PARTIAL OBSERVABILITY ESTIMATES OF SUPPLY AND DEMAND FOR TRADEMARKS OF START-UPS

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Abstract

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. This is run on a large (N > 13k) representative unbalanced longitudinal panel of surviving start-ups, derived from the Kauffman Foundation start-up dataset (2004-2011) for the USA. Our model is shown to provide a good explanation of supply and demand determinants of trademark adoption, in terms of signs of key variables, and statistical significance. 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. Policy implications are considered, focusing on marginal and elasticity effects.

Keywords: Trademark adoption, business start-ups, intellectual property, supply, and demand.

JEL codes: D01, D22, K11, L21, L26

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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 and 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), Poirier (2014), Greene (2018, Ch. 17). 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 eighty years (at a rate of over 8% growth), Ribeiro et al. (2021), 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.

3. Background

Intellectual property (IP), Parr and Smith (2004), is important to small and medium sized enterprises (SMEs), De Rassenfosse et al. (2012), Power and Reid (2021a). 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 USA, 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 specific intellectual property (IP) type, of which trademarks, Economides (1988), Blackett (1998), 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, see Oduro (2019) who finds open innovation practices common 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. (2021). 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, 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.

2. Intellectual Property 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), and the United States Copyright Office (USPTO). 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. (2019), Lyalkov et al. (2020). This has made trademarks very attractive to SMEs seeking IP protection, Ribeiro e al. (2021).

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 and Raskind, 1991; Landes and Posner, 1987). 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. (2021). SMEs are more likely to engage in trademarking than large firms (Greenhalgh and Rogers, 2010). 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. Arguably they signal quality to venture capital funders and foster partnerships and strategic alliances (Motohashi, 2008; Block et al., 2015). There is much expert evidence to conclude that the effect of trademarks on firm performance, in all its dimensions, is positive cf. (Sandner and Block, 2011; Greenhalgh and Rogers, 2012). Supporting this view, Srinivasan et al. (2008), Jensen et al. (2008) and Helmer et al. (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 maximization of a concave entrepreneurial ordinal utility function, Reid (1987), Power and Reid (2021b, c), with a decision format that involves, first, optimization of the awareness (A) of potential means of securing IP, *cf.* Thomä and Bizer (2013); and second, optimization of the evaluation (E) of the best IP to adopt, *cf.* Van den Bulte and Lilien (2001), Dimara and Skuras (2008). Here, the variables A and E are treated as binary (1, 0), with 1 representing, respectively: (a) for A, achieving awareness of the feasible IP options; and (b) for E, deciding specifically on the adoption of trademarks. A is considered prior to E, which represents the conditional decision mode ($E = 1 \mid A = 1$). 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: $P(Y = 1 \mid Y_{-1} = 0) = P(Y=1 (E = 1 \mid A = 1, Y_{-1} = 0) \times P(A = 1 \mid Y_{-1} = 0)$, 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 the determinants of D and S are linear in form, and a unit standard normal cumulative density function $\Phi(.)$ for the error structure, we can derive maximum likelihood estimators for the following demand and supply functions:

Supply Model: $Y_1 \equiv S = \boldsymbol{X_1\beta_1} + \boldsymbol{X_2\beta_2} + \mu$ (1)

Demand Model: $Y_2 \equiv D = \boldsymbol{X_1\beta_1} + \boldsymbol{X_3\beta_3} + \varepsilon$, (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 regressors $\boldsymbol{X}_i$ is provided in Table A2 of the appendix. The $\boldsymbol{X_2}$ of equation (1) explain the supply of trademarks, reflecting the resource-based theory of the firm (Galbreath, 2005). The $\boldsymbol{X_3}$ of equation (2) explain the demand for trademarks and reflect the inclusive stakeholder theory of business interests (Mitchell et al., 2015). The $\mathbf{X_1}$ explain both the supply and demand.

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 and Reedy (2011), (see Section 5 and Appendix), 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), were applied to all our estimates, using start-up closure data (see Table A2 in 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. 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 from hypothesis testing.

5. Data

The data used in our paper were obtained from the Kauffman Foundation of Kansas City, MO, see Robb and Reedy (2011). They support the longitudinal Kauffman Firm Survey of US start-ups, see DesRoches et al. (2013), Power and Reid (2021a). This dataset applies to the period 2004 to 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, 4,928 start-ups were included. These initial firms were subsequently tracked annually until 2012. Table A1 of the 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, meaning we are dealing with an unbalanced panel. Because of various restrictions on variables (due to exit, non-response etc.), for our estimated models (see Section 6) the sample is an unbalanced panel, with N = 13, 427 start-ups. This sample is known to be a good representation of the population of US start-ups at the times of sampling, see Farhat et al. (2018).

To give a comprehensive statistical picture of our sample of start-ups, key variables, and their definitions, we refer readers to the detailed Table A1, in the Appendix. Alternatively, for a quick aperçu of the data, we refer the reader to the summary of 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, interpolated values can be derived, e.g., 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 in the Appendix) show that, on average, our start-ups are solely owned, incorporated micro-firms (with headcounts of three). They carry little debt or equity (< $5k), *cf.* Reid (2003), and mainly sell services (rather than goods) out of rented property, *cf.* Reid (1993) and Andersen et al. (1993). About a fifth (19%) of them incur R&D expenditure. In orders of magnitude (from the largest, to the least) the extent of adoption of IP types are copyrights, trademarks, and patents, *cf.* Meiners and Staff (1990), Power and Reid (2021a). About 6,700 start-ups in our sample hold trademarks (our dependent variable, y). Licensing-in and licensing-out are comparatively rare (< 10%), with the former (8%) being over twice more prevalent than the latter (3%). Most (59%) of the start-ups think they have a comparative competitive advantage over rivals cf. Andersen et al. (1993). In terms of outside equity, formal arrangements are rare (< 1%), but business angels (3%) and venture capital (2%) do have a presence *cf.* Reid (1996, 1998, 2003), Reid and Smith (2008).

Not shown in Table 1, but available in the Appendix (Table A1), are the following illuminating statistics. Trademark adoption (28%) is much higher than patent adoption (17%), *cf.* De Vries et al. (2017), Power and 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.

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, for comparative purposes, are the more familiar estimates for the simple probit model (Column III). The comparative implications from these are expounded briefly in Section 6.3.

Table 1: Key Statistics

Variables (*x*)	Mean (Standard Error)
Size (FT +PT)- headcount of all full-time and part-time employees	2.94 (6.15)
Product – business sells a product (1, 0)	0.49 (0.50)
Copyrights – count of firm's copyrights	1.49 (0.50)
Patents – count of firm's patents	0.17 (1.99)
Licensing in – intensity of licensing-in, 0-3 scale	0.08 (0.37)
Licensing-out – intensity of licensing-out, 0-3 scale	0.03 (0.19)
Incorporated (1, 0)	0.65 (0.48)
Expenditure on R&D (1, 0)	0.19 (0.39)
Competitive advantage (1, 0)	0.59 (0.49)
Equity - Investment Angels (1, 0)	0.03 (0.17)
Equity - Venture Capitalists (1,0)	0.02 (0.13)
Construction (1, 0)	0.08 (0.27)
Knowledge IS – knowledge intensive services (1, 0)	0.38 0.59)

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	-0.00413*** (0.0015)	1.4290*** (0.2070)	0.00347** (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. Percent of Sales from Business	-	-0.0009 (0.0006)	-0.0001 (0.0006)
18. Percent of Sales from Govt.	-	-0.0026** (0.0013)	-0.0026** (0.0012)

19. Equity - Investment Angels	-	0.2540* (0.1300)	0.3280*** (0.0880)
20. Equity - Companies	-	0.0123 (0.1150)	0.0760 (0.1130)
21. Equity - Govt.	-	0.4140* (0.2350)	0.3020 (0.2230)
22. Equity - Venture Capitalists	-	0.4930* (0.2540)	0.7210*** (0.1790)
23. Nonbank business loans	-	0.0432 (0.1140)	0.0472 (0.1270)
24. Govt. business loans	-	0.0452 (0.1610)	-0.0530 (0.1610)
25. Other business loans	-	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		
34. Wald χ^2 (66 df)	4936.11***		

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

We note first that the overall fit of the POBP model of Table 2 is good, as denoted by the Wald χ^2 statistic (which is highly significant, $p < 0.01$). Further, there are numerous highly significant coefficients on both the Supply side (e.g., *Size*, *Competitive advantage*) and on the Demand side (e.g., *Copyrights*, *Licensing out*). These results offer insightful interpretation, as in Sections 6.1 and 6.2.

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-size, 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 and Kabla, 1998; Cohen et al., 2000). This is also concordant with the findings that the better-resourced and the larger the firm, 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 *Size* on the demand-side (Table 2, column II, line 1). As a micro-firm grows, becoming *Incorporated* (Table 2, column 1, 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 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) supply-side drivers of trademark registration, supporting Guo-Fitoussi et al. (2019) and Leiponen and Byma (2009), who find that firms which spend on R&D have a 30% higher likelihood of registering trademarks. *Copyrights* on the supply-size (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 substitutive effects. This supports the findings 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 on the supply-side. 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 in knowledge intensive services (*Knowledge IS*) (Table 2, column I, line 29) for which there a is a negative (-0.547) and significant ($p < 0.05$) coefficient.

This all suggests that the strength of the supply-side of our model is well represented by our data analysis. It is a strong guide to unambiguous determinants of trademark adoption. As such, it therefore is supportive of other empirical work on trademarks which finds them to be a cheaper, and more effective, formal method of protecting IP, than of 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) which displays one of the merits of this kind of 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 *Size* is highly significant on the supply-side, but 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 supply include the owner-manager of the start-up, who are keen to 'grow on' the firm (e.g., to exploit economics of scale), whereas on the demand-side, the prime concerns of stakeholders, like venture capitalists, is rate of return or profitability, Reid (1998). Such stakeholders are wary of mere growth *per se* (e.g., by increasing headcount, which will - to their way of thinking – simply increase the wage bill) and have more concern for measures of financial performance, especially the rate of return on equity invested in the start-up. Reflecting this reasoning, we observe that the *Copyrights* variables have different signs on their coefficients for both the supply-side (-0.004) and the demand-side (+1.43), (Table 2, columns I and II, line 8,) and are each highly significant ($p < 0.01$). This confirms a synergistic relationship between adopting copyrights and trademarks, as observed in studies such as Greenhalgh et al. (2003), Loundes and Rogers (2003) and Amara et al. (2008).

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 and 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 in the likes of Parr and Smith (2004), and Bei (2019). Parties within the stakeholders on the demand-side, like banks, business angels, and venture capitalists, would tend to view *Licensing out* favorably. This is because, as an IP type, it is relatively cheap to adopt, in terms of transactions costs, as well as being efficacious too e.g., in terms of its potential for early contribution to the performance of the start-up, see Almeida (2021), Oduro (2019). Finally, we see that being in a high *Knowledge IS* sector has a coefficient which 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 of Belderbos et al. (2020), who suggest that information-intense sectors attract a relatively stronger investment flow, which can be associated with the greater adoption of trademarks.

6.3 Simple probit

For comparison, for those more familiar with binary probits, rather than POBP, we consider the results in Table 2, column III. Whilst 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 II 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 microeconomic-effects. We see that the simple probit picks up more significant coefficients overall than POBP. This includes a few coefficients in areas which 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 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, so the net effect is significant, while the individual effects, while negative, are not. The construction sector illustrates a complex and intricate IP setting, where trade secrets abound, and copyrights (which we do not model) are the main work horse in IP terms. They struggle to give effective protection to architectural work, technical drawings, elevations, building information modelling (BIM), and much more, see Adibar et al. (2020). To conclude, we note in Table A5 of the Appendix, that the elasticity effect of the *Construction* variable, is statistically insignificant, and small (-1.5%).

7. Discussion of results

Here, we summarize and illustrate the key findings, with an eye to what is important in a policy sense. To this end, in Table 3 we present key determinants (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, the variables which had statistically insignificant marginal, or elasticity, values have been removed. The full set of such estimates underpinning Table 3 can be found in the large Table A5 of the Appendix to this paper. 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 *(∂y/∂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 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 get provides empirical guidance on what is important, in the policy sense of offering leverage over: *the decision by owner-managers of startups to adopt trademarks.*

Table 3: Significant Marginal Effects and Elasticities

Variables	Trademarks	
	Marginal ∂y/∂x	**Elasticity** η = ey/ex
1. Size	0.0112*** (0.00408)	0.0791*** (0.02888)
2. Total equity of owners	0.0103* (0.0059)	0.0400* (0.02343)
3. Copyrights	0.0569* (0.0303)	0.1485* (0.07725)
4. Licensing in	0.0991*** (0.0267)	0.0118*** (0.00349)
5. Incorporated	0.0942** (0.0388)	0.1562** (0.06662)
6. Expenditure on R&D	0.0958*** (0.0000)	0.0352*** (0.00958)
7. Competitive advantage	0.1116*** (0.02867)	0.1244*** (0.0348)
8. Knowledge IS	-0.1929** (0.08464)	-0.1329** (0.05976)

Notes:

(1) Computed using POBP estimation, subject to the joint probability (P) constraint: y = P (Trademarks Supply = 1, Trademarks Demand = 1).

(2) Table A5, note (b), see Appendix, explains the calculation of elasticities in Table 3.

We note that the *Size* variable (Table 3, line 1) is highly significant, as is its elasticity. Whilst 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 a 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 (Lee et al. 2017; Ribeiro et al. 2022) rather than substitutes in SME's IP portfolios (Bei, 2019; Block et al. 2015; and De Rassenfosse 2012). A similar remark can be made of *Licensing in* which is highly significant ($p < 0.01$), (see Table 3, line 4), for both marginal and elasticity measures, see Motohashi (2008) and Parr et al. (2004). This variable has the same complementary IP attributes as *Copyrights*, but smaller quantitative impact e.g., compare 2% 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 startup does, but rather – to a degree – to the environment in which it functions, that is its 'startup community'. This is now called more grandly the 'entrepreneurial ecosystem' within which startups function, *cf.* Feld and Hathaway (2022) and Audretsch et al. (2019). 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 and Yueh (2011).

By contrast, the *Competitive advantage* variable (Table 3, line 7), cf. Reid 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 business measure merits more detailed research examination *cf.* Amara et al. (2008), as here its estimated coefficient is significant ($p < 0.05$), negative, and has the highest marginal effect (- 0.1929) of all the variables in the model, and it also has one on 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. In brief, the key determinants of the supply of trademarks are size, copyrights, incorporation, R&D spend, and competitive advantage, with all of these being positive, apart from copyrights. As is the nature of supply, these are all things that are within the control, to a great extent, of the owner-manager of a start-up, their staff, and their advisors. On the demand side key determinants of trademarks are copyrights, licensing out, and locating in a high knowledge intensive sector. The latter are largely the province of IP lawyers, the financiers (other firms, banks, venture capitalists, private equity, business angels) that buy their advice before investing, and small business incubator advisors who influence startups on the likes of how to protect their IP, how to finance their business growth, and which industrial sectors to favor.

In terms of policy effectiveness, the elasticities estimates highlight just four determinants as having the highest leverage on the decision within startups to adopt trademark: size, licensing in, expenditure on R&D and competitive advantage. As we have seen, both supply and demand are important, but the preponderance of influence is through the supply side where all these determinants play a significant and quantitively important role. That is, several attributes of the construction of the startup firm itself, mediated by actions of its owner manager, are the key influencers.

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APPENDIX

Table A1 Kauffman Firm Survey

Survey Round	Data Collection	Information Gathered for	Completed Interviews	Survivors to the next survey Round	Non survivors at end of survey round
Baseline survey (Year 0)	July 2005 – July 2006	2004	4,928	4,625	303
First Follow Up (Year 1)	June 2006 – Jan 2007	2005	3,998	4,068	346
Second Follow Up (Year 2)	May – Dec 2007	2006	3,390	3,598	338
Third Follow Up (Year 3)	June – July 2008	2007	2,915	3,203	429
Fourth Follow Up (Year 4)	June – July 2009	2008	2,606	2,811	320
Fifth Follow Up (Year 5)	May – Nov 2010	2009	2,408	2,591	296
Sixth Follow Up (Year 6)	May – Nov 2011	2010	2,126	2,300	295
Seventh Follow Up (Year 7)	May - Dec 2012	2011	2,046	2,046	-

Source: Adapted from DesRoches et al. (2013).

Note: 4928 firms completed the baseline survey which gathered data for the year 2004. When the first follow-up survey occurred only 4625 firms are known to have survived and 303 firms had ceased to trade in the meantime. Of the 4625 surviving start-ups firms 3998 completed interviews in the first follow-up, the difference being survey attrition etc. After the first follow-up 4,068 firms are known to have survived to the second follow up out of the 4,928 firms originally interviewed. A further 346 firms had ceased to trade. In the second follow-up, 3390 surviving start-ups completed interviews. After the second follow-up 3,598 firms are known to have survived to the third follow up; 338 ceased to trade and 2,915 start-ups were interviewed in this third follow-up. This explanation should assist in interpreting the information in Table 1.

Table A2 Full Variable Definitions and Summary Statistics (Panel Estimates)

Variable		Definition	N	Mean	SD	Min	Max
1.	Size	A count of all full-time and part-time employees excluding contract workers and the business owner(s)	24,429	2.9367	6.1482	0	61
2.	Debt	Includes total debt of the owner operators and total debt of the business (bank and non-bank debt sources). It is captured on an ordered scale where 0=$0; 1= less than $500; 2=$501-$1,000; 3=$1,001- $2,000; 4=$2,000-$5,000; 5=$5,001 to $10,000; 6=$10,001 to $25,000; 7=$25,001 to $100,000; 8 =$100,001 to $1,000,000; and 9=greater than $1,000,000.	24,483	2.8857	3.1711	0	9
3.	Team of owners	=1 if a business with more than one owner; = 0 otherwise	24,660	0.3811	0.4856	0	1
4.	Purchased	=1 if the business operates out of premises which the business purchased; = 0 otherwise	24,650	0.0643	0.2453	0	1
5.	Incorporated	=1 if the business is incorporated; = 0 otherwise	24,650	0.6475	0.4777	0	1
6.	Total equity of owners	Includes total equity of the owner operators. It is captured on an ordered scale where 0=$0; 1= less than $500; 2=$501-$1,000; 3=$1,001- $2,000; 4=$2,000-$5,000; 5=$5,001 to $10,000; 6=$10,001 to $25,000; 7=$25,001 to $100,000; 8 =$100,001 to $1,000,000; and 9=greater than $1,000,000.	24,387	2.1494	2.8010	0	9
7.	Service	=1 if a business sells a service; = 0 otherwise	24,570	0.8610	0.3459	0	1
8.	Product	=1 if a business sells a product; = 0 otherwise	24,567	0.4861	0.4998	0	1
9.	PhD	Count of owners with PhD degree	25,542	0.0945	0.3608	0	6
10.	Expenditure on R&D	=1 if the business spent money on research and development of new products and services during calendar; = 0 otherwise.	24,343	0.1890	0.3915	0	1
11.	High tech	=1 if 28 Chemicals and allied products, 35 Industrial machinery and equipment, 36 Electrical and electronic equipment or 38 Instruments and related products; = 0 otherwise	25,542	0.1281	0.3342	0	1
12.	Patents	Count of patents of the business	24,335	0.1717	1.99	0	100
13.	Copyrights	Count of copyrights of the business	24,058	1.4881	12.24	0	250
14.	Licensing out	A measure of the intensity of licensing out patents, trademarks and/or copyrights. =0 if the firm does not engage in licensing out; =1 licensing out one form of legal property rights; =2 licensing out two forms of legal property rights; and =3 licensing out three forms of legal property rights	25,542	0.0252	0.1910	0	3
15.	Licensing in	A measure of the intensity of licensing in patents, trademarks and/or copyrights. =0 if the firm does not engage in licensing in; =1 licensing in one form of legal property rights; =2 licensing in two forms of legal property rights; and =3 licensing in three forms of legal property rights	24,310	0.0822	0.3737	0	3

16.	Competitive Advantage	=1 if the business has a competitive advantage; = 0 otherwise.	24,492	0.5928	0.4913	0	1
17.	Trademark Adoption	=1 registered a trademark; = 0 otherwise.	23,987	0.1346	0.3413	0	1
18.	Patent Adoption	=1 registered a patent adoption; = 0 otherwise.	24,335	0.0402	0.1963	0	1
19.	Construction	=1 Construction; = 0 otherwise.	25,513	0.0796	0. 2707	0	1
20.	Wholesale & Retail	=1 Wholesale & Retail; = 0 otherwise.	25,513	0.1436	0.3507	0	1
21.	Low Knowledge Intensive services	=1 Low knowledge intensive services; = 0 otherwise.	25,513	0.2383	0.4261	0	1
22.	Knowledge Intensive Services	=1 knowledge intensive services; = 0 otherwise.	25,513	0.3828	0.4861	0	1
23.	Other	= Other sectors; = 0 otherwise	25,513	0.3828	0.4861	0	1
24.	Equity investment by business angels	=1 if a business angel has invested; = 0 otherwise.	16,872	0.0287	0.1671	0	1
25.	Equity investment by venture capitalists	=1 if a venture capitalist has invested; = 0 otherwise.	16,844	0.0163	0.1267	0	1
26.	Equity investment by government	=1 if the government has invested; = 0 otherwise.	16,854	0.0050	0.0704	0	1
27.	Equity investment by businesses (CVC)	=1 if other businesses have invested in the business; = 0 otherwise.	16,860	0.0079	0.0885	0	1
28.	Non-bank loans	=1 obtained finance from non-bank; = 0 otherwise.	24,322	0.0150	0.1217	0	1
29.	Government business loans	=1 has a government business loan; = 0 otherwise.	24,277	0.0055	0.0741	0	1
30.	Business loans from other businesses	=1 has a business loan from other business; = 0 otherwise.	24,304	0.0037	0.0604	0	1
31.	Percentage of sales to other businesses	Percentage of sales to other businesses	21,832	46.23	42.58	0	100
32.	Percentage of sales to government	Percentage of sales to government	21,823	7.10	20.86	0	100

Table A3: Survival Equation Estimates for the Panel Sample Selection Correction

VARIABLES	(I) 2004	(II) 2005	(III) 2006	(IV) 2007	(V) 2008	(VI) 2009	(VII) 2010	(VIII) 2011
Incorporated	0.0935	0.0665	-0.0646	-0.0010	0.0452	0.0338	0.0719	0.0494
	(0.0657)	(0.0732)	(0.0822)	(0.0919)	(0.0937)	(0.0937)	(0.0949)	(0.0307)
Purchased	0.104	0.0527	0.0897	0.182	0.318	0.0643	-0.0247	0.108*
	(0.154)	(0.143)	(0.156)	(0.184)	(0.194)	(0.170)	(0.173)	(0.0611)
Team of owners	0.105	-0.00260	0.164**	-0.00856	0.0425	0.107	0.134	0.0645**
	(0.0685)	(0.0725)	(0.0824)	(0.0932)	(0.0984)	(0.0953)	(0.103)	(0.0316)
Debt	0.0163	0.0065	0.0086	0.0080	-0.0051	0.0355**	0.0349**	0.0111**
	(0.0101)	(0.0106)	(0.0117)	(0.0129)	(0.0130)	(0.0145)	(0.0150)	(0.0045)
Size	0.0199**	0.0235**	0.0106	0.0263**	0.00418	0.00817	0.0113	0.0153***
	(0.0101)	(0.0092)	(0.0089)	(0.0108)	(0.0086)	(0.0108)	(0.0098)	(0.0036)
Competitive Advantage	0.0790	0.245***	0.181**	0.216***	0.243***	0.317***	0.131	0.157***
	(0.0608)	(0.0653)	(0.0735)	(0.0798)	(0.0815)	(0.0846)	(0.0835)	(0.0270)
Service	0.212**	0.253***	0.0652	0.00694	-0.124	0.0820	0.350***	0.132***
	(0.0888)	(0.0937)	(0.109)	(0.128)	(0.128)	(0.136)	(0.126)	(0.0414)
Product	0.0618	-0.0207	-0.0508	-0.0832	-0.0972	0.00270	-0.0774	-0.0291
	(0.0713)	(0.0729)	(0.0858)	(0.0936)	(0.0983)	(0.0975)	(0.101)	(0.0322)
High-tech	-0.0452	0.0849	0.124	-0.0864	0.274*	0.200	-0.0594	0.0499
	(0.0930)	(0.106)	(0.121)	(0.128)	(0.149)	(0.144)	(0.137)	(0.0445)
Constant	1.235***	1.085***	1.458***	1.616***	1.627***	1.485***	1.223***	1.409***
	(0.147)	(0.155)	(0.183)	(0.212)	(0.202)	(0.219)	(0.217)	(0.0678)
Observations	4,724	3,896	3,272	2,703	2,571	2,371	2,099	23,658
χ^2	37.74	51.14	26.95	30.56	35.33	39.96	35.85	152.85
Prob > χ^2	0.0027	0.0000	0.0420	0.0226	0.0056	0.0013	0.0048	0.0163

Note: Robust standard errors in parentheses; Significance: *** p < 0.01, ** p < 0.05, * p<0.1; Sectoral and regional dummies were included in the estimation; The tabled estimates were used to calculate Mills ratios for the panel sample selection adjustment of estimates of eq. (3) and eq (4) in line with Wooldridge (1995) and Vella (1998).

Table A4: Sensitivity Analysis to Exclusion Restrictions

	Original estimates as per Table 2		Sensitivity Analysis of Tested Variables		
Variables Tested	Supply Equation (I)	Demand Equation (II)	Dropped from demand & Added to Supply Equation (III)	Dropped from Supply and Added to Demand Equation (IV)	Added to Both Demand and Supply Equations (V)
Variables in the Demand and Supply Equations					
Size	0.0295***	-0.0097	-0.0197***	0.111***	-
Debt	0.0209	-0.0064	0.015**	0.012**	-
Team of owners	-0.1700	0.2070*	-0.0632	0.016	-
Equity	0.0266	-0.0038	0.0232***	0.018***	-
Provide a service	0.0379	-0.4050*	-0.2990***	-.2711***	-
Provide a product	0.0327	0.1300	0.1485***	Not concave	-
High tech	0.0507	-0.0301	0.0227	0.0157	-
Copyrights	- 0.0041***	1.4290***	1.633***	Not concave	-
Patents	-0.0106	0.2880	concave	0.2326	-
Variables in the Supply Equation Only					
Competitive advantage	0.2840***	-	-	0.223***	0.151 [S]; 0.165 [D]
Purchased	-0.0632			0.111	-0.0721 [S]; 0.131[D]
Incorporated	0.2380***	-	-	0.1787**	0.2677*** [S]; -0.6334 [D]
PhD	0.0312	-	-	0.0942	-0.2955*** [S]; 0.4745*** [D]
R&D	0.2490***	-	-	0.2006***	0.0452 [S]; 0.1593 [D]
Licensing-in	0.261**	-	-	Not concave	0.4558*** [S]; -0.1399 [D]
Variables in the Demand Equation Only					
Licensing-out	-	5.7580***	6.1298***	-	0.2578** [S]; 5.6507*** [D]
Percentage of sales to other businesses	-	-0.0009	-0.0004	-	0.0035** [S]; -0.0042**[D]
Percentage of sales to government	-	-0.0026**	-0.003**	-	-0.004 [S]; 0.0012 [D]
Equity investment by business angels	-	0.2540*	0.2743**	-	0.2223 [S]; 0.0646 [D]
Equity investment by businesses (CVC)	-	0.0123	0.0498	-	0.1557[S]; -01117
Equity investment by government	-	0.4140*	0.3818	-	-0.1021[S]; 0.5024 [D]
Equity investment by venture capitalists	-	0.4930*	0.8747**	-	1.042[S]; -0.1476 [D]
Nonbank business loans	-	0.0432	0.0418	-	-0.0103[S]; 0.0515 [D]
Government business loans	-	0.0452	0.0123	-	-0.9312**[S]; 0.8549 [D]

Business loans from other businesses	-	0.1260	0.0032	-	-0.9933[S]; 1.3951 [D]

Note: Just the coefficients and their significance are presented here for the variable being tested in each new estimation referred to in columns III to V. For each variable two sets of new estimates were run depending on their role in the original estimates presented in Columns I-II. For example, Size appears in both the demand and supply equations in Table 2 so here we test what happens to its coefficient and significance (and the other coefficients and their significance though not presented here) if (1) it is dropped from the demand equation and added to the supply (Column III) and if (2) it is dropped from the supply equation and added to the supply (Column III). A similar approach was taken for all the other variables in the estimation. In general, these results support our classification of variables as being of supply, demand, or both, as in the estimates in Table 2, Columns I and II.

Table A5: Marginal Effects and Elasticities for Trademarks

Variables	II Marginals ∂y/∂x	III Elasticities η = ey/ex
1. Size	0.0112*** (0.0041)	0.0791*** (0.0289)
2. Debt	0.0079 (0.0057)	0.0477 (0.03421)
3. Team of Owners	-0.0577 (0.0426)	-0.0574 (0.0426)
4. Total equity of owners	0.0103* (0.0059)	0.0400* (0.0234)
5. Service	0.0026 (0.0754)	-0.0027 (0.1108)
6. Product	0.0182 (0.0494)	0.0159 (0.0437)
7. High tech	0.0185 (0.0477)	0.0049 (0.0126)
8. Patents	0.0076 (0.0124)	0.0024 (0.0038)
9. Copyrights	0.0569* (0.0303)	0.1485* (0.0773)
10. Licensing in	0.0991*** (0.0267)	0.0118*** (0.0035)
11. Licensing out	0.0223 (0.0161)	0.0091 (0.00582)
12. Purchased	-0.0249 (0.0332)	-0.0034 (0.0045)
13. Incorporated	0.0942** (0.0388)	0.1562** (0.0666)
14. PhD	0.0122 (0.0349)	0.0024 (0.0068)
15. Expenditure on R&D	0.0958*** (0.0000)	0.0352*** (0.0096)
16. Competitive advantage	0.1116*** (0.0287)	0.1244*** (0.0348)
17. Percentage of sales to other businesses	0.0000 (0.00003)	-0.0032 (0.0030)
18. Percentage of sales to government	-0.0001 (0.0001)	-0.0015 (0.0012)

19. Equity investment by business angels	0.0081 (0.0062)	0.0004 (0.0004)
20. Equity investment by businesses (CVC)	0.0005 (0.0046)	0.0000 (0.0001)
21. Equity investment by government	0.0110 (0.0086)	0.0001 (0.0001)
22. Equity investment by venture capitalists	0.0122 (0.0090)	0.0002 (0.0002)
23. Nonbank business loans	0.0017 (0.0044)	0.0001 (0.0002)
24. Government business loans	0.0018 (0.0060)	0.0000 (0.0001)
25. Business loans from other businesses	0.0045 (0.0074)	0.0000 (0.0001)
26. Construction	-0.0997 (0.1719)	-0.0145 (0.0258)
27. Wholesale Retail	-0.0868 (0.1047)	-0.0219 (0.0262)
28. Low Knowledge IS	-0.0769 (0.1210)	-0.0286 (0.0448)
29. Knowledge IS	-0.1929** (0.0846)	-0.1329** (0.0598)
30. Other	-0.2429 (0.1716)	-0.0041 (0.1204)
31. Mills Ratio	-0.4604 (0.5557)	0.0091 (0.0058)

Significance: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Notes:
(a) Table A5 was computed using POBP estimation, subject to the probability (P) constraints: y = P (Trademarks Supply = 1, Trademarks Demand = 1).

(b) For an elasticity (ey/ex), as in the top label of column three of Table A5, we have ey = $\delta y/y$ and ex = $\delta x/x$ for small increments (δ) of x and y. Thus, the elasticity can be expressed as $(\delta y/y) \div (\delta x/x)$, that is, the proportional effect of a small change (δx) in a determinant (x) of trademarks (e.g., like equity) on a small change (δy) in the probability (y) of trademarking. For computing purposes, we can express the elasticity as $(\partial y/\partial x) \div (y^*/x^*)$ where the numerator is expressed as a partial derivative in the limit when $\delta x \rightarrow 0$, and where the asterisks denote mean values of y and x.