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FINANCING OF TECHNOLOGY-INTENSIVE SMALL BUSINESSES: Some Evidence on the Uniqueness of the ICT Industry*

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ABSTRACT: Using recently collected data on Finnish small businesses, we provide evidence that the debt capacity of growth options, defined as the amount of debt that firms optimally raise for an incremental project, is negative, especially in the information and communications technology (ICT) sector. We relate the finding to the R&D projects that small ICT firms pursue. This may explain why the recent ICT 'revolution' relied more on equity than on debt. We run a battery of robustness tests, such as estimating robust regressions, addressing reverse causality and developing a sample selection model for the capital structure choice, to illustrate the robustness of our findings.

KEYWORDS: Corporate finance, capital structure, ICT, R&D, growth options.

JEL: E50, G21, G24, G32

HYYTINEN, Ari – **PAJARINEN**, Mika. **PIENTEN TEKNOLOGIA–INTENSIIVISTEN YRITYSTEN RAHOITUSRAKENNE: TULOKSIA ICT–SEKTORIN ERIKOISPIIRTEISTÄ.** Helsinki: ETLA, Elinkeinoelämän Tutkimuslaitos, The Research Institute of the Finnish Economy, 2002, 22 s. Keskusteluaiheita, Discussion Papers, ISSN 0781-6847; No. 813.

TIIVISTELMÄ: Tutkimuksessa analysoidaan pienten ja keskisuurten yritysten kasvuoptioiden velkakapasiteettia yritystason kyselyaineiston avulla. Keskeinen tulos on, että kasvuoptioiden velkakapasiteetti, määriteltynä velan määränä, joka yrityksen on optimaalista ottaa potentiaaliselle kasvuprojektille, on negatiivinen etenkin ICT-sektorilla. Osoitamme, että tämä tulos liittyy pienten ICT-yritysten T&K-toimintaan. Tulos voi selittää sen, miksi viime vuosien voimakas kasvu ICT-sektorilla on tukeutunut enemmän osake- kuin velkarahoitukseen. Tutkimuksen tulosten vahvuutta testataan erilaisilla ekonometrisilla menetelmillä; ne tukevat tutkimuksen keskeisiä tuloksia.

AVAINSANAT: Yritysrahoitus, pääomarakenne, ICT, T&K, kasvuoptiot.

Table of Contents

1 INTRODUCTION........1

2 THEORETICAL CONSIDERATIONS........2

2.1 THEORIES OF CAPITAL STRUCTURE........2

2.2 GROWTH OPTIONS, R&D AND THE FINANCING OF TECHNOLOGY-INTENSIVE SMALL BUSINESSES........3

2.3 WHAT'S DIFFERENT ABOUT ICT FIRMS?........4

3 EMPIRICAL ANALYSIS........5

3.1 THE DATA........5

3.2 DESCRIPTIVE STATISTICS AND UNIVARIATE ANALYSIS........7

3.3 REGRESSION RESULTS........9

3.4 ROBUSTNESS........12

4 CONCLUSIONS AND IMPLICATIONS........17

REFERENCES........19

1 Introduction

The rapid technological advance, especially in the information and communications technology (ICT), that began in the early 1980s and the coincident adoption of new technologies brought to light new growth opportunities and favored *de novo* entry (see for example Hobijn and Jovanovic 2001). Like to the periods of rapid technological advance in the past, a financial boom and bust was integral to the growth of the ICT sector. A quick look at the bygone headlines of financial press suggests that the ICT 'revolution' relied more on equity than on debt and that the financial boom of the late 1990s was characterized by raising stock prices, wave of initial public offerings (IPOs) and growth of venture capital.

Unlike on large listed firms and recently floated IPO-firms, there is relatively little information available on the financing of privately held, technology-intensive small business, or, if you will, small 'new economy firms'. Mayer (2002) has recently concluded that a distinguishing characteristic of the financing of technology-intensive firms is their evolving pattern of control by different investor groups. In light of the recent ICT 'revolution' and the coincident financial boom, several unanswered questions however remain: Is equity finance as important for ICT firms as the anecdotal evidence from the stock and venture capital markets suggest? What are the critical factors in setting the leverage ratio of a small technology-intensive business? Are they different for an ICT firm? In this paper, we approach these questions by empirically examining the capital structure of small technology-intensive businesses in Finland, a country with significant recent track record in competitiveness (WEF 2001, IMD 2001), innovativeness (Trajtenberg 2000) and developing ICT technology (Koski, Rouvinen and Ylä-Anttila 2002).[1]

The received finance literature suggests that the nature of a firm's assets is a primary determinant of its leverage ratio: there is an inverse relationship between firms' 'growth options' and leverage (see, e.g., Bradley, Jarell and Kim 1984, Smith and Watts 1992, Barclay, Morellec and Smith 1995, Rajan and Zingales 1995, Barclay, Morellec and Smith 2001). The inverse relationship suggests that the debt capacity of an asset, i.e., the amount of debt that a firm optimally raises for an incremental venture, may be less for growth options than for 'assets in place' (see Barclay, Morellec and Smith 2001). Because more growth options both increase the under-investment costs of debt (Myers 1977) and reduce the benefits of debt in limiting the scope for over-investment and 'empire building' (Jensen 1986, Stulz 1990), the debt capacity of growth options may even be negative (Barclay, Morellec and Smith 2001).

The studies listed above have almost solely analyzed large listed firms (mostly with US data) and used the ratio of debt to the market value of a firm's assets as a proxy for leverage and the market-to-book ratio as a proxy for growth options. Because no market values are available for privately held small businesses, this study employs other proxies. The proxies are based on unique recently collected data on privately held Finnish small businesses. The data provide us with information on firms' capital structure and characteristics beyond what financial statements reveal. Specifically, we estimate our book-leverage regressions using the ratio of R&D to sales,

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1 See also Appendix 1 where a snapshot of the recent developments in the Finnish economy is provided.

lagged one period, as a primary proxy for growth options.[2] Besides the ratio of R&D to sales, we include other proxies for growth options, such as variables describing firms' past innovativeness and entrepreneurs' own estimates for future growth. We also have controls for firms' ownership structure, corporate governance and market structure.

The results of this paper show that ICT firms run conservative leverage ratios, quite like the anecdotal evidence from the stock and venture capital markets suggests. We also find that the critical factors in setting the leverage ratio of a small technology-intensive business are by and large the same as the existing empirical studies suggest (Harris and Raviv 1991): firm size and age, profitability and growth options are the primary determinants. However, our empirical analysis suggests an explanation for the conservative debt ratios of the ICT firms: Growth options generated by R&D have a disproportionately low debt capacity in the ICT sector. This makes a case that the R&D of small ICT firms is 'special'. The findings of this paper may thus explain why the ICT 'revolution' relied more on equity than on debt.

The paper proceeds as follows. In Section 2 we contemplate various capital structure theories and the financing of technology-intensive small businesses. Section 3 describes the data and presents regression results of leverage on proxies of growth options and other 'determinants' of capital structure. In this section, we also run a battery of additional empirical tests to illustrate the robustness of our findings. The robustness tests include estimating robust regressions, addressing reverse causality, and developing a sample selection model for the capital structure choice. Section 5 concludes. In Appendix 1 we present a stylized view of the recent developments in the Finnish economy.

2 Theoretical Considerations

While there is no universal theory of capital structure, at the core of current theoretical explanations are taxes, information costs and agency (contracting) costs (see Harris and Raviv 1991, Barclay and Smith 1999, and Myers 2001). In what follows, we first briefly go through the main arguments of these explanations. We thereafter consider the financing of technology-intensive businesses. We conclude the section by asking what's different, if anything, in setting the leverage ratio for ICT firms.

2.1 Theories of Capital Structure

The tradeoff theory of capital structure considers the balance between the tax advantages of additional debt ('interest tax shield') and the costs of possible financial distress, such as the direct and indirect costs of bankruptcy, that increasing debt would cause. It predicts moderate borrowing by tax-paying firms, i.e., that the most profitable firms borrow the least.

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2 The setup is motivated by the recent study of Barclay, Morellec and Smith (2001) who formally show that if the debt capacity of growth options is negative, also the relation between growth options and book leverage is negative.

The pecking order theory of Myers and Majluf (1984) and Myers (1984) posits that because of informational asymmetry between corporate insiders and outside investors, firms can minimize the costs of financing by preferring internal to external finance and if external finance is required, by issuing debt before equity. If the need for external finance reduces, firms first trim down their use of equity and then use of risky debt so that as a consequence, a firm's debt ratio reflects its cumulative requirement for external finance (see Myers 2001 for further discussion).

The free-cash flow theory of Jensen (1986) focuses on agency problems. It applies best to firms with plenty of (internal) finance available, as debt can reduce inefficient over-investment in firms with plenty of cash but limited investment opportunities (see also Stulz 1990). Conflicts of interest between debt and equity investor are another source of agency costs. Managers operating in the interest of current stock holders may wish to shift to riskier operating strategies (Jensen and Meckling 1976), cut back equity-financed investment in high-risk firms (the under-investment problem of Myers 1977) and conceal emerging problems from creditors (see also Myers 2001). Because these temptations increase the costs of debt as well as the need for complex debt covenants and monitoring by creditors, they provide a good reason to run conservative leverage ratios.

Overall, the received literature supports the view that the nature of a firm's assets can be considered a primary determinant of its leverage ratio. In particular, there seems to be an inverse relationship between firms' growth options and leverage (see, e.g., Bradley, Jarell and Kim 1984, Smith and Watts 1992, Barclay, Morellec and Smith 1995, Rajan and Zingales 1995, Barclay, Morellec and Smith 2001). Because more growth options increase the above-mentioned under-investment costs of debt and reduce the benefits of debt in limiting the scope for over-investment and 'empire building' (Jensen 1986), the debt capacity of growth options may be negative, as formally shown in Barclay, Morellec and Smith (2001).

2.2 Growth Options, R&D and the Financing of Technology-Intensive Small Businesses

R&D is a source of technological improvement and a manifestation of systematic search for inventions and innovations. It is therefore an important determinant of growth options, especially for technology-intensive small business. For example, Garner, Nam and Ottoo (2002) show in their study of the determinants of growth options that the larger the relative R&D investment, the greater the market value of the emerging firm. To the extent that R&D generates growth options for a firm, we expect to it to co-vary negatively with book value of leverage (which, as Barclay, Morellec and Smith 2001 have shown, is an instrument for the ratio of debt to the firm's assets in place).

There are good reasons to consider the possibility that the growth options generated by R&D are special. First, R&D firms may suffer from a number of capital market failures, especially due to asymmetric information. An example of such capital market failures is adverse selection that arises because the insiders of an R&D-intensive firm know more about the likelihood of the firm delivering an innovation than outside investors.

Second, because the exact nature of technological improvements and innovations is ill-defined ex ante, agency costs (and moral hazard) may disproportionately characterize R&D projects. Holmström's (1989) analysis for example suggests that because of the forward-looking, high-risk, labor-intensive and idiosyncratic nature of innovative activities, designing appropriate incentive schemes for R&D activities is difficult. Another related source of agency costs is the incompleteness of R&D contracts (Aghion and Tirole 1994), as it is difficult, if not impossible, to contract for a delivery of a specific innovation.[3]

Finally, technology-intensive small businesses may find it difficult to convey the quality of their ventures to the providers of external finance due to confidential nature of the ventures (Anton and Yao 1994).

To sum up, these considerations suggest that the agency costs of R&D projects are likely to be high. They may therefore have a disproportionate effect on leverage compared to the effects of the growth options generated by other means.

2.3 What's different about ICT firms?

While ICT industries are subject to the same market forces as every other industry, economic theory suggests there are some forces that may be particularly important in determining the capital structure in the ICT sector. We tentatively put forward three such forces:

First, network effects, leading particularly to demand-side economies of scale, characterize some ICT industries. If the positive feedback effects of a network good 'kick in', they increase the under-investment costs of debt and reduce the benefits of debt in limiting the scope for over-investment. However, if no one adopts the network good, it has no value and the risk of failure is high. Moreover, because it may be very difficult to predict the success of telecommunication services in the presence of strong network effects (Schoder 2000), cash flows from R&D investments can be expected to be volatile. These characteristics suggest that equity may be a preferred form of finance for ICT firms with network effects, especially for those investing in R&D.

Second, intermediate ICT good industries, such as software and ICT equipment, where the predominant form of innovation is the development of higher quality products for related industries, appropriability of (non-generic) innovations can be high (Dosi 1988, Martin and Scott 2000). The high appropriability opens up new investment opportunities and thus increases the under-investment costs of debt. It also reduces the benefits of debt in limiting the scope for over-investing in R&D.

Third, in some ICT industries costs of entry are fixed, whereas marginal and 'transportation' costs (degree of product differentiation) are low because of the nature of products, such as 'information goods' and, e.g., chips (Varian 2001). Because of this and because there is evidence that ICT incumbents may adopt aggressive entry deterrence strategies (Koski and Majumbar 2002), there is a high risk that the

3 R&D intensive small businesses may also face more severe appropriability problems than the small firms face on average, as it is sometimes prohibitively costly to obtain intellectual property rights for innovations. Neither are small businesses likely to own complementary assets, such as reputation and existing distribution channels, to enhance the appropriability (see Gans and Stern 2000).

fixed (possibly R&D related) investment cannot be recovered. This implies that use of debt to finance the investment may be infeasible in the first place and that the benefits of debt in limiting the scope for over-investment (in R&D) may be low.

These forces may especially work through the effects that R&D has on the capital structure; if they do, the debt capacity of growth options generated by R&D projects may be disproportionately low in the ICT sector. In the empirical analysis that next follows, we provide evidence for the above conjectures by investigating whether the magnitude of the impact of R&D on leverage is larger for ICT firms.

3 Empirical Analysis

3.1 The Data

Details of Data

The data used in this paper originate from a recent survey administrated by the Research Institute of the Finnish Economy (ETLA) and Etlatieto Ltd between December 2001 and January 2002. The main objective of the survey was to obtain quantitative information on financial structure of Finnish small businesses, particularly those of technology-based small businesses and their ‘innovativeness’. The survey covered firms from most major sectors of the Finnish economy as only farm (agricultural), financial, and real-estate sectors were fully excluded, as were firms that are proprietorships, partnerships, or subsidiaries. A detailed description of the survey and data is presented in Hyytinen and Pajarinen (2002).

The survey resulted in an original sample that consists of 936 firms. For this paper we use a sample of 638 firms. The sample we use here is smaller because some firms in the original sample are not small businesses and because for some firms, key financial items were missing or inconsistent. In addition, we excluded (a small number of) firms from trade, construction and energy sectors, because our primary objective is to study the financing of technology-intensive small businesses.

All financial data are book values. The dependent variable of this study, i.e., book leverage, refers to the latest fiscal year (that for most firms is 2000). To mitigate the potential problems due to endogeneity, all the explanatory variables that are based on the financial statements are, if possible, from the second latest fiscal year. Non-financial explanatory variables refer either to the latest fiscal year or to a fixed period in the past.

Dependent Variable

Our dependent variable, book leverage (LEV), is the ratio of book value of total debt to book value of total debt and equity. Total debt consists of long-term debt and current liabilities, excluding ‘capital loans’.[4]

[4] Capital loans are loans that satisfy the regulations set out in the Finnish Companies Act. Because of their special treatment in the Companies Act, capital loans must in the financial statements be included in the shareholders’ equity.

Explanatory Variables

As summarized in Harris and Ravid (1991), the received literature on capital structure puts forward that leverage is inversely related to growth opportunities, bankruptcy probability, profitability, cash-flow volatility, and uniqueness of the product and directly related to fixed assets, firms size and non-debt tax shields. However, as Zingales (2000) has recently argued, the (theory-of-the-firm) foundations of corporate finance may have fundamentally changed as the nature of firms has changed. For example, firms no longer have clear-cut boundaries, they have become human-capital intensive, and the balance of power within firms has changed: physical assets are not commanding large rents anymore. Because these considerations apply aptly to technology-intensive small businesses, the type of firms we are focusing on, the explanatory variables to include become a matter of conjecture. We therefore use a rich set of firm-level explanatory variables to control for the known and less well-known 'determinants' of leverage in the analysis that follows.

The explanatory variable of most interest is R&D intensity (R&D = the ratio of R&D expenditure to net sales) that is our primary proxy for growth options. We also control in all regressions for firm size (EMP = the number of employees), firm age (AGE = the age of firm in years), profitability (PROFIT = the ratio of profit for the fiscal period to total assets), and for changes in profitability, i.e., 'cash-flow volatility' (PROFITCH = dummy set to 1 if firm's profitability in the last fiscal year was better than the average profitability during the previous three years and to 0 otherwise), for firm industry (ICT = dummy set to 1 if firm's industry code matches with OECD's (2000) classification of ICT industries[5]) and for geographical location of the firm (unreported 14 area / region dummies).[6]

Other explanatory variables include additional proxies for growth options. The proxies are entrepreneurs' own growth expectations (GROWTH = the entrepreneur's estimate for the average annual growth rate of net sales for the next three years), innovativeness (INNOV = dummy set to 1 if firm has innovated its products, production processes, or both during the last three years), patent holdings (PATENT = dummy set to 1 if firm has patents) and nature of its assets (INTANG = dummy set to 1 if the entrepreneur evaluates that his/her firm owns other intangible assets than patents).

We also have a broad set of controls for corporate governance and ownership structures. The controls include CEOAGE (the number of years firm's current CEO has managed the firm), CEOEDUC (dummy set to 1 if firm's CEO has a university degree), AUDIT (dummy set to 1 if firm is audited by one of the internationally recognized 'Big Five' accounting firms), PRINSOWN (dummy set to 1 if firm has a strong principal, i.e. controlling, owner), SHAREAGR (dummy set to 1 if firm's shareholders have a shareholders' agreement), CONCOWN (dummy set to 1 if the total ownership of the three largest shareholders exceeds 50%), FOREOWN (dummy set to 1 if firm has foreign shareholders), BOARDOWN (dummy set to 1 if the total ownership proportion of firm's board members exceeds 50%), BOARD (the number of board mem-

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5 We use this classification throughout the paper.

6 We have also run all our regressions using a full set of industry dummies. The industry dummies were formed on the basis of two-level SIC codes. The qualitative results are not affected by the inclusion of the industry dummies.

bers), BOARDINS (the number of firm's executives and other personnel in the board), and CEOCHAIR (dummy set to 1 if firm's CEO is the chairman of the board).

Finally, we have proxies for the structure of markets that firms face and the nature of production. They include SUBCDEP (dummy set to 1 if more than 1/3 of firm's purchases come from a single supplier), CUSTDEP (dummy set to 1 if one of firm's customers' share of the firm's net sales exceeds 1/3), ONEPROD (dummy set to 1 if a single product account for more than 90% of firm's net sales), EXPORT (dummy set to 1 if firm has exports), GOVSUBS (dummy set to 1 if firm has received subsidies (other than loans or venture capital) from governmental sources.

3.2 Descriptive Statistics and Univariate Analysis

Table 1 gives an overview of the sample: It presents descriptive statistics for the full set of explanatory variables. Firms are relative small and young, as the median firm has 7 employees and is 11 years old. They can also be considered R&D intensive

Table 1 Descriptive Statistics of Explanatory Variables

	Obs	Mean	Median	Std. Dev.	Min	Max
ICT	638	0.34	0	0.47	0	1
R&D	499	0.12	0.01	0.72	0.00	15.00
PROFIT	638	0.12	0.06	0.23	-2.00	2.38
PROFITCH	626	0.52	1	0.50	0	1
EMP	604	16.67	7	26.18	0	230
AGE	637	15.80	11	16.36	0	118
GROWTH	589	0.21	0.10	0.53	0.00	10.00
INNO	636	0.58	1	0.49	0	1
PATENT	637	0.14	0	0.35	0	1
INTANG	635	0.23	0	0.42	0	1
CEOAGE	621	9.28	8	7.05	0	42
CEOEDUC	627	0.31	0	0.46	0	1
AUDIT	635	0.25	0	0.43	0	1
PRINSOWN	638	0.74	1	0.44	0	1
SHAREAGR	625	0.25	0	0.43	0	1
CONCOWN	637	0.95	1	0.21	0	1
FOREOWN	638	0.04	0	0.21	0	1
BOARDOWN	637	0.89	1	0.32	0	1
BOARD	637	2.91	3	1.51	0	12
BOARDINS	637	1.77	2	1.05	0	8
CEOCHAIR	637	0.49	0	0.50	0	1
SUBCDEP	637	0.21	0	0.41	0	1
CUSTDEP	638	0.38	0	0.49	0	1
ONEPROD	635	0.30	0	0.46	0	1
EXPORT	638	0.44	0	0.50	0	1
GOVSUBS	636	0.44	0	0.50	0	1

Note: ICT = dummy set to 1 if firm's industry code matches with OECD's (2000) classification of ICT industries; for the definition of the other variables, see the main text.

(the mean of R&D is 12%), growth-oriented (the median of GROWTH is 10%) and innovative (the means of INNO and PATENT are 58% and 14%). Finally, 34% of the firms are from the ICT sector.

Panel A in Table 2 summarizes LEV for the whole sample and for the following sub-samples: 1) ICT and non-ICT firms 2) high R&D (the ratio of R&D expenditure to sales > 5%) and low R&D firms, 3) high and low R&D firms in the ICT sector 4) high and low R&D firms in the non-ICT sector. Panel B in turn summarizes the results of *t*-tests for the null hypothesis that the differences in means are negligible.

Table 2 Descriptive Statistics of Leverage

Panel A: Summary statistics of leverage

	Obs	Mean	Median	Std. Dev.	Min	Max
Whole sample	638	0.45	0.44	0.31	0.00	1.00
ICT firms	214	0.40	0.36	0.32	0.00	1.00
Other firms	424	0.47	0.47	0.31	0.00	1.00
High R&D firms	146	0.41	0.37	0.31	0.00	1.00
Low R&D firms	353	0.47	0.47	0.31	0.00	1.00
ICT firms						
High R&D firms	92	0.37	0.33	0.31	0.00	1.00
Low R&D firms	84	0.46	0.41	0.33	0.00	1.00
Other firms						
High R&D firms	54	0.48	0.53	0.31	0.00	0.99
Low R&D firms	269	0.47	0.49	0.30	0.00	1.00

Panel B: Summary statistics of *t*-test with H_0: group means are equal

	t-value	*p*-value
ICT vs. other firms	2.39	0.018
High R&D vs. low R&D firms	2.39	0.017
ICT firms: high R&D vs. low R&D	1.93	0.055
Non-ICT firms: high R&D vs. low R&D	-0.30	0.763

Note: ICT = dummy set to 1 if firm's industry code matches with OECD's (2000) classification of ICT industries; high (low) R&D firms are firms for which the ratio of R&D expenditure to sales is higher (smaller) than 5%.

Panel A shows that both the mean and median of leverage are smaller for ICT firms than for their counterparts. The pair-wise comparisons of the means in Panel B indicate that the difference in the means is statistically significant at the 5% level. The result shows that small ICT firms run conservative leverage ratios, confirming what the recent anecdotal evidence on larger firms from the stock and venture capital markets suggests. We find that the same conclusions apply to high R&D firms. However, Panel A depicts that in the ICT sector, high R&D firms are clearly less leveraged than low R&D firms; the *p*-value of the test is low, at 0.055. For non-ICT firms, we find that an opposite result holds, though the difference in the means is not statistically significant. These patterns hint that the conservative leverage ratios of ICT firms may be related to R&D that they pursue.

Table 3 depicts pair-wise correlation between LEV and selected explanatory variables that reflect growth options. Table reveals that LEV is negatively correlated with R&D, GROWTH and ICT dummy. However, only the correlation with ICT is statistically significant. As expected, R&D correlates positively with the other proxies for growth options. ICT dummy correlates positively with GROWTH, INNO and INTANG and a bit surprisingly, negatively with PATENT. The negative correlation may be partly explained by the fact that the current Finnish patenting system does not give protection for software.

Table 3 Selected Correlations

	LEV	R&D	GROWTH	INNO	PATENT	INTANG	ICT
LEV	1.00						
R&D	-0.07 (0.12)	1.00					
GROWTH	-0.03 (0.45)	0.39 (0.00)	1.00				
INNO	0.02 (0.69)	0.08 (0.07)	0.09 (0.02)	1.00			
PATENT	0.03 (0.45)	0.15 (0.00)	0.21 (0.00)	0.23 (0.00)	1.00		
INTANG	0.05 (0.26)	0.11 (0.01)	0.17 (0.00)	0.29 (0.00)	0.30 (0.00)	1.00	
ICT	-0.10 (0.02)	0.05 (0.23)	0.15 (0.00)	0.12 (0.00)	-0.09 (0.03)	0.09 (0.03)	1.00

Note: Pairwise sample correlations, with p-values in parentheses. ICT = dummy set to 1 if firm's industry code matches with OECD's (2000) classification of ICT industries; for the definition of the other variables, see the main text.

The findings so far confirm that the sample firms are technology-intensive and small and that R&D is likely to be related to the growth options that the small technology-intensive businesses have. Moreover, ICT firms seem to run conservative leverage ratios, as we (to some extent) expected.

3.3 Regression Results

The basic regression that we consider takes the form

$$LEV_{i,j,a} = \alpha + \eta_1 \cdot ICT_j + \eta_2 R\&D_{i,j,a} + \eta_3 ICT_j \cdot R\&D_{i,j,a} + \Phi_1 \cdot X_{i,j,a} + \Phi_2 \cdot A_a + \varepsilon_{i,j,a} \qquad (1)$$

where $LEV_{i,j,a}$ is the book leverage of firm *i* in industry *j* in region (area) *a*, ICT_j is the dummy that is set to one if firm *i* is in industry *j* belonging to the ICT sector, $R\&D_{i,j,a}$ is firm *i*'s ratio of R&D expenditures to sales, lagged one period, $X_{i,j,a}$ is a vector of firm-level control variables, A_a is a vector of region dummies, and $\varepsilon_{i,j,a}$ is an error term. The uppercase coefficients (Φ_1 and Φ_2) indicate vectors.

Table 4 reports ordinary least squares (OLS), without and with robust standard errors, and Tobit estimations of model (1) for two different sets of control variables (Panel A and B). The robust OLS standard errors refer to White-corrected standard errors in the presence of heteroscedasticity. The Tobit model corrects for the censoring of the dependent variable at zero, as 15 percent of the firms in the data that have no debt. In Panel A, the vector of control variables only includes EMP, AGE, PROFIT, PROFITCH and the (unreported) 14 area dummies. In Panel B the full vector of control variables is included.

As Panel A of the table shows, the conventional determinants of capital structure (EMP, AGE, PROFIT, PROFITCH) obtain expected signs and statistically significant coefficients. ICT dummy is negative but not significantly different from zero. R&D has a negative effect on the leverage, but the effect is statistically significant at the 5% level only in the second column reporting the t-statistics using robust standard errors. However, the magnitude of the impact of R&D on leverage is larger for ICT firms. The interaction term between R&D and the ICT dummy is negative and statistically significant at the 5% level irrespective of the estimation method. From Panel B we observe that the basic findings do not change when a full set of control variables is included in the model. They reveal, however, that the characteristics of CEO matter for leverage. They also reveal that holdings other things constant, the other proxies for growth options have no effect on leverage.

Table 4 Regression Results – Panel A

PANEL A	Dependent variable: LEV					
	OLS		OLS(Robust)		TOBIT	
	Coeff.	t-stat.	Coeff.	t-stat.	Coeff.	t-stat.
ICT	-6.1E-03	-0.20	-6.1E-03	-0.19	8.1E-04	0.02
R&D	-0.03	-1.40	-0.03	-5.40	-0.03	-1.16
ICT*R&D	-0.13	-2.31	-0.13	-2.36	-0.17	-2.63
PROFIT	-0.36	-6.63	-0.36	-6.17	-0.49	-6.86
PROFITCH	-0.05	-2.01	-0.05	-2.03	-0.06	-2.06
EMP	2.5E-03	4.16	2.5E-03	4.40	2.9E-03	4.31
AGE	-3.0E-03	-3.27	-3.0E-03	-3.31	-3.1E-03	-3.11
Observations	493		493		493	
Log likelihood	-		-		-202.17	
F-stat (Chi^2 for Tobit)	3.69		5.46		97.48	
degrees of freedom	25, 467		25, 467		25	
significance level	0.00		0.00		0.00	
R^2_{adj} (R^2_{pseudo} for Tobit)	0.12		0.12		0.19	

Table 4 Regression Results Continued – Panel B

PANEL B	Dependent variable: LEV					
	OLS		OLS(Robust)		TOBIT	
	Coeff.	t-stat.	Coeff.	t-stat.	Coeff.	t-stat.
ICT	-0.01	-0.34	-0.01	-0.35	-7.8E-04	-0.02
R&D	-0.03	-1.57	-0.03	-3.39	-0.03	-1.38
ICT*R&D	-0.15	-2.39	-0.15	-2.51	-0.18	-2.57
PROFIT	-0.32	-5.22	-0.32	-4.92	-0.43	-5.52
PROFITCH	-0.05	-1.81	-0.05	-1.85	-0.06	-1.92
EMP	2.0E-03	2.80	2.0E-03	2.65	2.4E-03	2.97
AGE	-2.2E-03	-2.01	-2.2E-03	-2.07	-2.4E-03	-2.00
GROWTH	-0.02	-0.45	-0.02	-0.45	-0.04	-0.65
INNO	-3.1E-03	-0.09	-3.1E-03	-0.09	-6.6E-03	-0.18
PATENT	-4.6E-03	-0.09	-4.6E-03	-0.09	-8.4E-03	-0.15
INTANG	0.06	1.41	0.06	1.37	0.07	1.56
CEOAGE	-6.2E-03	-2.42	-6.2E-03	-2.53	-6.7E-03	-2.34
CEOEDUC	-0.07	-2.07	-0.07	-2.06	-0.10	-2.45
AUDIT	0.02	0.46	0.02	0.46	0.03	0.69
PRINSOWN	-7.3E-03	-0.19	-7.3E-03	-0.19	-9.5E-03	-0.22
SHAREAGR	0.08	1.98	0.08	2.03	0.09	2.14
CONCOWN	0.03	0.32	0.03	0.40	0.02	0.22
FOREOWN	0.04	0.49	0.04	0.57	0.05	0.60
BOARDOWN	-0.02	-0.32	-0.02	-0.31	-0.03	-0.43
BOARD	2.5E-03	0.17	2.5E-03	0.18	2.1E-03	0.13
BOARDINS	-1.8E-04	-0.01	-1.8E-04	-0.01	-2.8E-04	-0.01
CEOCHAIR	-1.2E-03	-0.03	-1.2E-03	-0.03	-9.6E-03	-0.25
SUBCDEP	-0.02	-0.44	-0.02	-0.46	-9.6E-03	-0.24
CUSTDEP	0.04	1.35	0.04	1.36	0.05	1.37
ONEPROD	-0.04	-1.25	-0.04	-1.27	-0.06	-1.55
EXPORT	7.2E-03	0.28	7.2E-03	0.29	0.02	0.58
GOVSUBS	0.08	2.40	0.08	2.43	0.10	2.64
Observations	428		428		428	
Log likelihood	-		-		-169.58	
F-stat (Chi^2 for Tobit)	2.50		6.43		118.12	
degrees of freedom	45, 382		45, 382		45	
significance level	0.00		0.00		0.00	
R^2_{adj} (R^2_{pseudo} for Tobit)	0.14		0.14		0.26	

Note: ICT = dummy set to 1 if firm's industry code matches with OECD's (2000) classification of ICT industries; for the definition of the other variables, see the main text. All regressions include 14 regional dummies.

To sum up, the results suggest an explanation for the conservative debt ratios of the ICT firms: the capital structure of ICT firms is special in that when they acquire additional growth options through R&D, the debt level declines. In other words, the evidence is consistent with the hypothesis that the R&D of ICT firms is 'special': It generates growth options that have a disproportionately low debt capacity. The finding may thus explain why the ICT 'revolution' relied more on equity than on debt.

3.4 Robustness

In this section, we run a battery of additional empirical tests to illustrate the robustness of our findings. The robustness tests include estimating robust regressions, addressing reverse causality and developing a sample selection model for the capital structure choice.

Robust Regressions

To eliminate the potential influence of outliers on our results we estimate equation (1) using robust estimation methods (see Rousseeuw and Leroy 1987). We use the

Table 5 Robustness – Robust Regressions

	Dependent variable: LEV					
	Robust Regr. 1		Robust Regr. 2		Robust Regr. 3	
	Coeff.	t-stat.	Coeff.	t-stat.	Coeff.	t-stat.
ICT	-3.5E-03	-0.10	-0.01	-0.28	-0.01	-0.31
R&D	0.12	0.79	0.12	0.77	0.10	0.59
ICT*R&D	-0.28	-1.73	-0.29	-1.74	-0.28	-1.62
PROFIT	-0.38	-6.37	-0.37	-5.90	-0.33	-4.96
PROFITCH	-0.05	-1.77	-0.04	-1.44	-0.05	-1.67
EMP	2.6E-03	3.91	2.6E-03	3.79	2.2E-03	2.72
AGE	-3.1E-03	-3.12	-3.1E-03	-2.99	-2.4E-03	-2.05
GROWTH			0.01	0.22	-0.03	-0.52
INNO			0.03	0.76	4.8E-03	0.14
PATENT			0.01	0.26	-7.0E-03	-0.12
INTANG			0.05	1.36	0.05	1.24
CEOAGE					-6.4E-03	-2.32
CEOEDUC					-0.09	-2.17
AUDIT					0.02	0.46
PRINSOWN					-5.0E-03	-0.12
SHAREAGR					0.08	1.99
CONCOWN					0.02	0.15
FOREOWN					0.04	0.43
BOARDOWN					-0.02	-0.38
BOARD					4.4E-04	0.03
BOARDINS					3.6E-03	0.18
CEOCHAIR					-9.6E-03	-0.25
SUBCDEP					-0.02	-0.51
CUSTDEP					0.04	1.28
ONEPROD					-0.04	-1.22
EXPORT					5.8E-03	0.20
GOVSUBS					0.09	2.40
Observations	492		456		427	
F-statistic	3.37		2.87		2.37	
degrees of freedom	25, 466		29, 426		45, 381	
significance level	0.00		0.00		0.00	

Note: ICT = dummy set to 1 if firm's industry code matches with OECD's (2000) classification of ICT industries; for the definition of the other variables, see the main text. All regressions include 14 regional dummies.

robust methods because we prefer using proper statistical methods to arbitrarily judging what constitutes an outlier.

Table 5 presents the results for the robust regressions, estimated using the same two sets of control variables as before. The table also reports results for a third trimmed vector of control variables which includes GROWTH, INNO, PATENT, INTANG in addition to EMP, AGE, PROFIT, PROFITCH included in the basic vector of control variables and the (unreported) 14 area dummies. The results show that outliers do not drive our primary findings. The coefficient of the interaction term for R&D and the ICT dummy is negative at the 10 percent level. The decrease in statistical significance is explained by a decrease in the accuracy at which the coefficient can be estimated, because the (absolute) value of coefficient seems to increase rather than decrease when compared to the earlier OLS regressions.

Omitted Variables and Reverse Causality

R&D or 'knowledge' spillovers are externalities that flow between two adjacent R&D performing firms. The empirical evidence supports the existence of such spillovers, and they seem to be especially prevalent in high R&D sectors (Griliches 1992, and Geroski 1995). If the debt capacity of growth options generated by R&D is disproportionately negative, also the debt capacity of the growth options generated by R&D spillovers should be negative. The reasoning suggests a simple and powerful test of the special effects of R&D generated growth options on leverage in the ICT sector: Do ICT firms located in R&D intensive regions run disproportionately low debt ratios?

To address the question, we consider the following modification of equation (1):

$$\begin{aligned} LEV_{i,j,a} = {} & \alpha + \eta_1 \cdot ICT_j + \overline{\eta}_2 \cdot (ICT_j \cdot \text{Business sector } R\&D_a) + \\ & + \Phi_1 \cdot X_{i,j,a} + \Phi_2 \cdot A_a + \varepsilon_{i,j,a} \end{aligned} \qquad (2)$$

In equation (2) we have replaced $R\&D_{i,j,a}$ and its interaction with the ICT dummy by a new interaction term. The new interaction term is the product of the ratio of business sector R&D expenditures to sales in region *a* (where firm *i* is located) and the ICT dummy.[7] The specification has the advantage over equation (1) that when estimating the coefficient for the interaction term, we can correct for fixed industry (by means of the ICT dummy) and region characteristics (by means of the area dummies). The specification is therefore less subject criticism about an omitted variables bias (even though it does not allow us to identify first-order effects of R&D on leverage).[8] Moreover, it is highly unlikely that the level of business sector R&D in area *a* is caused by the capital structure choice of firm *i*. Thus, should we find a

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[7] When computed over the 14 regions (that cover the entire Finland), the mean (median) business sector R&D is 1.29% (1.50%). The variable ranges from 0.27% to 2.95%.

[8] See also Rajan and Zingales (1998) and Colin and Mayer (2000) who use a similar specification.

negative coefficient for the new interaction term, reverse causality is unlikely to explain it.

Table 6 reports the regression results obtained using OLS (without and with robust standard errors) and Tobit for model (2). In the estimations the full set of control variables was used. As the table reveals, the interaction term is negative and significant at the 10% level. This implies that ICT firms located in R&D intensive regions run disproportionately low debt ratios, supporting the hypothesis that the debt capacity of growth options generated by R&D is negative especially in the ICT sector.

Table 6 Robustness – Omitted Variables and Reverse Causality

	Dependent variable: LEV					
	OLS		OLS(Robust)		TOBIT	
	Coeff.	t-stat.	Coeff.	t-stat.	Coeff.	t-stat.
ICT	0.05	0.93	0.05	0.91	0.07	1.07
$ICT*R\&D_a$	-6.94	-1.89	-6.94	-1.87	-8.16	-1.98
PROFIT	-0.30	-5.22	-0.30	-4.80	-0.38	-5.35
PROFITCH	-0.04	-1.37	-0.04	-1.36	-0.04	-1.38
EMP	1.8E-03	2.87	1.8E-03	2.88	2.1E-03	3.05
AGE	-1.9E-03	-1.85	-1.9E-03	-2.04	-2.0E-03	-1.79
GROWTH	-0.06	-2.41	-0.06	-3.31	-0.07	-2.43
INNO	-7.4E-04	-0.02	-7.4E-04	-0.02	-7.4E-03	-0.22
PATENT	-0.04	-0.86	-0.04	-0.82	-0.05	-0.95
INTANG	0.05	1.34	0.05	1.28	0.06	1.44
CEOAGE	-4.5E-03	-2.01	-4.5E-03	-2.01	-5.0E-03	-1.97
CEOEDUC	-0.07	-2.18	-0.07	-2.22	-0.09	-2.59
AUDIT	0.02	0.65	0.02	0.66	0.04	0.96
PRINSOWN	0.01	0.40	0.01	0.42	0.02	0.39
SHAREAGR	0.05	1.43	0.05	1.47	0.06	1.53
CONCOWN	0.09	1.12	0.09	1.23	0.08	0.89
FOREOWN	-6.5E-03	-0.09	-6.5E-03	-0.11	-3.2E-03	-0.04
BOARDOWN	-0.01	-0.28	-0.01	-0.27	-0.02	-0.40
BOARD	6.2E-03	0.48	6.2E-03	0.50	7.3E-03	0.50
BOARDINS	9.3E-03	0.58	9.3E-03	0.62	0.01	0.57
CEOCHAIR	-9.2E-03	-0.29	-9.2E-03	-0.28	-0.02	-0.49
SUBCDEP	-0.04	-1.07	-0.04	-1.09	-0.03	-0.87
CUSTDEP	0.03	0.89	0.03	0.90	0.03	0.92
ONEPROD	-0.03	-1.13	-0.03	-1.13	-0.05	-1.39
EXPORT	-5.3E-04	-0.02	-5.3E-04	-0.02	6.2E-03	0.24
GOVSUBS	0.10	3.34	0.10	3.35	0.13	3.69
Observations	516		516		516	
Log likelihood	-		-		-218.81	
F-stat (Chi^2 for Tobit)	2.69		5.53		124.10	
degrees of freedom	44, 471		44, 471		44	
significance level	0.00		0.00		0.00	
R^2_{adj} (R^2_{pseudo} for Tobit)	0.13		0.13		0.22	

Note: ICT = dummy set to 1 if firm's industry code matches with OECD's (2000) classification of ICT industries; for the definition of the other variables, see the main text. All regressions include 14 regional dummies.

Sample Selection

As a final robustness check, we develop a sample selection model that allows for the possibility that the probability of a firm having a positive amount of debt and the amount of the debt conditional of having debt both depend on growth options, but in opposite directions. There are two rationales to consider such a model. First, it is a means to check whether the difference between levered and un-levered (all-equity) firms is driving our results. The model of Barclay, Morellec and Smith (2001) suggest for example that there is a threshold amount of investment opportunities beyond which the optimal (value maximizing) level of debt is zero. Their comparative statistics results and especially the result that book leverage decreases with growth options are therefore conditional, i.e., they apply best to firms with a positive amount of debt. Second, R&D could correlate *positively* with the probability of a firm having a positive amount of debt because the need to finance R&D projects may increase the overall demand for external finance. However, if the debt capacity of R&D generated growth options is negative, the amount of debt conditional of having debt should depend negatively on R&D.

Because the two effects are interdependent, we cannot simply use a Probit model for the indicator of whether leverage is positive or not and a truncated regression model for the non-limit observations. We must therefore consider a sample selection model. To this end, let $LEV^*_{i,j,a}$ denote the value of running a positive debt ratio for firm *i*, given its access to capital markets. The complete set of values of $LEV^*_{i,j,a}$ is not observed, only whether leverage is positive or not. This is captured by the indicator variable:

$$I_{i,j,a} = \begin{cases} 1 & if\ LEV^*_{i,j,a} > 0 \\ 0 & if\ LEV^*_{i,j,a} \le 0 \end{cases} \tag{3}$$

We parameterize the indicator function in

$$\begin{aligned} LEV^*_{i,j,a} = \alpha^* + \eta^*_1 \cdot ICT_j + \eta^*_2 R\&D_{i,j,a} + \eta^*_3 ICT_j \cdot R\&D_{i,j,a} + \\ \Phi^*_1 \cdot X_{i,j,a} + \Phi^*_2 \cdot A_a + \varepsilon^*_{i,j,a} \end{aligned} \tag{4}$$

where $\varepsilon^*_{i,j,a}$ is a normally distributed term. The empirical model for the amount of debt, which is only observed if $I_{i,j,a} = 1$, is

$$\begin{aligned} LEV_{i,j,a|I_{i,j,a}=1} = \alpha^{**} + \eta^{**}_1 \cdot ICT_j + \eta^{**}_2 R\&D_{i,j,a} + \eta^{**}_3 ICT_j \cdot R\&D_{i,j,a} + \\ \Phi^{**}_1 \cdot X_{i,j,a} + \Phi^{**}_2 \cdot A_a + \theta\lambda_{i,j,a} + \varepsilon^{**}_{i,j,a} \end{aligned} \tag{5}$$

where, under the assumption of normality, formula for the selection term, $\lambda_{i,j,a}$, is the usual Mill's ratio in selection models and $\varepsilon^{**}_{i,j,a}$ a normally distributed error term.

Table 7 gives estimates for 'selection' equation (3) as well as for 'debt holdings' equation (5). The first two columns correspond to the specifications reported in the first two columns of Table (5). The third column of the table augments debt holdings equation with a third order polynomial of AGE to capture life-cycle patterns

Table 7 Robustness – Sample Selection Model

PANEL A	Dependent variable: LEV (Estimated with the sample with positive debt)					
	Selection Eq. 1		Selection Eq. 2		Selection Eq. 3	
	Coeff.	z-stat.	Coeff.	z-stat.	Coeff.	z-stat.
ICT	5.9E-03	0.20	-4.4E-03	-0.14	-4.1E-03	-0.13
R&D	-0.04	-2.44	-0.05	-2.55	-0.05	-2.65
ICT*R&D	-0.15	-2.79	-0.16	-2.89	-0.16	-2.91
PROFIT	-0.32	-4.75	-0.32	-4.44	-0.30	-4.25
PROFITCH	-0.05	-1.94	-0.04	-1.44	-0.04	-1.43
EMP	6.3E-04	1.07	6.3E-04	1.06	7.4E-04	1.25
AGE	-2.6E-03	-3.13	-2.5E-03	-3.00	-0.01	-2.98
GROWTH			0.02	0.45	8.1E-03	0.18
INNO			0.02	0.64	0.01	0.44
PATENT			-8.5E-03	-0.19	3.2E-03	0.07
INTANG			0.03	0.82	0.02	0.62
AGE^2					3.0E-04	2.55
AGE^3					-2.0E-06	-2.50
Lambda	-0.13	-2.23	-0.11	-1.89	-0.10	-1.77
Uncensored obs.	418		383		383	

PANEL B	Dependent variable: LEV (Probit estimates for selection model)					
	Selection Eq. 1		Selection Eq. 2		Selection Eq. 3	
	Coeff.	z-stat.	Coeff.	z-stat.	Coeff.	z-stat.
ICT	0.13	0.69	0.16	0.81	0.15	0.75
R&D	2.31	1.64	2.29	1.46	2.24	1.42
ICT*R&D	-2.31	-1.60	-2.28	-1.44	-2.23	-1.40
PROFIT	-1.26	-3.95	-1.21	-3.72	-1.22	-3.73
PROFITCH	-0.22	-1.31	-0.25	-1.44	-0.25	-1.45
EMP	0.08	5.24	0.07	5.00	0.07	4.95
AGE	-0.01	-1.53	-9.9E-03	-1.39	-9.7E-03	-1.33
GROWTH			0.03	0.11	0.03	0.10
INNO			-0.03	-0.18	-0.03	-0.18
PATENT			0.16	0.46	0.15	0.45
INTANG			0.06	0.26	0.06	0.27
Observations	493		457		457	
Log likelihood	-163.65		-155.61		-152.38	
LR test of independence of equations						
Chi^2	3.92		2.99		2.69	
degrees of freedom	1		1		1	
significance level	0.05		0.08		0.10	

Note: ICT = dummy set to 1 if firm's industry code matches with OECD's (2000) classification of ICT industries; for the definition of the other variables, see the main text. All regressions include 14 regional dummies.

in debt holdings (should they exist). The non-linear terms of AGE are excluded from selection equation (3) just to illustrate that the results also hold for an asymmetric pair of equations.[9]

The table shows that while R&D has a positive effect on the probability of a firm having a positive amount of debt, the effect is not statistically significant at the 10% level. For ICT firms, the effect however is negative and statistically significant. We also find that debt holdings are negatively and significantly correlated with R&D and that the effect is disproportionately stronger for ICT firms. Finally, there is a non-linear life-cycle pattern in debt holdings, as the second and third order polynomials of AGE are both significant.

The selection term is negative and significant in the first two columns. This suggests that the two equations are interdependent and implies that unobserved factors that increase the probability of running a positive debt ratio are negatively correlated with the unobserved factors that affect debt holdings. This is consistent with the hypothesis that there are factors that have an effect both on the probability of a firm having a positive amount of debt and on the amount of the debt conditional of having debt, but in opposite directions.

Taken together, the estimated sample selection models provide additional support for the hypothesis that the debt capacity of growth options generated by R&D is negative, especially for ICT firms. The negative correlation between R&D and leverage in the ICT sector is not driven by the difference between levered and un-levered firms.

4 Conclusions and Implications

Received corporate finance literature seems to be converging to the view that firms should use relatively more equity to finance growth options and relatively more debt to finance assets in place. Specifically, because more growth options increase the under-investment costs of debt and reduce the benefits of debt in limiting the scope for over-investment and 'empire building', the debt capacity of growth options may be negative, as formally shown in Barclay, Morellec and Smith (2001).

R&D is a source of technological improvement and a manifestation of systematic search for inventions and innovations. It is therefore an important determinant of growth options, especially for technology-intensive small business on which this study focuses. Because no market values are available for privately held small businesses, this study focuses on the link between R&D and leverage in general and in the ICT sector in particular. While ICT industries are subject to the same market forces as every other industry, economic theory suggests there may be some forces, related to network effects, appropriability of (non-generic) ICT innovations, and the cost structure of certain ICT industries, that are consequential for the debt capacity of

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9 We acknowledge that the identification of the equations in the sample selection model is weak, as we have no a priori reason to exclude some of our explanatory variables from one equation and not to exclude them simultaneously from the other. We have, however, tried various other asymmetric specifications besides the one reported in the table, but they had no effect on the results.

ICT firms' R&D-generated growth options. It is this conjecture on which much of our empirical analysis focuses.

The results of this paper show that ICT firms run conservative leverage ratios. We also find that the critical factors in setting the leverage ratio of a small technology-intensive business are by and large the same as the existing empirical studies suggest (Harris and Raviv 1991): firm size and age, profitability and growth options are the primary determinants. However, our empirical analysis suggests an explanation for the conservative debt ratios of the ICT firms: Growth options generated by R&D have a disproportionately low debt capacity in the ICT sector. This makes a case that the R&D of small ICT firms is 'special'. The findings of this paper may thus explain why the ICT 'revolution' relied more on equity than on debt.

The results of this paper support the conjecture that there may be some forces in the ICT sector that affect the debt capacity of ICT firms' R&D-generated growth options. *Why* the R&D-generated growth options of ICT firms are different is an open question that warrants further research.

The results of this paper also raise a number of interesting implications for the design of public policy measures to support technology-intensive firms. First, greater reliance on equity finance makes R&D intensive small businesses, especially in the ICT sector, more vulnerable to changes in macroeconomic conditions, shifts in venture investors' confidence and the clustering of equity offerings over time. The fortune of equity dependent firms may also be disproportionately sensitive to a non-fundamental component of stock prices (Baker, Stein and Wurgler 2001) and to variations in the cap between the cost of external and internal equity that reflects adverse election problems (Myers and Majluf 1984). Second, because many small firms will at some point of their life-cycle become acquired by large firms, the appropriability of innovations depends on the value of the firm and therefore on the value maximizing capital structure. This in turn suggests that especially in the ICT sector, the appropriability of innovations and hence the incentives to innovate in the first place may be related to the availability of equity finance on the market place.

Finally, substantial sums of government funding are in many countries spent in the form of debt finance and debt-related subsidies, most often to support technology-intensive firms and to alleviate 'debt caps' that these firms are alleged to face in the market for credit. However, because the ICT sector plays a larger role in some countries than in others, the findings of this paper suggest that in countries in which the ICT sector is disproportionately important, the design of public policy measures should perhaps focus more on developing the availability of equity capital than on providing (subsidized) debt finance and debt-related subsidies. This emphasizes the importance of designing effective public venture capital programs and supporting the growth of venture capital and corporate venturing.

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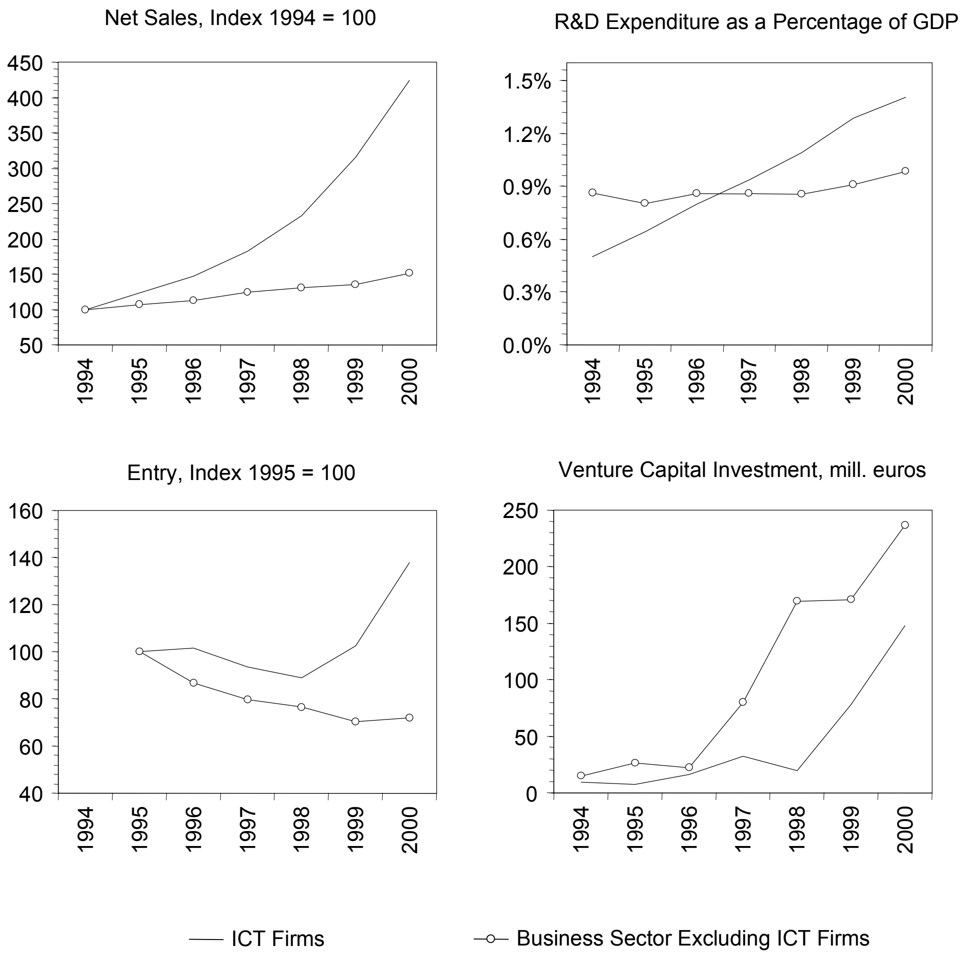
Appendix 1. Recent Developments in the Finnish Economy

Finland's industrial structure has recently undergone a large-scale reform. An integral part to it was the growth of the ICT sector. Simultaneously, the Finnish financial system has undergone a major reorganization. The co-development is potentially important for understanding our empirical results, because there may be a close relation between the types of activities undertaken in different countries and their institutional structures (Carlin and Mayer 2000, Mayer 2002). We therefore provide a snapshot of these recent developments in the Finnish economy in what follows.

Developments in the Finnish ICT Sector

Figure A1 displays recent developments in the Finnish ICT sector in terms of net sales, R&D expenditures, entry by new firms and supply of venture capital. The figure shows that in the 1990s the Finnish ICT sector witnessed remarkable growth both in production and R&D expenditure. Overall, the impact of Nokia, the best-known Finnish ICT corporation, has been quite substantial on these recent developments,

Figure A1 The ICT Sector Compared to the Rest of the Business Sector in Finland in 1994-2000



Sources: European Venture Capital Association's yearbooks, Statistics Denmark, Finland, Iceland, Norway and Sweden (2000), Statistics Finland, calculations by the authors.

including its role in the Finnish innovation system. On the other hand, the figure shows that also *de novo* entry and venture capital investments in the ICT sector grew drastically during the last years of the 1990s.

Compared to many European countries, the production of ICT-related goods and services has in Finland grown relatively rapidly to an industry that is of a significant economy-wide importance. For instance, the shares of ICT sector in total business sector value added, R&D expenditures and exports, were 8%, 51% and 20% in Finland whereas the corresponding shares in the EU were 6%, 24% and 10%, respectively, in the late 1990s (OECD 2000). Furthermore, in an analysis of the clustering of European ICT activities Koski, Rouvinen and Ylä-Anttila (2002) have recently found that there seems to be an intensifying concentration tendency of ICT-related production and R&D and that there are two hubs of European ICT activity. The larger is the one covering the greater London area and Germany's industrial heartland, and ending in northern Italy. The second one is a smaller Nordic hub, covering mainly the Helsinki metropolitan area in Finland and the Stockholm metropolitan area in Sweden.

Developments in the Finnish Financial System

During the past two decades, the Finnish financial system has recently undergone a major reorganization in which a bank-centered financial system shifted from relationship-based debt finance towards increasing dominance by the stock and venture capital markets (Hyytinen, Kuosa and Takalo 2002). Over the same period, shareholder protection has been strengthened whereas creditor protection has been weakened. The changes in creditor protection and the structure of the banking system have mirrored the market developments, most notably the severe banking crisis of the early 1990s that followed the liberalization of financial markets in the 1980s.

Despite the recent growth, both the stock and venture capital markets may lack a degree or two of maturity: The Finnish venture capital industry is at an earlier stage in the venture capital cycle than its European counterparts (Hyytinen and Pajarinen 2001), whereas the Finnish stock market is volatile and rather illiquid even by European standards (except for a handful of the largest firms). It has been argued that the Finnish stock market may provide a sub-optimal exit venue for high-technology firms.

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