

Reid, G. C. (1987). *Theories of industrial organization*. Basil Blackwell.

Reid, G. C. (1993). *Small business enterprise: An economic analysis*. Routledge.

Reid, G. C. (1996). Fast growing small entrepreneurial firms and their venture capital backers: An applied principal-agent analysis. *Small Business Economics*, *8*(3), 235–248. https://www.jstor.org/stable/40228717

Reid, G. C. (1998). *Venture capital investment: An agency analysis of practice*. Routledge.

Reid, G. C., & Smith, J. A. (2008). *Risk appraisal and venture capital in high technology new ventures*. Routledge.

Ribeiro, L. C., Dos Santon, U. P., & Muzaka, V. (2022). Trademarks as an indicator of innovation: Towards a fuller picture. *Scientometrics*, *127*(1), 481–508. https://doi.org/10.1007/s11192-021-04197-2

Robb, A., & Reedy, E. J. (2011). *An overview of the Kauffman firm survey*. Kauffman Foundation.

Robinson, J. (1933). *The economics of imperfect competition*. Macmillan.

Rogers, M., Helmers, C., & Greenhalgh, C. (2007). An analysis of the characteristics of small and medium enterprises that use intellectual property. Available at: https://webarchive.nationalarchives.gov.uk/20140603115023/, http://www.ipo.gov.uk/ipresearch-characteristics-200710.pdf (accessed 13 July 2022).

Sandner, P. G., & Block, J. (2011). The market value of R&D, patents, and trademarks. *Research Policy*, *40*(7), 969–985. https://doi.org/10.1016/j.respol.2011.04.004

Srinivasan, R., Lilien, G. L., & Rangaswamy, A. (2008). Survival of high-tech firms: The effects of diversity of product–market portfolios, patents, and trademarks. *International Journal of Research in Marketing*, *25*(2), 119–128. https://doi.org/10.1016/j.ijresmar.2007.12.005

Thomä, J., & Bizer, K. (2013). To protect or not to protect? Modes of appropriability in the small enterprise sector. *Research Policy*, *42*(1), 35–49. https://doi.org/10.1016/j.respol.2012.04.019

Ughetto, E., Cowling, M., & Neil, N. (2019). Regional and spatial issues in the financing of small and medium-sized enterprises and new ventures. *Regional Studies*, *53*(5), 617–619, 619. https://doi.org/10.1080/00343404.2019.1601174

Van den Bulte, C., & Lilien, G. L. (2001). Two-stage partial observability models of innovation adoption. Wharton School, University of Pennsylvania, Working Paper (October 9, 2001), pp. 1–47.

Vella, F. (1998). Estimating models with sample selection bias: A survey. *Journal of Human Resources*, *33*(1), 127–169. https://www.jstor.org/stable/146317. https://doi.org/10.2307/146317

Wheeler, D., & Sillanpa, M. (1998). Including the stakeholders: The business case. *Long Range Planning*, *31*(2), 201–210. https://doi.org/10.1016/S0024-6301(98)00004-1

Wonnacott, R. J., & Wonnacott, T. H. (1970). *Econometrics*. Wiley.

Wooldridge, J. M. (2010). *Econometric analysis of cross section and panel data* (2nd ed.). MIT Press.

SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

How to cite this article: Power, B., & Reid, G. C. (2022). Lifting the hood of supply and demand for trademarks of start-ups: Partial observability estimates. *Managerial and Decision Economics*, 1–11. https://doi.org/10.1002/mde.3683