Productivity and Financial Structure: Evidence from Indian High-Tech Firms

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Abstract: The paper utilizes data on high-tech Indian firms for 1996-2007 to explain the association between leverage and productivity. Accordingly, firm-level productivity measures are regressed on a set of control variables, which includes leverage among the regressors. The findings suggest that low leveraged firms tend to be more productive, on average. Robustness tests support the results.

JEL Classification: D 24, G 32

I. Introduction

The literature on corporate finance points to an equilibrium relationship between the firm's share of intangible assets and its financial structure. In particular, firms undertaking innovative activities tend to hold a large share of immaterial assets. As a consequence, their capital structure seems to be at distinct variance as compared with less innovative ones. Ultimately, differences in the propensity to innovative are likely to translate into differences in total factor productivity (TFP) levels (Grilliches and Lichtenberg, 1984). Financial systems more capable of providing the type of funding needed by innovative firms should therefore also ensure higher aggregate productivity.

The relationship between a firm's leverage and its share of immaterial assets is not obvious, because many different mechanisms link financial structure to the propensity to innovate. One set of theories suggest that firms holding larger portions of immaterial assets are less likely to be reliant on debt finance (Jensen and Meckling, 1976; Hart, 1995). The alternate line of thinking contends that equity financing is subject to severe underpricing in firms holding more intangibles (Myers and Majluf, 1984), favoring the use of debt over equity financing (i.e., higher leverage).

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The alternate theoretical predictions lend themselves to empirical exploration. In this paper, we rely upon a detailed dataset of a panel of Indian firms to study the relationship between firms' financial structure and their productivity. More specifically, we focus on the electronics industry to understand whether productivity differences matter for firms' financial structure. To avoid the endogenity problems that would otherwise confound the regression of TFP on leverage, we concentrate on exogenously driven variation of the firm's financial structure.

The Indian electronics industry provides an ideal backdrop to explore this issue. For one, the electronics industry has emerged as the fastest growing segment of the industry both in terms of production and exports. The production of the electronics industry grew from less than US $6 billion in 1996 to over US $ 60 billion in 2006-07, registering a compound annual growth of nearly 25% over 11-year period (Government of India, 2008). Even in terms of exports, the compound growth rate over this period has been nearly 34% to US $ 38 billion in 2006-07. The software industry, which was worth less than US $ 1 billion in 1991-92 and accounted for less than 10% of total electronics and IT production, has recorded a turnover of US $ 45 billion in 2006-07, surpassing electronics hardware production. Given that firms in this industry are R&D intensive and the fact that R&D-intensive firms typically opt for particular sources of finance, it remains a moot issue as to the interlinkage between productivity and capital structure for these firms in general and the software firms, in particular.

The reminder of the paper proceeds as follows. In the next section, we present the theoretical and empirical background of our framework, reviewing the major results of the literature related to the present study. Section 3 presents a brief overview of the Indian electronics industry. Section 4 describes the methodology to be applied in the empirical sections. Section 5 discusses data-related issues. Section 6 estimates the coefficients of the production function, from which the firm level productivity measures are calculated. Section 7 studies the determinants of firm productivity, highlighting the role played by leverage in this context. This section also conducts certain robustness checks of the baseline results. The final section highlights policy issues and gathers the concluding remarks.

2. Background and related literature

The present analysis is closely related to that on the firms' financial structure. If the Modigliani Miller theorem holds, then there would be no reason to expect a relationship between a firm's financial structure and its productivity. However, absent perfect competition, which is typically the case in real world, it is possible to discern several channels through which difference in firms' funding sources affect their investment and output decisions (Harris and Raviv, 1991; Shleifer and Vishny, 1997; Myers, 2001). Salient among these relate to bankruptcy costs, agency problems or asset control.

According to the *bankruptcy cost* theories, firms encounter problems in offering collateral to eventual debt lenders, and additionally, cannot attend a rigid payment scheme of their financial obligations, in view of the volatility of their project returns. It is, therefore, not difficult to envisage a low debt equity ratio for these firms.

Theories based on *agency problems* have considered different types of conflict of interests. Harris and Raviv (1990) study the effects of the conflicts between equity holders and managers: given that the latter hold less than full residual claim, they have an incentive to look for personal benefits. To mitigate this problem, equity holders can increase the firm's share of debt, thereby limiting the amount of free cash available to managers. Clearly, it will be easier for managers to divert resources for their personal benefits when they are dealing with more opaque projects, as is typically the case for innovative firms. It this is the case, equity holders should require a higher leverage for such firms.

Another line of thinking, following from the *pecking order hypothesis* (Myers and Majluf, 1984) suggests that for innovative firms, there is likely to be a greater degree of asymmetric information between insiders and outsiders, making it difficult for them to make equity offerings. This needs to be weighed against the fact that innovative firms are likely to generate greater investment opportunities. In such a case, these firms are more likely to be reliant on external finance. Combining this with our earlier argument, it seems that reliance on debt finance for innovative firms is likely to be high.

Finally, since the seminal works of Jensen and Meckling (1976) and Myers (1977), the *conflict of interest* between debt holders and equity holders has also been analyzed. The basic idea is that equity holders, as residual claimants, have an incentive to take on riskier projects than what would be optimal. Because debt holders anticipate this behavior, the value of debt is underpriced, reducing the incentive for equity holders to use it as a source of finance. Clearly, if innovative firms are likely to face riskier investment opportunities, their debt issues should suffer even more from under-pricing, compelling firms to make a larger use of equity financing.

The last class of theories emphasizes the role of *control rights*, building on the work of Aghion and Bolton (1992) and Hart (1995). More specifically, the optimal capital structure of the firm is the outcome of the trade-off between the marginal cost of diluting the control rights by issuing new equities and the marginal cost of debt, in case of default. Since the latter increases with the share of intangibles, these theories predict that innovative firms are less likely to use debt financing.

In sum, the first set of theories – based on bankruptcy costs, conflicts of interests between equity- and debt holders and on control rights - contend that more innovative firms exhibit lower leverage; the other set, based on conflicts of interest between managers and shareholders and between insiders and outsiders, predict the opposite.

The empirical literature on the determinants of capital structure has searched for the effect of a number of firms' characterized on their capital structure. Titman and Wessels (1988) find that firms with higher growth opportunities – as measured by capital expense to total assets, R&D expenses to total sales and the growth rate of total assets – have lower debt financing. Among the other variables that have been found to positively affect the equilibrium share of debt financing are firm size (Smith and Warner, 1979), earnings volatility (Bradley *et al.,* 1984) and the probability of bankruptcy (Castanias, 1983). More recently, Aghion *et al*., (2004) find that firms with no R&D

expenses and with high R&D expenses have a larger share of new equity financing, whereas firms with positive but low R&D expense have a larger share of debt financing. The authors view these results as consistent with theories based on control rights.

3. The Indian electronics industry – An overview

The beginnings of the Indian electronics industry can be traced back to the early 1960s. At that time, the industry concentrated on developing and maintaining fundamental communication systems, such as radio-broadcasting as also telephonic and telegraphic communications. Visualizing the importance of electronics and information technology in the emerging milieu, the Federal Government established the Department of Electronics (DoE) in 1970. The policy of 'self-reliance' practiced around this period led to the establishment of several Federal/ sub-national electronics corporations to promote the development of indigenous technology. Buttressed with important policy announcements, such as the Computer Policy (1984), Electronics Policy (1985) and the Software Policy (1986), these measures laid the foundations for the growth of the electronics and software industry in the country.

The economic reforms ushered in a sea change in the growth trajectory of the electronics industry. In tandem with the Government's policy of liberalization and promote the emergence of an export-oriented electronics industry, the industry was opened to private participation. Accordingly, foreign investment norms were eased, 100% foreign equity was allowed, the threshold limit for American Depository Receipts (ADR)/ Global Depository Receipts (GDR) issues was increased and a slew of important policy initiatives undertaken towards strengthening this segment. Illustratively, the National Task Force on IT and software development was constituted in 1998 with the purpose of formulating a long-term IT policy to leverage the country's potential to become a knowledge economy. In view of the increasing convergence between communications and IT, a Ministry of Communications and IT was constituted in 1999 for focused attention to this sector. Subsequently, the IT Act was enacted in 2000, which provided the basic regulatory framework for the domestic IT industry. The

Communications Convergence Act (2001) envisages a unified regulatory regime to address the convergence of telecom, data communications, internet, satellite, and terrestrial broadcasting, cable television, software and content creation for seamless transition to the new services and information delivery systems. The Bill is awaiting Parliamentary approval.

The electronics sector in India comprises of four components: consumer electronics, computers, communications and broadcasting and other electronics (comprising industrial electronics, strategic electronics and electronic components).[2] The size of the industry is presently of the order of US $25 billion and has been growing at roughly 18% compound average growth rate (CAGR) over the past decade. Out of this, the consumer electronics segment dominates the industry with a share of nearly 35% in 2006; the share of computer and communications are roughly of the order of 18% and 9%, respectively.

Within electronics, a major success story has been the IT industry. In general, IT comprises of hardware and software. Earlier, it was hardware which accounted for the major chunk of IT revenues. Illustratively, in 1990-91, hardware accounted for nearly 50% of total IT revenues, while software's share was just 22%. By 2006-07, the share of hardware declined to less than a fifth, whereas the share of software increased to over 60%. The software industry is worth roughly US $ 20 billion in 2006-07. As Arora (2006) observes, the software industry has gradually moved up the value chain from programming to systems analysis and design: IT-enabled services (ITES)/business and knowledge process outsourcing (BPO/KPO) is presently been the fastest growing segment; within several years of its emergence in 1999-2000, its size grew to US $ 565 million in 1999-2000 to just over US $10 billion in 2006-07. More than 40% of the *Fortune 500* companies utilize the services of Indian enablers; leading companies such as Microsoft, Lucent, AT&T, IBM, British Telecom and British Aerospace have set up R&D

[2] Industrial electronics comprises of products used by other industries such as process control instrumentation, automation systems and medical equipments; strategic electronics covers satellite-based communications, navigation and surveillance, underwater electronics, disaster management and GPS-based vehicle tracking system and finally, electronic components caters to the need of consumer electronics telecom, defense and IT sectors

centers in India (Kagami and Tsuji, 2001). As a result, the role of R&D in fostering productivity improvements has increasingly assumed prominence. The industry has become a destination of choice not only for low-end work like ITES/ BPO, but also high-end development work like application design and implementation, driven by a wide range of enabling factors (Heeks, 1998; Arora *et al.*, 1999; Athreye, 2005). Given the R&D-driven nature of the industry, the impact of capital structure on productivity for such an industry and especially in an emerging economy provides an interesting case study. With several emerging economies undertaking policy initiatives to provide a boost to their high-tech sectors, the findings so obtained could have implications for the association between these important variables in other emerging markets as well.

4. Methodology

The traditional approach employed in productivity measurement is to estimate a production function and subsequently utilize the residuals not explained by the input factors (capital, labor) as a proxy for total factor productivity (Solow residuals). However, as Levinsohn and Petrin (2003) remark, when estimating the production function, one needs to account for the correlation between input levels and productivity, as profit maximizing firms respond to increase in productivity by increasing use of factor inputs. Therefore, methods that ignore this endogeneity such as OLS or the fixed effects estimator inevitably lead to inconsistent estimates of the parameters of the production function.

To address this deficiency, we employ a modification of the semi-parametric approach originally suggested by Olley and Pakes (1996) and subsequently modified by Levinsohn and Petrin (2003). The methodology by Olley and Pakes allows for consistent estimation of the coefficients of a production function, taking into consideration the two possible sources of bias, sample selection bias and a simultaneity bias.[3] The former problem is handled by modeling the exit decision by the firm. The latter, on the other

[3] The selection bias refers to the fact that many firms would have left the market during the sample period. It is, therefore, reasonable to imagine that the unobservable productivity variable and the decision to leave the market are correlated, causing a potential bias. The simultaneity problem is related to the correlation between the unobservable productivity variable and the amount of inputs chosen by the firm.

hand, is solved by inverting an investment function, which is affected by unobserved productivity.

Levinsohn and Petrin (2003) introduced an important improvement in the Olley and Pakes methodology making use of an intermediate input, instead of investment as a proxy variable for productivity. Investment can work as a valid proxy if it does not take zero values, which can be very restrictive conditions for the data sets typically found in emerging economies.

Instead, Levinsohn and Petrin argue that the monotonicity condition required for the inversion of the investment function may not be valid due to capital adjustment costs. The monotonicity condition for investment is then replaced by an equivalent requirement for an intermediate input function. The authors choose electricity as the productivity proxy on account that all firms need such input.

5. Data and sample

The data for the analysis is extracted from *Prowess*, a firm-level database on Indian manufacturing and services entities, generated and maintained by a leading private think-tank in India (Center for Monitoring of Indian Economy, 2007). The companies in the database comprise over three-quarter of the economic activity of the organized industrial sector in India. The database contains information on all companies recognized on recognized stock exchanges as also several Federal public sector enterprises. The database contains detailed information on balance sheet numbers as well as income and expenditure statements of firms. Additionally, it also contains information on share price and other stock market indicators, besides a host of useful financial ratios and values. As it is not a census of manufacturing firms and submission of returns to the data collecting agency is purely voluntary, information for certain firms for several years is missing from the sample. As a result, even though firms that exit and reenter the database are excluded, the exit is not tantamount to the fact that the firm has exited the industry for good. Therefore, we use an unbalanced panel of firms for purposes of estimation. The database contains information on nearly 4500 individual manufacturing companies. Firms are categorized by industry according to the National Industrial Classification (NIC) Code and encompass the entire industrial spectrum of the economy.

From the database, we extract information on all firms in the electronics industry for the period 1996-2007. This provided us with a total of 425 firms. We then delete a number of firms from the sample. First, we delete firms which do not report their year of incorporation and those with less than five years of incorporation, lowering the sample to 414 firms. Next, we delete firms which have been merged with their parent entities, since subsequent to this merger, information on these firms is not reported in the database. We delete 20 such firms from the sample. Finally, we exclude 7 firms which do not report their ownership status. Consequent upon these exclusions, the final sample comprises of 387 firms.

Table 1 provides the sample description. The largest segment, measured by the number of companies, is 'other electronics', 57% of the sample. Firms belonging to computer industry comprise nearly 15% of the sample. We base our analysis on this data and collate information on the relevant variables of interest to our study using this database.

[Table 1: Sample description of high-tech firms]

The empirical section estimates a Cobb-Douglas production function having a measure of output as dependent variable and thee productive inputs as explanatory variables. The inputs are real wages, capital and intermediate inputs. A separate intermediate input is used as a proxy variable for productivity, this follows Levinsohn and Petrin (2003). We take expenditures on electricity as the proxy for unobserved productivity. Since information on number of employees is not reported in the database, the total wages paid by the firm is taken as the proxy for labor.

Following Levinsohn and Petrin (2003), a real capital stock series was constructed using the perpetual inventory capital adjustment method, as given by the expression:

$$K_t = (1-\delta)\, K_{t-1} + deflated\ \ gross\ investment_t \qquad \textbf{(1)}$$

where K_t is the capital stock to be used for each year, gross investment is the change in the firm's undepreciated capital stock since the preceding year, and δ is the rate of depreciation taken at 7.5%, as suggested by Unel (2003). The initial capital stock equals the net book value of capital stock for 1995.

Output is measured as gross sales, consistent with the literature (Ikhsan-Modjo, 2006; Van Beveren, 2007). We also report results for a broader measure of output, defined as the sum of gross sales *plus* other income. Constant values were obtained by scaling all nominal variables by the GDP deflator.

6. Estimation of firm productivity

This section implements the Levinsohn and Petrin (2003) methodology to obtain measures of productivity. In the next section, the firm-level productivity measures so obtained are regressed on several control variables to ascertain their importance for productivity.

The first step of the algorithm involves the estimation of the following partially linear equation:

$$y_{it} = \gamma_o + \gamma_l l_{it} + \gamma_k k_{it} + \gamma_e\, e_{it} + h_t(\, k_{it}) + \varepsilon_{it} \qquad \textbf{(2)}$$

where lower case letters represent natural logarithms; y is firm output, l is labor, e is electricity, k is capital and ε is the random error term. The function $h(.)$ is estimated by means of a polynomial series expansion where terms up to the fourth degree of k_{it} are utilized.

The first step in the estimation allows one to obtain consistent estimates of the variable factor coefficients, γ_i and γ_e. Once these are obtained, we compute the term:

$$y_{it}^P = y_{it} - \hat{\gamma}_l\, l_{it} - \hat{\gamma}_e\, e_{it} \qquad \textbf{(3)}$$

This term is then regressed on a polynomial series in $\{k_{it}\}$. The fitted value from the regression is denoted as $\hat{\psi}_t(k_{it})$.

In the second step, consistent estimates for γ_k and γ_e are obtained through non-linear least squares applied to expression (4) as under:

$$y_{it}^{P} = \gamma_o + \gamma_k k_{it} + g[\hat{\psi}_{t-1}(k_{it-1})] - \gamma_o - \gamma_k k_{it-1}] + \xi_{it} + \eta_{it} \quad \textbf{(4)}$$

where ξ_{it} is the innovation term in productivity.

Table 2 presents the production function coefficients estimated through the Levinsohn-Petrin (L-P) algorithm, alongside the coefficients obtained through OLS methodology. The results are shown for the two measures of output.

[Table 2: Estimation of production function parameters]

The estimated coefficients are observed to be robust to the use of different output measures. The coefficient on labor is negative under the OLS technique, irrespective of the choice of dependent variable. When the L-P method is employed, the coefficient on labor and capital are much more reasonable, although the latter is only weakly significant. In the reminder of the analysis therefore, we employ the coefficients as obtained under the L-P method. The computed total factor productivity measures under the two alterative measures of output are labeled as TFP1 and TFP2, respectively.

As discussed earlier, it is important that monotonicity with respect to productivity holds for intermediate input. If this assumption is violated, it is not possible to invert this function to express productivity as a function of observable variables. To ascertain the validity of this assumption, power/fuel was regressed on productivity and on capital and labor. All estimated coefficients were observed to be positive and significant.

The firm level (natural log of) total factor productivity is computed as the difference between actual and fitted output, according as:

$$\omega_{it} = y_{it} - \hat{\gamma}_l l_{it} - \hat{\gamma}_k k_{it} - \hat{\gamma}_e e_{it} \quad \textbf{(5)}$$

[Table 3. Descriptive statistics for productivity scores]

Table 3 reports the summary statistics for the two measures of total factor productivity according to their status by industry. The productivity values under TFP1 are observed to be higher, with average value of 3.329. In terms of productivity differences across industries, the estimates reveal that productivity estimates are the highest in consumer electronics; computer segment displays the lowest variability.

7. Empirical results

7.1 Baseline specification

This section examines the interlinkage between productivity and financial structure. Different theories of corporate governance have different implications for the equilibrium relationship between capital structure and the extent to which firm innovate. Accordingly, we estimate the following reduced form specification of *TFP1* for firm *i* at time *t*:

$$Ln(TFP1)_{i,t} = \alpha_o + \alpha_1 [Controls]_{i,t} + \alpha_2 \, (LEV) + ID_t + OD_t + YD_t + \eta_i + \xi_{i,t} \qquad \textbf{(6)}$$

where *Controls* is the set of control variables, *LEV* denotes firm leverage. Industry dummies (*ID*, not reported) are included to control for industry-specific features not explicitly factored into the analysis. Finally, year dummies (*YD*, not reported) are included in all models to control for common trends or business cycle effects. η_i is the firm-specific effect and $\xi_{i,t}$ is a random error term, $\xi_{i,t} \sim N(0, \sigma^2)$.

An emerging body of literature has examined the interface between ownership and productivity. Illustratively, for a panel of 268 listed UK companies for 1985-1997, Criscuolo (2007) finds that concentrated ownership has a salutary impact on productivity. Taking this observation on board, we introduce dummies (OD) to control for ownership groups. In our sample, 60% of the firms are Indian private firms; 7.8% are foreign firms, 96 (or 25%) firms belong to business groups and the remaining are state-owned. Summary statistics of the relevant variables are provided in Table 4.

The empirical analysis is based on the following framework. First, we identify exogenous variations in firms' financial structure induced by factors that do not directly affect productivity. Second, we examine whether the exogenous variation in leverage induce firms to change their propensity to innovate and as a consequence, their productivity.

[Table 4. Variable definitions and summary statistics]

The reason for considering exogenously driven variations of the firm's financial structure is that a straightforward regression of TFP on leverage would be subject to endogeneity problems. For one, firms' with higher TFP are likely to generate higher profits and therefore, make lesser use of debt. On the other hand, a firm intending to innovate by increase its share of immaterial assets is likely to alter its leverage.[4]

In view of these concerns, we adopt a two-stage process. In the first stage, we regress leverage on the exogenous variables. This way, we obtain a value of leverage purged of its endogenous elements. To complete the two-stage process, we regress (6) after replacing leverage by its estimated value and include the predicted value of exports among the regressors.

We follow Titman and Wessels (1998), Rajan and Zingales (1995) and Faulkender and Petersen (2006) in selecting the instrumental variables for leverage. First, we use the ratio of R&D expense to total sales (*R&D*) and the ratio of advertising expense to total sales (*Adv*) to measure a firm's intangible assets. Faulkender and Petersen (2006) uncover a negative and significant relationship between these variables and leverage. Second, we use the natural logarithm of total sales to measure firm size (*Size*). Rajan and Zingales (1995) report a positive and significant relationship between this variable and leverage, whereas Titman and Wessels (1998) find a negative relationship. Finally, we follow Titman and Wessels (1998) and employ the ratio of depreciation and amortization to total assets (*Depcn*) to measure non-debt tax shields. Accordingly, we estimate the following equation in stage one.

$$LEV_{i,t} = \delta_1 \, R\,\&\,D_{i,t} + \delta_2 \, Adv_{i,t} + \delta_3 \, Depcn_{i,t} + \delta_4 \, Size + OD_t + YD_t + ID_t + \eta_i + \nu_{i,t} \quad \textbf{(7)}$$

where the error term $v_{i,t} \sim N(0, \sigma^2)$.

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[4] Following Margaritis and Psillaki (2007), we also experimented with leverage squared to ascertain possible non-linearities in the relationship with TFP. The results (not reported) indicated that both leverage and leverage squared were not significant.

Table 5 reports the results of the first-stage regression. The main message than can be gleaned from the table can be summarized as follows. The estimated coefficient on *Size* is negative and statistically significant at the 0.01 level when leverage is measured as the debt to asset ratio. This concurs with the pecking order hypothesis which suggests that large firms, being more closely observed by analysts and other market participants, should be more capable of using informationally more sensitive equity and therefore, exhibit lower debt. Depreciation exhibits a negative sign. This is consistent with tax theories which suggest that firms with larger non-debt tax shields tend to employ less debt, because the tax advantage is offset by a larger amount of depreciation. The results are broadly similar when *DER* is employed as the dependent variable; however, the fit of the model is uniformly lower in this case.

[Table 5. Determinants of firm leverage]

The results of the baseline regression of eq. (6) are set out in Table 6. The evidence indicates that firms with lower leverage are on average, more productive. In particular, when we use the 2SLS (between) estimator, which focuses on average firm values, the estimated coefficient associated to leverage is -1.606 which a standard error of 0.569 (Model I). A one standard deviation increase in leverage lowers TFP by -0.29 standard deviation. More important than the statistical significance is the economic significance of the relationship. By way of example, consider Model 3 wherein the estimated coefficient is -1.79. As one moves from the bottom 10 th percentile of leverage (0.110) to the 90 th percentile (0.510), TFP1 decreases by 15 percentage points.[5]

[Table 6. Leverage and firm productivity – Baseline regressions]

With the 2SLS within (fixed) effects, which exploits the time-series instead of the cross-section variability of the data, the coefficient is still negative and equal to -0.721, with a standard error of 0.180 (Model IV). The fact that the negative coefficient of the FE

[A]At the 10 th percentile, the computed TFP1 equals 4.71 (=4.915-0.110*1.797) percent. Likewise, at the 90 th percentile, the computed TFP1 equals 3.99 (=4.915-0.510*1.797) per cent. The difference is roughly 15 percentage points.

estimator is of smaller size (in absolute terms) indicates that the cross-sectional differences across firms in the financial structure play an important role in explaining productivity. Still, the negative estimated coefficient of the FE specification suggests that, for the same firm, an increase in leverage is associated with lower TFP.

The control variables also enter significantly. *Size* enters all specifications with a positive sign. In economic terms, size is likely to exert two counteracting effects on productivity growth (Geroski *et al*., 2008). On the one hand, large-scale productivity-growth enhancing investments are likely to be undertaken mainly by larger firms, and may enable them to enjoy persistent success *vis-à-vis* smaller rivals, suggesting a positive coefficient on this variable. On the other hand, larger firms may be less able to change their production (and other) processes in response to exogenous shocks, and they may be less willing to adopt new products and processes in the light of changed circumstances, indicative of a negative coefficient on *Size*. The balance of evidence indicates that the former effect dominates the latter.

Age bears a negative sign, indicative of the fact that older firms are less productive *vis-à-vis* young ones. Following from the product life cycle model (Klepper, 1996), the relation between age and productivity is likely to be inverse, since older firms face less technological opportunities and hence, less inclined to invest in R&D and thereby, are less productive.

The soundness of the empirical specification is confirmed by the diagnostic tests. The Hausman test to discriminate the fixed versus the random effects estimator rejects the null hypothesis, indicating that the random effect estimator would be inconsistent. The Wald-type test confirms the joint significance of instruments in the first stage panel regression, in both cases of between and within estimates, the p-value of the test is 0.00. Finally, to test the exogenity of the instruments, we run a Hausman test of over-identifying restrictions, which leads in both cases to the rejection of the null hypothesis of instrument endogeneity.

On balance, the findings lend support to the view that firms which are less reliant on debt finance tend to undertake more innovative activities. Ultimately, this translates into higher TFP.

7.2 Sensitivity analyses

We extend the baseline analysis along two parallel lines. First, we test whether the firm's financial structure is indeed an explanatory factor for the intensity of innovative activities. Second, we directly verify the relationship between TFP and the extent of innovative activities.

To address the first issue, we run a panel regression, identical to (6), also instrumented, where the dependent variable is the degree of innovative activities. The latter variable is approximated by the share of R&D in total sales. Because this new dependent variable *R&D* is a share, whose value ranges between zero and one, we consider its logistic transformation, *Ln* [*R&D*/(1-*R&D*)].

In Table 7, we report the estimation results of this regression, for which we continue to use both the BE and FE instrumental variable estimator. Consistent with our conjecture, the estimated effect of leverage on R&D is of the same sign as the effect of leverage on productivity. Not only is the estimated effect negative, but it is also statistically significant. With the BE estimator, the coefficient on leverage is -1.297 (with a standard error of 0.463) while, when FE is considered, the estimate is -0.515, with a standard error of 0.211.

[Table 7: Effect of leverage on firm's innovative activities]

So long as we consider the degree of innovation as a good proxy for the firm's propensity towards innovative activities, these findings indicate that less leveraged firms tend to be more innovative. We add another piece of evidence by testing the relationship between TFP and the extent to which a firm innovates. To do so, we simply run a panel regression of firm's *TFP* on the share of R&D. The estimation results, presented in Table 8, point to a positive and strongly significant relationship. The estimated parameter ranges from -8.189 (standard error of 3.783) in BE estimator to -3.765 (standard error of 1.081) in the FE estimator.

[Table 8: Productivity and firm R&D]

7.3 Sample splits

The findings that less leveraged firms have, on average, higher TFP might be analyzed in greater detail by testing for the presence of non-linearities in the relationship between financial structure and total factor productivity. The argument in favor of such non-linearities is that there are a number of characteristics that may uncover a degree of difference across firms in the sensitivity of TFP to leverage. A natural way to address this is by splitting the entire sample of firms according to each of these characteristics and investigating whether the estimated effect of leverage on TFP varies according to the two groups of firms and is magnified by the presence of this characteristic.

The first hypothesis we test is whether the negative TFP-leverage relationship varies according to firm ownership. Accordingly, we split the sample by considering two groups of firms: those in the top 10 percentile by promoter ownership (high promoter ownership) and those in the bottom 10 percentile (low promoter ownership). Criscuolo (2007) finds that ownership concentration has a positive effect on productivity for a sample of UK firms. If that were to be the case, then the magnitude of the TFP-leverage relation would be lower (in absolute terms) for firms with high promoter holdings.

Table 9 (Panel A) shows that this is indeed the case. In particular, wherever significant, the magnitude of the coefficient (in absolute terms) on leverage under high promoter holdings, both in the between and fixed effects specifications, is uniformly lower than under low promoter holdings. By way of example, the coefficient on between effects under high promoter holdings equals 1.39, which is far lower than that obtained under low promoter holdings, which equals 1.91. This concurs with the evidence on the ownership-productivity nexus for UK firms (Criscuolo, 2007).

[Table 9. The effect of leverage on firm productivity – robustness tests]

The alternate investigation deals with the role of liquid assets in shaping the relation between leverage and productivity. Arguably, if a firm has to decide whether to undertake projects with high-growth potentials and has a large share of liquid assets, it can exploit the opportunities by relying on a significant extent by taking recourse to internal funds. Therefore, for these firms, the capital structure may be less relevant than it would be for other firms and no matter, whether the firm's leverage is high or low, the performance-enhancing activities can be undertaken by utilizing the internal cash flows. The empirical results, however, do not support this contention. Irrespective of the share of liquid assets, across none of the specifications, the coefficient on leverage is significant, indicating that the firm's internal funds do not seem to exert any bearing on its propensity to undertake innovative activities and hence, TFP.

8. Summary and conclusions

The article utilizes data on a sample of Indian firms in the electronics industry to explore the relationship between firm leverage and its financial structure. Since the primary channel through which financial structure is likely to impact productivity is *via* innovation, whether and to what extent does such innovative activity impact firm leverage is not evident, *a priori,* since the theoretical predictions suggest that the relationship can vary either way.

In this context, the present study utilizes advanced techniques to compute productivity. Firm-level productivity measures are obtained as the difference between actual and expected output, where the latter is the fitted value from the estimation of a production function. The estimated production function follows from the strategy suggested by Levinsohn and Petrin (2003) to account for endogeneity problems.

In the second stage of the investigation, we evaluate how leverage impacts firm productivity. The evidence indicates that low leveraged firms tend to be more productive, on average. This concurs with theories of capital structure that emphasize the role of bankruptcy costs or for that matter, the conflicts of interests between equity- and debt-holders, which suggests that high propensity to innovate is likely to manifest in higher productivity. Robustness tests tend to lend credence to several of the baseline findings.

From the policy standpoint therefore, the main message than can be gleaned from the paper is that lower leverage may imply faster accumulation of immaterial assets (e.g., knowledge capital) and therefore, higher TFP levels; these findings therefore call for inventions favoring market finance and equity accumulation.

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Table 1: Sample description of high-tech firms

Firm category	Initial number of firms	Step 1: Delete firms with no reported year of incorporation/ less than five years of incorporation	Step 2: Merged firms	Step 3: Delete firms with no reported ownership data
Communications	66	64	58	56
Computer	80	77	72	70
Consumer electronics	40	39	39	39
Other electronics	239	234	225	222
Total	425	414	394	387

Table 2: Estimation of production function parameters

Variable	Least squares		Levinsohn-Petrin	
	Ln Sales	Ln (sales *plus* other income)	Ln Sales	Ln (sales *plus* other income)
Ln (Labor)	-0.875 (0.030)***	-0.861 (0.041)***	0.807 (0.056)***	0.823 (0.058)***
Ln (power and fuel)	0.031 (0.029)	0.027 (0.022)	0.117 (0.161)	0.122 (0.105)
Ln (capital)	0.084(0.032)***	0.092 (0.036)***	0.098 (0.059)*	0.105 (0.064)*
Constant	2.829 (0.121)***	2.703 (0.135)***	2.202 (0.177)***	2.159 (0.246)***
Time period	1996-2007	1996-2007	1996-2007	1996-2007
No. of firms, Obs.	387, 1225	387; 12225	387; 1225	387; 1225
Wald test of CRS	2.85 (0.09)*	2.02 (0.11)	0.74 (0.38)	0.85 (0.37)

Standard errors are within parentheses

***, ** and * indicates statistical significance at 1, 5 and 10%, respectively

Table 3. Descriptive statistics for productivity scores

	Obs.	Mean	Median	Std. devn.	Minimum	Maximum	25 percentile	75 percentile
All firms – 387 firms								
TFP 1	1225	3.329	3.267	0.948	-0.743	7.347	2.751	3.828
TFP 2	1225	2.715	2.486	1.058	-0.636	6.907	2.023	3.159
TFP 1 industry groups								
Communications	199	3.335	3.327	0.963	-0.743	5.786	2.780	3.834
Computers	263	3.129	3.060	0.729	1.452	5.580	2.608	3.554
Consumer electronics	112	3.428	3.435	0.793	2.086	5.336	2.900	3.902
Other electronics	651	3.391	3.365	1.022	-0.458	7.347	2.802	3.916

TFP1 is natural log of total factor productivity when output as measured as (real) gross sales

TFP2 is natural log of total factor productivity when output is measured as aggregate of (real) gross sales and other (real) income

Table 4. Variable definitions and summary statistics

Variable	Empirical definition	Mean (S.D)	Top 10 percentile	Bottom 10 percentile
Firm characteristics				
TFP 1	Natural log of TFP computed using L-P method	3.329 (0.948)	4.550	2.220
LEVERAGE (hat)	Predicted value of leverage obtained from Eq.7	0.304 (0.171)	0.510	0.110
Size	Ln(real sales)	-2.213 (2.352)	0.455	-5.438
Age	Ln (1+number of years since firm incorporation)	2.713 (0.660)	3.434	1.946
Liquid	Cash and bank balances/Asset	0.061 (0.098)	0.147	0.003
Risk	Three-year rolling standard deviation of firm profitability	0.093 (0.237)	0.184	0.004
Promoter	Promoter's equity share in the firm	0.118 (0.227)	0.529	0.000
Group	Dummy=1, if a firm belongs to business group, else zero	0.248 (0.432)	1.000	0.000
State	Dummy=1 if a firm is state-owned, else zero	0.072 (0.259)	1.000	0.000
Indian private	Dummy=1, if a firm is Indian private, else zero	0.602 (0.489)	1.000	0.000
Foreign	Dummy=1, if a firm is foreign-owned, else zero	0.076 (0.267)	1.000	0.000

Table 5. Determinants of firm leverage

Dependent variable	LEV	DER
Constant	0.150 (0.086)*	0.079 (0.055)
Size	-0.043 (0.017)***	-0.031 (0.018)
Depreciation/Asset	0.426 (0.113)***	0.238 (0.079)***
R&D/Sales	-0.543 (0.379)	-0.298 (0.336)
Advertising/Sales	-0.245 (0.211)	-0.162 (0.167)
Ownership dummies		
Group	-0.002 (0.063)	-0.001 (0.041)
Indian private	-0.013 (0.057)	-0.006 (0.036)
Foreign	-0.157 (0.064)***	-0.087 (0.041)**
Year dummies	Yes	Yes
Industry dummies	Yes	Yes
No. of firms, Observations	328, 2211	328, 2211
Time period	1996-2007	1996-2007
R-square	0.111	0.084
Prob > F-value	0.002	0.026

Standard errors (allowing for clustering by firm) are within parentheses
***, ** and * indicates statistical significance at 1, 5 and 10%, respectively

Table 6. Leverage and firm productivity – Baseline regressions

Dependent Variable	Between effects IV	Between effects IV	Between effects IV	Fixed effects IV	Fixed effects IV	Fixed effects IV
	(1)	(2)	(3)	(4)	(5)	(6)
Leverage	**-1.606 (0.569)*** **	**-1.907 (0.604)*** **	**-1.797 (0.704)*** **	**-0.721 (0.175)*** **	**-0.716 (0.180)*** **	**-0.674 (0.176)*** **
Ln Sales	0.196 (0.031)***	0.205 (0.031)***	0.207 (0.031)***	0.395 (0.021)***	0.401 (0.021)***	0.392 (0.021)***
Liquid		-1.353 (0.759)*	-1.224 (0.758)*		0.032 (0.231)	0.052 (0.229)
Ln Age		-0.465 (0.114)***	-0.464 (0.112)***		-0.707 (0.154)***	-0.736 (0.155)***
Risk			0.030 (0.669)			0.025 (0.072)
Constant	3.115 (0.294)***	4.949 (0.513)***	4.915 (0.515)***	4.003 (0.053)***	6.197 (0.480)***	6.256 (0.484)***
Industry dummies	Yes	Yes	Yes	No	No	No
Ownership dummies	Yes	Yes	Yes	No	No	No
Year dummies	No	No	No	Yes	Yes	Yes
Over-identifying restrictions	86.51 (p-Value =0.00)	71.68 (p-Value = 0.00)	72.10 (p-Value=0.00)	19.24 (p-Value = 0.11)	18.71 (p-Value = 0.22)	16.79 (p-Value=0.26)
Firms; N.Observations	242; 1225	242; 1225	242, 1205	242; 1225	242; 1225	242, 1205
R-square (overall)	0.227	0.229	0.235	0. 122	0.223	0.229
Period	1996-2007	1996-2007	1996-2007	1996-2007	1996-2007	1996-2007

Standard errors are within parentheses
***, ** and * indicates statistical significance at 1, 5 and 10%, respectively

Table 7: Effect of leverage on firm's innovative activities

	Between effects IV	Fixed effects IV
Leverage	-1.297 (0.463)***	-0.515 (0.211)***
Constant	2.631 (0.363)***	4.095 (0. 627)***
Controls	Yes	Yes
Industry dummies	Yes	No
Ownership dummies	Yes	No
Year dummies	No	Yes
Firms; N.Observations	242; 1225	242; 1225
Overall R-square	0.261	0.139
Over-identifying restrictions	0.79 (p-Value = 0.43)	5.71 (p-Value = 0.06)

Standard errors are within parentheses
***, ** and * indicates statistical significance at 1, 5 and 10%, respectively

Table 8: Productivity and firm R&D

	Between effects	Fixed effects
R&D	8.189 (3.783)**	3.765 (1.051)***
Constant	4.530 (0.433)***	6.318 (0. 418)***
Controls	Yes	Yes
Industry dummies	Yes	No
Ownership dummies	Yes	No
Year dummies	No	Yes
Firms; N.Observations	242; 1225	242; 1225
Overall R-square	0.368	0.226

Standard errors are within parentheses
***, ** and * indicates statistical significance at 1, 5 and 10%, respectively

Table 9. The effect of leverage on firm productivity – robustness tests

	Sub-samples with			
Panel A:	Low promoter holdings		High promoter holdings	
	Between effects IV	Fixed effects IV	Between effects IV	Fixed effects IV
Leverage	-1.913 (0.679)***	-0.581 (0.362)*	-1.393 (0.819)*	-1.064 (1.757)
Constant	4.989 (0.536)***	5.895 (0.762)***	5.463 (1.163)***	7.475 (2.611)***
Industry dummies	Yes	No	Yes	No
Ownership dummies	Yes	No	Yes	No
Year dummies	No	Yes	No	Yes
Firms; N.observations	212; 546	212; 546	64; 218	64; 218
Overall R-square	0.236	0.173	0.496	0.315
Period	2001-2007		2001-2007	
Panel B	Low liquid assets		High liquid assets	
	Between effects IV	Fixed effects IV	Between effects IV	Fixed effects IV
Leverage	-1.019 (0.652)	-3.615 (2.316)	2.367 (3.162)	1.854 (2.423)
Constant	8.839 (1.405)***	6.989 (3.037)**	3.936 (0.989)***	6.591 (1.143)***
Industry dummies	Yes	No	Yes	No
Ownership dummies	Yes	No	Yes	No
Year dummies	No	Yes	No	Yes
Firms; N.observations	41, 68	41, 68	61, 146	61, 146
R-square (overall)	0.608	0.167	0.377	0.232
Period	1996-2007		1996-2007	

Under each panel, Low refers to bottom 10 percentile and High refers to top 10 percentile of the concerned variable
Standard errors are within parentheses
***, ** and * indicates statistical significance at 1, 5 and 10%, respectively