THE EFFECTS OF R&D, COMPETITION AND INSTITUTIONAL QUALITY ON FIRM VALUE: EVIDENCE FROM INTERNATIONAL DATA

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Abstract: Using a comprehensive database from 75 countries spanning 2004-2013, we scrutinize the joint effects of R&D intensity and competition on value-creation of a firm. We also introduce country-specific differences in institutional quality and test whether country-level determinants play an important role in supporting firm's R&D. Our findings suggests a clear evidence of positive effects from R&D intensity on Tobin's Q. The effect is always stronger for low competitive industries as compared to high competitive industries. However, for developing countries, the effects of R&D disappears in high and medium competitive industries. The results are empirically robust after controlling for endogeinity and employing different types of country-level diterminants. Our findings have strong policy implications based on differences in R&D related investment dicisions made by firms in developing versus developed countries.

JEL classification: D40; L10; L60; O30

Keywords: firm R&D, competition, Tobin's Q

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1. Introduction

Investment in research and development (R&D) is critical to a firm's performance. Whether we measure a firm's performance by its productivity (see Griliches *et al.*, 1991; Griliches, 1995) or by its market valuation (see Hall, 2000), there is a consensus that higher research activity within a firm has a positive effect on both measures. However, this connection between research activity and firm performance is not straightforward when we allow for competition among firms with various degrees of market power. For example, it is not always the case that increased competition in the market leads to more product innovations. Following Schumpeter (1934), there is a growing literature that supports the view that less competition or a monopoly market generates higher returns to R&D. Here, the firm adopts R&D to mitigate the adverse effects of competition and establish itself as a market leader. Monopoly deadweight loss is the price that the society has to pay to achieve higher research intensity in the industry. In contrast, Fellner (1951) and Arrow (1962) theoretically argue that strong competition leads to innovation. The survival instinct of a firm creates incentives to perform better than its competitor, which leads to investment in R&D and better quality products in the market (Porter, 1990).

Although, the extant literature investigates the relationship between competition and innovation in detail, it is silent on the effects of this relationship on market valuation of a firm. Chauvin and Hirschey (1993) and Connolly and Hirschey (2005) consider the effects of firm size[2] and R&D on Tobin's Q and find that the returns to R&D is higher for larger firms than smaller firms. The results are consistent for manufacturing and non-manufacturing sectors across 80 countries. Following a similar approach, this paper uses a comprehensive firm-level database to analyse the effect of R&D intensity on firm valuation after controlling for competition and other factors. One major contribution is the focus on the effect of institutional differences among countries on the relationship between firm valuation and R&D.

This study contributes to the literature in multiple ways: first, using a comprehensive database of 82,367 firm-year observations from 75 countries spanning 2004-2013, we scrutinize whether R&D intensity contributes towards value-creation. This database,

[2] Firm size refers to how big a firm is. Bigger firm size means that the firm has more market power and faces less competition in the market. In other words, an industry, which faces very high competition, is expected to have many firms, each of which is smaller in size.

consisting of firm-level data from developed, developing and transitional economies, covering both the surviving and ceased firms has been not studied as extensively before. Thus, the findings will help us form a general understanding about the effects of R&D intensity on Tobin's Q in a multi-country setting. Second, unlike previous studies which investigate the the linkages between competition and R&D, as well as R&D and firm value in isolation, this paper evaluates the joint effects of R&D intensity and competition on value-creation of a firm. Thus, we contribute to the existing literature by documenting whether the value-enhancing effect of R&D is observed under various levels of competition in the market.

Third, we introduce country-specific differences in institutional quality and test whether country-level determinants play an important role in supporting firm's R&D in value-creation of a firm in a competitive and non-competitive environment. The importance of government policy or geographical location in competition is highlighted by Porter (1994) and Porter and Porter (1998). Other papers that show the effect of institutional quality or intellectual property rights in a framework of competition and R&D are Guellec and Potterie (2004), Acemoglu and Akcigit (2012) and Spulber (2013). However, none of these studies test the effect of country-specific institutional differences on firm valuation. To check the existence of such an effect on firm's Tobin's Q, we split our sample of countries into stronger and weaker institutional quality and check whether the same results hold for each sample. A continuous measure of institutional quality is also used to check for robustness of the results. To the best of our knowledge, this is the first study to look at the effects of R&D on firm valuation in depth, capturing multiple dimensions of market and institutional characteristics.

The paper is organised as follows. The next section provides an overview of the literature showing the linkages among competition, R&D and Tobin's Q. Section 3 details the empirical methodology used in this paper and defines the key variables. Section 4 presents the main empirical analysis and discusses the results. In section 5, we present additional robustness checks using different measures of firm valuation and institutional quality. Finally, section 6 concludes.

2. Competition, R&D and Tobin's Q

The ideal way to understand the nexus among competition, R&D and market valuation of firms is, by initially studying the link between competition and R&D; and then, the effects of R&D and competition on Tobin's Q.

2.1.Competition and R&D

The literature on the effect of competition on R&D is longstanding. As mentioned above, it mainly follows either Schumpeter (1934), supporting the view that less competition induces higher R&D, or Fellner (1951) and Arrow (1962), in favour of more competition leads to higher R&D. However, more recent studies agree with the view that market concentration and R&D intensity are both endogenous to each other and are jointly determined in a market equilibrium system (Nickell, 1996; Sutton, 1996; Blundell *et al.*, 1999; Marín and Siotis, 2007). Based on a Schumpeterian endogenous growth framework, Aghion and Howitt (1992) show that the two variables are endogenous to the model and predicts a negative correlation between competition and R&D. Aghion and Howitt (1998) further extend their 1992 model by assuming that the effectiveness of R&D is diluted due to the proliferation of products when an economy expands. Therefore, they show that when an economy is expanding, the negative correlation is reversed into positive correlation between competition and R&D intensity. The two models together yield an inverted U-shaped relationship between the two variables as shown later in Aghion *et al.* (2005).

The empirical evidence shows that the effects of competition on R&D may vary depending on the firm characteristics such as type of innovations: product or process, the type of industries or countries chosen and the time period of analysis. A comprehensive survey on the empirical debate can be found in Gilbert (2006).[3] However, most of the earlier studies suffer from limited data on innovative activity and market concentration. Furthermore, previous studies fail to distinguish between exclusive and nonexclusive property rights and they do not capture the differences in technological opportunities across industries and time (Gilbert, 2006). In more recent studies, the empirical evidence is generally consistent supporting the view that these variables are jointly determined in a market system, and they follow an inverted U-shaped relationship (Levin *et al.*, 1985; Aghion *et al.*, 2005; Tingvall & Poldahl, 2006; Yeh *et al.*, 2008). Thus R&D intensity increases in proportion to firm size above some threshold value that varies across industries.[4] Although these results are very insightful, they examine only the effect of firm size on R&D spending and R&D stock and

[3] In a nutshell, the negative relationship between competition and R&D get some empirical support from Horowitz (1962), Hamberg (1964), Mansfield (1968), Kraft (1989) and Blundell *et al.* (1995). In contrast, positive relationship between R&D and competition is established by (Mukhopadhyay, 1985; Geroski, 1990; Nickell, 1996; Blundell *et al.*, 1999). Many of the earlier studies could not even offer any valid relationship between market concentration and R&D (Levin & Reiss, 1984; Scott, 1984; Levin *et al.*, 1985).
[4] In contrast, Sacco and Schmutzler (2011) adopt a laboratory experiment-setting and find a direct and non-inverted U shaped relationship between the two variables.

vice versa. It is important to note that the aim of this paper is not to re-examine the inverted U-shape relationship using a different data set, but to look at the joint effect of these two variables on Tobin's Q.

2.2.Effect of R&D and competition on Tobin's Q

Hall (2000) provides an excellent survey of literature that relates Tobin's Q to R&D and patent measures. Using firm-level US manufacturing data, initially for 1980s in Hall (1993) and Hall *et al.* (1993), and later extended to 1995 in Hall (2000), the main findings support the view that R&D assets are valued by financial markets and thus, there is a positive effect coming from R&D (either measured by R&D expenditure or stock of R&D) on Tobin's Q. One important finding is the R&D coefficient, although positive, is not stable over time either in the US or in the UK. Patents, on the other hand, are more informative than R&D, but have weak correlation with Tobin's Q. Since then, a number of other studies look at this effect using either more recent data on a particular set of industries, regions or a group of countries and using different measures of R&D intensity. Nevertheless, the general conclusion remains unchanged that R&D affects Tobin's Q positively (Toivanen *et al.*, 2002; Del Monte & Papagni, 2003; Hall *et al.*, 2005; Bracker & Ramaya, 2011; Sandner & Block, 2011; García-Manjón & Romero-Merino, 2012). Most of these aforementioned studies consider a sample of firms from a particular country or a specific region (e.g. European Union) and the time period varies largely across all these studies.[5]

Except for the work of Chauvin and Hirschey (1993) and Connolly and Hirschey (2005), very little research, if any, has been done to see the effect of competition or firm size on Tobin's Q.[6] Pindado *et al.* (2010) is a recent study analysing the joint effects of R&D and firm size. They developed a valuation model based on capital market arbitrage conditions and find that the effectiveness of R&D spending depends on firm characteristics, such as, size, firm growth, market share and others. Although their study is restricted to countries from Eurozone for the period 1986-2003, each firm characteristic is interacted with R&D in order to investigate the joint effects coming from firm attributes. Consistent with earlier studies, they find bigger firm size increases the market valuation of R&D spending. Economies of

[5] One notable exception is Sandner and Block (2011). Looking at the effects of trademarks on market value of firms, they consider 1216 traded companies from more than ten OECD countries and find trademarks positively impacts firm value. Although this study considers many countries, it does not differentiate between strong and weak institutions.
[6] Conolly and Hirschey (2005) consider 15,709 publicly traded companies, on average 3,100 firms per year between 1997 and 2001, find that the valuation effect of R&D is greater in larger firms than smaller ones.

scale, easier access to capital markets and spreading of R&D cost benefit the big firms to take advantage of R&D in the market.

While documenting the size-related consequences of R&D, the literature is silent on the findings outside the industrialized nations. This clearly avoids the issue of looking at the differences in institutional quality that may affect the relationship between firm size and market valuation of R&D spending. This study fills this gap by first looking at the under-researched area of examining the effect of competition on Tobin's Q and then by further distinguishing between strong and weak institutional countries. The main issues, still a subject of substantial debate, are as follows: firstly, how the positive effect of R&D on Tobin's Q changes for various levels of competition; and secondly, whether the R&D coefficient is generalizable across countries, across industries and over time.

3. Data and Empirical Methodology

3.1. Data description

Our sample consists of 82,367 firm-year observations from 75 countries, which includes developing, developed and transitional economies, and covers a period of 2004-2013. The list of countries and a brief description of the sample along with country-level determinants are provided in Table 1 below. As evident from the table, the sample distribution is uneven and some countries dominate the sample while few other countries have small firm-year observations. We thus drop the countries where the firm-year observations are below 10. Similarly, we exclude US-listed firms as they dominate the sample.[7]

We include the following country-level determinants in our empirical analysis. The *international country risk guide* (*ICRG*) is a widely accepted and used measure of political, financial, and economic risk for over 140 countries.[8] We also make use of the *Overall Infrastructure* variable which offers an assessment of the general infrastructure (transport, telephony, energy, etc.) in a country. The rating varies from 1 to 7; 1 representing extreme underdevelopment, and 7 suggesting an extensive and efficient infrastructure in a given

[7] Including observations from countries with lower firm-year observations and/or the US-listed firms generate qualitatively similar results as the ones presented in the next section.
[8] The data on ICRG is extracted from the international country risk guide index calculated by the PRS group. For detailed methodology of the construction of this series, please consult the following link: https://www.prsgroup.com/about-us/our-two-methodologies/icrg

country.[9] Similarly, we make use of the *Research and Training Services* variable measuring the availability of specialized research and training services, again measured between 1 (not available) and 7 (widely available).[10] Lastly, the *Local Competition* variable measures the intensity of competition in the local markets in a given country. The rating for local competition again varies between 1, for limited competition in most industries, to 7, for intense competition in most industries in a given country.[11] A detailed description of the construction of the key variables of interest and the control variables is provided in the next section.

[Insert Table 1 here – sample description]

3.2. *Construction of key variables*

Tobin's Q ratio, defined as the market value of firm normalised by the replacement cost of tangible and intangible assets, is the most widely used indicator among researchers to measure firm value (Chauvin & Hirschey, 1993). In this study, Tobin's Q is calculated as the sum of total assets less the book value of equity plus the market value of equity, divided by the total assets (see Doidge *et al.*, 2007; Aggarwal *et al.*, 2010).[12]

R&D intensity measure is computed as R&D expenses scaled by the total assets. Competition refers to product market competition and it is proxied by sales Herfindahl-Hirschman Index (HHI).[13] It is calculated by squaring the market share of each firm in the industry, country, year and then adding the resulting numbers. Thus, the empirical formulation yields:

$$Sales\ HHI_{j,c,t} = \sum_{i=1}^{N_j} s_{i,j,c,t}^2 \qquad (2)$$

where $s_{i,j,c,t}$ is the sales market share of firm *i* in industry *j*, country *c*, in year *t*. The HHI takes the value between zero and one, where a high number implies that the firms in the industry have more market power. In the extreme case, a single firm will represent the whole industry and acts as a monopoly.

Sales market shares are calculated based on FF48 industry classification provided by Fama and French (1997). The data is collected from multiple sources. First, Worldscope

[9] See the World Economic Forum (WEF) 2013 report for more details.
[10] See the World Economic Forum (WEF) 2013 report for more details.
[11] See the World Economic Forum (WEF) 2013 report for more details.
[12] The data on total assets, book value of equity and market value of equity are sourced from the Worldscope database.
[13] The HHI is used widely in the industrial organisation literature to measure product competition among firms (see Tirole, 1988).

database is used to obtain sales of publicly listed firms, which consists of 318,292 firm-year sales data of 54,784 public firms. Then, following the critique of Ali *et al.* (2009) that solely relying on the public company sales data may result in poor proxy of product market competition both public and private data is compiled to calculate product market competition. Private data is retrieved from Bureau van Dijk's Orbis database. The sample is then restricted to only those firms that have at least US$ 100,000 in sales.[14] The private firm data covers 14,293,283 firm-year sales data of 3,847,684 private firms spanning 2004 to 2013. Next, the databases of Orbis and Worldscope are matched together by using the first two digits of the International Securities Identification Number (ISIN) code. The sales HHI of at least four firms out of 50 firms is calculated in the industry with highest sales every year. This is consistent with the US Census methods that use the 50 largest firms within each industry to compute the HHI and to calculate the largest four-firm concentration ratio in industries. Alternative approaches, such as not imposing a filter on the maximum number of firms in an industry and only considering top four firms' sales instead of all 50 firms, generate qualitatively similar results.

In the empirical analysis section, control variables are added to the regression equation to examine the contributions from other factors, which are potentially important determinants of firm value. Without the inclusion of the control variables, the empirical model is potentially misspecified, and estimated coefficients become biased due to the problem of omitted variables. The control variables are *illiquidity*, *standard deviation of stock returns*, *log of total asset*, and *blockholding*. The control variables are winsorised at 1 and 99 percentile to minimize the effect of outliers. [15]

While stock liquidity is expected to raise firm value (Fang *et al.*, 2009), greater risk, measured by daily standard deviation of stock returns over the last one year, is expected to decrease firm value. Illiquidity measure is calculated as the daily ratio of absolute stock return to dollar volume (Amihud & Mendelson, 1986). Since bigger firms have greater access to market resources generating higher R&D and Tobin's Q, following Stulz (1994), firm size is controlled for by logarithm of total assets. Finally, McConnell and Servaes (1990) find a significant curvilinear relation between Tobin's Q and the fraction of common stock owned

[14] Borell *et al.* (2010) argue that it is important to limit the impact of "phantom" firms by imposing some filters on basic information reported by firms.

[15] Data cleaning procedures and guidelines of Ince and Porter (2006) and Chui *et al.* (2010) are followed to address the data issues noted in Datastream.

by corporate insiders. Consequently, blockholding is controlled for in the empirical estimations, which is measured by percentage of shares closely held by insiders.[16]

In Table 2 we report summary statistics of the key variables used in this study. The mean and median Tobin's Q is 1.70 and 1.26 respectively. We find that the R&D intensity ratio is on average 3.49% of the total assets. The median R&D intensity ratio is 0.62% suggesting that many firms spend less (or no spending) on R&D. The mean and median Sales HHI is 14.77% and 9.58%, suggesting that overall firms are based in moderately competitive industries. We find that on average 38.83% of shares are closely held. Firms' on average spend 4.88% on capital expenditure. Finally, most of the firms are moderately leveraged as the average leverage ratio is 11.32%.

[Insert Table 2 here – summary statistics]

3.3. Empirical methodology

To examine the effects of competition and R&D intensity on firm value, following Giroud and Mueller (2011), our regression equation takes the form:

$$Q_{i,j,c,t} = \propto_j + \propto_c + \alpha_t + \boldsymbol{\beta}'\left(RD_{i,j,c,t} \times \boldsymbol{I}_{j,c,t}\right) + \sum \boldsymbol{\gamma}' Controls + \varepsilon_{i,j,c,t} \quad (1)$$

where $Q_{i,j,c,t}$ is Tobin's Q of firm *i* in industry *j*, country *c*, in year *t*. Similarly, $RD_{i,j,c,t}$ is R&D intensity of firm *i* in industry *j*, country *c*, in year *t*. $I_{j,c,t}$ is a (3x1) vector of sales Herfindahl-Hirschman Index (HHI) dummies. The terciles are formed based on whether the firm is located in the lowest HHI industry, the medium HHI industry or the highest HHI industry.[17] We employ unbalanced panel data with industry (α_j), country (α_c) and year (α_t) fixed effects to control for unobservable heterogeneity and omitted factors that are related to both Tobin's Q and R&D intensity. Fixed effect estimators are generally considered superior to other measures in controlling for unobserved heterogeneity (see Gormley & Matsa, 2014). A set of controls, namely, illiquidity, standard deviation of stock returns, log of total asset, and blockholding, is added to the empirical equation based on the literature related to Tobin's Q.

[16] Stock prices are obtained from Datastream and other control variables are from Worldscope.
[17] Alternatively, (2x1) and (4x1) vector of sales HHI dummies are calculated to capture varying degrees of competition. The results do not differ substantially from those in the next section, and consequently are not reported.

4. Empirical results

Table 3 provides the baseline results from equation (1). While specification 1 estimates the coefficient of R&D intensity on Tobin's Q without controlling for competition, specifications 2 to 4 control for competition and bifurcate the whole sample into developing and developed countries. The split is based on development classifications provided by the International Monetary Fund (IMF).[18] Results from specification 1 confirm the positive effect of R&D intensity on firm value, where one percentage point change in R&D intensity causes 4.38 percentage points increase in Tobin's Q. This coefficient is statistically significant at the one percent level. We also note that large market size companies have a higher Tobin's Q. Similarly, firms with high percentage of blockholders have a higher Tobin's Q, suggesting that blockholding reduces agency costs and therefore contribute positively towards value-creation. Growth firms, proxied by capex ratio, also tend to have a higher Tobin's Q. Risky firms, proxied by percentage of long-term debt over the total assets, have a negative relationship with firm-valuation.

[Insert Table 3 here – Baseline results]

Specification 2 shows that after controlling for competition, positive effect of R&D intensity on Tobin's Q still subsists. The coefficients of interaction terms of various degrees of competition with R&D intensity are not significantly different to each other. However, industries that face low competition gain slightly more through R&D investment (4.89 percentage points in low competition as compared to 4.21 and 4.28 percentage points in medium and high competitions respectively).

For developing countries, the positive effect of R&D intensity on Tobin's Q disappears in high and medium competitive industries (see specification 3). This is consistent to the view that, competition and corruption are negatively related (see Emerson, 2006). Emerson (2006) argues both theoretically and empirically that in developing countries, government officials receive bribe payments to limit the number of firms. In other words, artificial barriers to entry are created by governments to protect market power. To a degree, our findings also support the findings of Clarke and Xu (2004) where bribe takers

[18] http://www.imf.org/external/pubs/ft/weo/weo0598/pdf/0598sta.pdf

(employees) in a sector are more likely to take part in illegal activities in countries with lower levels of competition and with higher number of state-owned companies.

In developing countries, due to lower institutional quality, higher corruption and less protection of property rights, positive returns from R&D can only be expected in low competitive industries. Access to credit from most formal financial institutions is relatively scarce for various purposes, including R&D. This is because information networks are poorly developed in these countries and imperfect signalling applies. Thus, industries with large firms enjoy oligopoly and monopoly powers in the market and gain preferential access to credit. They are also favoured by the banks, because of low risk and less monitoring costs (Levine, 1997; Little, 1987; Tybout, 1984). Moreover, probability of accessing legal system and lobbying power by these firms to obtain government benefits are much higher (Levenson and Maloney, 1997). Once these industries gain more market power (by facing less competition), they enjoy economies of scale over long period of time and this creates barriers to entry for future competitors. It is then expected that greater monopoly rents are available to protect their property rights on new product innovations. Therefore, we find in our empirical alanysis that the effect of R&D intensity on firm value becomes significantly positive for less competitive industries in developing countries.

On the other hand, in developed countries, where the intellectual property rights are well protected by the law, the effect of competition is relatively uniform and positive effect of R&D on Tobin's Q exists for all types of competitive levels. The positive effect is present in all sectors, but dominant in low competitive industries (see specification 4). Nevertheless, in both developing and developed countries, overall results from specification 2 suggest that industries, which face less competition, receive higher positive returns from R&D investment. This supports the Schumpeterian hypothesis where bigger firm size, with more market power and less competition generates higher returns to R&D.

One important factor that was not controlled for in Table 3 is reverse causality. Following the Schumpeterian hypothesis, if low competition gives rise to firms that have more market power and higher R&D investments, which raises their firm value, then it may also be the case that higher firm value will provide better scope for these firms in future R&D investments. In other words, higher firm value can positively influence investment in R&D and thus raises an issue of endogenity in our empirical estimations. One way to address this problem is to adopt a system Generalised Method of Moments (GMM) approach proposed by Arellano and Bover (1995) and Blundell and Bond (1998). A clear advantage of System GMM over other approaches is that instead of relying on an instrument, which may be weak or not readily available, it uses its own past realisations as well as independent variables that are not strictly exogenous as instrumental variables.

Another way to address the endogenity issue is to adopt a good instrument for R&D, which is correlated with R&D intensity, but has no direct effect on Tobin's Q. Following the work by (XXXX) a two-period lag of R&D ratio is used in regressions as an instrument for R&D intensity. This controls for the contemporaneous relation between Tobin's Q and R&D intensity. Table 4 presents both the system GMM and the instrumental variable regression results.

[Insert Table 4 here – GMM and IV results]

While in the first specification of Table 4, all countries in our sample are considered, specification 2 and 3 bifurcate the sample into developing and developed countries. For all three specifications of the GMM and IV regression results presented in Table 4, there is a clear evidence of positive effects from R&D intensity on Tobin's Q. The effect is always stronger for low competitive industries as compared to high competitive industries. For example, in specifications 1 and 3 of GMM, the coefficient of R&D intensity when interacted with low competition is 2.2 and 2.3 percentage points respectively, as compared to 1.6 and 1.7 percentage points respectively, when interacted with high competition. Although the magnitude of the coefficients using GMM are smaller than the baseline results presented in Table 3, the general conclusion remains the same. Positive effects of R&D is dominant in low competitive sectors, and for developing countries, the effects of R&D disappears in high and medium competitive industries (see specifications 2 and 5 in Table 4).

5. Additional Robustness checks

In this section, we provide some additional robustness checks to our empirical results. First, instead of splitting the sample into developed and developing countries, we use different country-level institutional determinants on our sample and check whether the effect of R&D on Tobin's Q varies with these institutional factors. This is crucial since in some countries the laws (and/or regulations) on competition might be biased toward specific firms or sectors, such as large firms, or public undertakings that are regulated or protected by the Government. Thus, country-level characteristics may discourage or encourage competition. The following country-level determinants are controlled for in each of the models in Table 5: *ICRG*, *overall infrastructure*, *research and training services* and *country level competition* *index*.[19] Under each country-level institutional factor, the column 'high' ('low') in Table 5 indicates that the scores of a particular group of countries are higher (lower) than the median score of that series.

[Insert Table 5 here – Country-level determinants on full sample only]

Table 5 presents the results based on country-level determinants. The results are very consistent to the baseline results presented in Table 3 across all determinants. We derive two important findings from this exercise. First, irrespective of whether the country-level institutional factor is low or high, except in one case, R&D intensity has a positive and significant effect on Tobin's Q.[20] Moreover, in the group with low country-specific institutional factors, the effect is always stronger for industries with low competition. For *ICRG* and *competition*, the coefficients of R&D intensity when interacted with low competition is 4.8 and 4.1 percentage points respectively, as compared to 3.7 and 3.2 percentage points respectively, when interacted with high competition. The gap is even higher for *overall infrastructure* and *research and training*, reducing from 5.1 and 4.2 percentage points respectively, in low competition to 1.6 and 1.2 percentage points respectively, in high competition. For the group of countries with high country-specific institutional factors, the gap in the effect of R&D intensity on Tobin's Q is substantially lower between low and high competition for all four country-specific determinants. In addition, the magnitudes of the coefficients are not significantly different from the baseline results presented in Table 3.

Second, under each country-level determinant, the effect of R&D intensity is stronger in 'high scores' group than the 'low scores' group for all levels of competition. For example, in *ICRG*, the coefficient of R&D intensity when interacted with low competition in the 'high' group is 5.1 and in the low group it is 4.7. The effect is even stronger when interacted with high competition in *ICRG*. The coefficient of R&D intensity when interacted with high competition in the 'high' group is 5.2 and in the low group it is 3.7. This is also true for all other three country-specific determinants considered in this paper. Thus our findings suggest that if the institutional quality of a country is higher (than the median score), the effect of R&D intensity on Tobin's Q is more dominant. This supports our earlier argument that in

[19] The method of construction of these measures is described in details in the data description section 3.1 above.
[20] The coefficient of the interaction effect of 'medium competition and R&D intensity' under the 'low' group in 'Research and training' is found positive but insignificant.

countries with lower institutional quality, the positive effect of R&D on Tobin's Q gets supressed for all levels of competition, and more prominently for high competition.

Finally, as an additional robustness check, instead of sales HHI, following Graham (2000) we employ an alternate measure of competition, assest-HHI. Industry-wide assest concentration ratio and asset-HHI are particularly important measures to capture cases where large firms, with more market power, in an industry may create entry barriers for new firms. They are even prepared to sustain losses in the short run to deter potential competing firms from entering the industry (Benoit, 1984). Due to their large asset holdings, these firms also enjoy economies of scale which further creates a barrier to entry (Bolton and Scharfstein, 1990).

The data source for asset-HHI and the method of construction is the same as sales-HHI documented in section 3.3. It is calculated by squaring the asset share of each firm in the industry, country, year and then adding the resulting numbers. Thus, the empirical formulation yields:

$$Asset\ HHI_{j,c,t} = \sum_{i=1}^{N_j} a_{i,j,c,t}^2 \qquad (3)$$

where $a_{i,j,c,t}$ is the asset share of firm i in industry j, country c, in year t. It takes the value between zero and one, where a high HHI index implies that the firms in the industry have more asset concentration. Industry classification based on FF48 classification provided by Fama and French (1997) is used to calculate the asset-HHI. The results are presented in Table 6 below.

[Insert Table 6 here – Asset-HHI results]

Specifications 1-3 in Table 6 clearly demonstrate that after using alternative measure of competition (assest-HHI), our key results from Table 3 still hold. The interaction term between R&D and low competition level for the full sample shows that one percentage point change in R&D intensity will increase Tobin's Q by 4.8 percentage points (specification 2). In contrast, the effects from medium and high competition levels are slightly lower, 4.2 and 4.3 percentage points respectively. While specification 2 shows the effect of R&D on Tobin's Q for developing countries, specification 3 presents the effect for developed countries. Similar to Table 3, the positive effect of R&D intensity on Tobin's Q disappears in high and medium competitive industries and is statistically significant only for low competitive industries (4.3 percentage points). For developed countries, we find that the positive effect is present in all sectors, but dominant in low competitive industries. Overall, our results from Table 6 are consistent with the Schumpeterian hypothesis that low competitive industries receive higher positive returns from R&D investment.

6. Conclusion

To be written…..

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Table 1: Sample description

No	Country	Firm-Years	Country-Years	ICRG	Overall Infrastructure	Research & Training Services	Competition
1	Argentina	71	10	71.11	3.23	4.36	3.08
2	Australia	3,606	10	80.32	5.2	5.07	5.12
3	Austria	282	10	83.40	6.24	6.09	5.01
4	Bahrain	11	4	77.48	5.73	4.42	5.33
5	Belgium	254	10	81.67	5.78	5.94	5.10
6	Bermuda	1,272	10	NA	NA	NA	NA
7	Brazil	197	10	71.77	3.36	4.71	3.63
8	British Virgin Islands	81	10	NA	NA	NA	NA
9	Bulgaria	3	1	NA	3.54	3.61	4.35
10	Canada	4,050	10	83.98	5.81	5.38	5.12
11	Cayman Islands	1,737	10	NA	NA	NA	NA
12	Chile	178	10	78.91	4.98	4.59	4.89
13	China	2,514	10	76.65	4.27	4.36	4.26
14	Colombia	52	10	66.01	3.35	4.25	3.78
15	Cyprus	5	2	NA	5.14	4.87	4.91
16	Czech Republic	10	6	76.86	5.15	5	4.68
17	Denmark	283	10	84.55	5.74	5.25	5.16
18	Egypt	84	7	63.49	3.32	3.67	3.93
19	Estonia	16	9	72.83	5.22	4.72	5.07
20	Finland	634	10	85.67	6.49	5.87	5.07
21	France	1,393	10	76.44	6.34	5.42	4.74
22	Germany	1,841	10	83.18	6.16	6.1	5.00
23	Greece	252	10	68.15	4.54	3.83	3.99
24	Hong Kong	266	10	83.62	6.55	5.75	5.74
25	Hungary	22	9	72.83	4.88	3.94	4.56
26	Iceland	9	4	75.36	6.31	4.72	4.47
27	India	6,689	10	69.57	3.89	4.48	4.32
28	Indonesia	558	10	66.98	4	4.46	4.45
29	Ireland	235	10	80.68	5.19	5.04	5.36
30	Isle of Man	17	8	NA	NA	NA	NA
31	Israel	624	10	72.18	4.84	4.77	4.65
32	Italy	524	10	76.00	4.82	4.79	4.11
33	Japan	12,207	10	82.87	6.03	5.52	4.69
34	Jersey	16	7	NA	NA	NA	NA
35	Jordan	59	9	70.24	5.15	4.58	4.70
36	Kenya	3	3	64.35	4.38	4.56	4.10
37	Kuwait	90	7	81.64	4.65	3.82	4.24
38	Latvia	1	1	NA	4.86	4.26	4.76
39	Lithuania	16	9	71.34	5.06	4.69	4.42
40	Luxembourg	27	10	88.58	6.03	5.26	5.45
41	Malaysia	1,073	10	78.98	5.52	5.3	5.21
42	Marshall Islands	58	10	NA	NA	NA	NA
43	Mauritius	1	1	NA	4.83	4.35	5.09
44	Mexico	53	7	73.48	4.41	4.44	4.07
45	Morocco	5	2	70.35	4.89	4.07	4.30
46	Netherlands	378	10	83.32	6.2	6.09	5.37
47	New Zealand	276	10	78.81	5.06	4.93	5.40
48	Nigeria	22	9	63.61	2.98	3.97	4.28
49	Norway	345	10	90.97	5.31	5.46	4.87
50	Oman	65	9	81.19	5.75	4.17	5.00

51	Pakistan	99	10	57.88	3.31	3.63	4.09
52	Peru	62	10	71.35	3.56	3.89	4.29
53	Philippines	213	10	69.49	3.73	4.43	3.94
54	Poland	316	10	75.07	3.98	4.78	4.47
55	Portugal	51	10	74.46	6.11	5	4.41
56	Qatar	4	3	80.31	5.39	5.38	5.37
57	Romania	7	5	65.64	3.45	3.87	4.19
58	Russia	250	10	72.93	3.77	4.14	3.72
59	Saudi Arabia	157	8	78.64	5.68	4.41	5.16
60	Singapore	766	10	87.03	6.36	5.44	5.92
61	Slovak Republic	2	1	NA	4.07	4.36	4.59
62	Slovenia	11	5	73.39	5.24	4.41	4.62
63	South Africa	432	10	71.56	4.48	4.42	4.82
64	South Korea	5,353	10	79.46	5.62	4.81	4.53
65	Spain	212	10	74.29	6.04	4.82	4.42
66	Sri Lanka	26	9	62.49	4.81	4.42	4.33
67	Sweden	739	10	85.88	5.7	5.69	5.15
68	Switzerland	806	10	88.43	6.61	6.47	5.11
69	Taiwan	5,480	10	82.53	5.51	5.39	5.16
70	Thailand	296	10	70.46	4.53	4.34	4.58
71	Turkey	921	10	64.04	5.13	4.23	4.49
72	United Arab Emirates	26	5	81.70	6.43	5.35	5.52
73	United Kingdom	4,426	10	78.76	5.35	5.61	5.16
74	United States	19,106	10	75.69	5.73	5.67	5.03
75	Vietnam	141	1	NA	3.41	3.33	4.43
	Total	**82,367**	**621**				

Table 2: Summary statistics

Variable	Mean	StDev	Distribution 5th	25th	50th	75th	95th
TobinQ	1.70	1.33	0.69	0.96	1.26	1.89	4.23
R&D Intensity	3.49%	7.26%	0.00%	0.00%	0.62%	3.34%	17.25%
Sales HHI	14.77%	13.97%	3.83%	5.85%	9.58%	18.26%	43.45%
Log of MV (~US$)	12.23	2.02	8.82	10.84	12.22	13.64	15.65
Blockholding	38.83%	24.92%	1.30%	17.90%	37.47%	58.28%	80.86%
Capex ratio	4.88%	5.66%	0.18%	1.31%	3.05%	6.22%	16.22%
Leverage	11.32%	14.21%	0.00%	0.00%	5.57%	18.18%	41.15%

Table 3: Baseline results

	(1)	(2)	(3)	(4)
	Without competition TobinQ	**Full sample TobinQ**	**Developing TobinQ**	**Developed TobinQ**
R&D Intensity	4.376***			
	(34.19)			
Medium Competition Dummy		0.00694	0.0620***	-0.0146
		(0.60)	(2.60)	(-1.09)
Low Competition Dummy		0.0253*	0.0609**	0.0176
		(1.91)	(2.08)	(1.15)
High Competition Dummy* R&D Intensity		4.284***	0.838	4.228***
		(22.24)	(1.42)	(21.26)
Medium Competition Dummy* R&D Intensity		4.214***	1.427	4.223***
		(24.09)	(1.31)	(23.13)
Low Competition Dummy* R&D Intensity		4.887***	4.051***	4.868***
		(21.31)	(2.80)	(20.34)
Log of MV	0.168***	0.167***	0.226***	0.155***
	(61.01)	(60.61)	(35.95)	(49.21)
Blockholding	0.273***	0.274***	0.163***	0.282***
	(12.80)	(12.84)	(3.63)	(11.29)
Capex	1.130***	1.137***	0.0168	1.482***
	(12.57)	(12.66)	(0.12)	(12.86)
Leverage	-1.148***	-1.149***	-1.109***	-1.139***
	(-33.42)	(-33.45)	(-15.97)	(-28.86)
Country F.E.?	Yes	Yes	Yes	Yes
Industry F.E.?	Yes	Yes	Yes	Yes
Year F.E.?	Yes	Yes	Yes	Yes
N	82367	82367	14716	64470
adj. R-sq	0.265	0.265	0.269	0.275

Table 4: Endogeneity checks

	GMM Model			Lag 2 R&D Ratio		
	(1)	(2)	(3)	(4)	(5)	(6)
	TobinQ	TobinQ	TobinQ	TobinQ	TobinQ	TobinQ
Medium Competition Dummy	0.00385	0.0302	-0.00475			
	(0.12)	(0.70)	(-0.12)			
Low Competition Dummy	0.0347	-0.0141	0.0187			
	(0.71)	(-0.19)	(0.30)			
High Competition Dummy* R&D Intensity	1.558***	-0.916	1.703***			
	(3.23)	(-1.26)	(3.28)			
Medium Competition Dummy* R&D Intensity	2.120***	-0.602	2.272***			
	(4.41)	(-0.37)	(4.56)			
Low Competition Dummy* R&D Intensity	2.203***	8.023**	2.331***			
	(3.41)	(2.41)	(3.32)			
Lag 2 Medium Competition Dummy				-0.00347	0.00846	0.00693
				(-0.25)	(0.27)	(0.44)
Lag 2 Low Competition Dummy				0.00726	0.0441	0.0183
				(0.44)	(0.96)	(1.01)
Lag 2 High Competition Dummy* R&D Intensity				3.587***	1.120	3.571***
				(17.48)	(1.23)	(16.84)
Lag 2 Medium Competition Dummy* R&D Intensity				4.150***	0.646	4.072***
				(18.54)	(0.76)	(17.48)
Lag 2 Low Competition Dummy* R&D Intensity				4.277***	9.756**	4.239***
				(15.17)	(2.47)	(14.44)
Log of MV	0.549***	0.473***	0.556***	0.174***	0.235***	0.160***
	(32.31)	(13.52)	(28.24)	(51.78)	(27.00)	(44.23)
Blockholding	0.330***	0.216	0.391***	0.140***	0.247***	0.119***
	(5.57)	(1.61)	(5.80)	(5.47)	(3.99)	(4.13)
Capex	0.667***	0.309	0.872***	1.127***	-0.316	1.536***

	(4.37)	(1.46)	(4.34)	(8.89)	(-1.63)	(9.81)
Leverage	-0.685***	-0.900***	-0.844***	-1.048***	-0.956***	-1.034***
	(-6.28)	(-3.97)	(-6.52)	(-24.94)	(-10.34)	(-22.00)
Country F.E.?	Yes	Yes	Yes	Yes	Yes	Yes
Industry F.E.?	Yes	Yes	Yes	Yes	Yes	Yes
Year F.E.?	Yes	Yes	Yes	Yes	Yes	Yes
N	71376	11540	57413	46830	6856	38532
adj. R-sq				0.285	0.346	0.293

Table 5: Country-level determinants

	ICRG		Overall Infrastructure		Research & Training Services		Competition	
	Low	High	Low	High	Low	High	Low	High
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Medium Competition Dummy	0.0709***	0.00250	0.0399	-0.00651	0.0565**	-0.00863	-0.0214	-0.00774
	(3.02)	(0.14)	(1.59)	(-0.49)	(2.18)	(-0.65)	(-0.97)	(-0.46)
Low Competition Dummy	0.0325	0.0461**	0.0410	0.0216	0.0862***	0.0190	-0.0251	0.0333*
	(1.14)	(2.27)	(1.35)	(1.43)	(2.58)	(1.28)	(-1.10)	(1.73)
High Competition Dummy* R&D Intensity	3.742***	5.171***	1.553***	4.263***	1.241*	4.218***	3.271***	3.969***
	(13.05)	(15.78)	(3.13)	(21.20)	(1.69)	(21.29)	(4.50)	(18.00)
Medium Competition Dummy* R&D Intensity	3.805***	4.392***	4.556**	4.205***	1.340	4.207***	3.539**	4.217***
	(14.39)	(15.04)	(2.54)	(23.37)	(1.04)	(23.17)	(2.50)	(20.65)
Low Competition Dummy* R&D Intensity	4.770***	5.076***	5.091***	4.845***	4.210***	4.858***	4.064***	4.738***
	(9.10)	(16.25)	(5.29)	(19.96)	(2.93)	(20.37)	(5.43)	(16.87)
Log of MV	0.207***	0.137***	0.222***	0.156***	0.230***	0.155***	0.180***	0.168***
	(40.18)	(32.23)	(35.61)	(49.39)	(35.46)	(49.78)	(36.18)	(43.36)
Blockholding	0.428***	0.232***	0.150***	0.287***	0.187***	0.276***	0.150***	0.282***
	(10.49)	(6.71)	(3.42)	(11.43)	(3.89)	(11.20)	(4.52)	(9.29)
Capex	1.052***	1.366***	0.168	1.439***	-0.0559	1.480***	0.221*	1.408***
	(6.61)	(8.88)	(1.20)	(12.59)	(-0.40)	(13.00)	(1.80)	(10.04)
Leverage	-1.188***	-1.159***	-1.080***	-1.149***	-1.125***	-1.132***	-0.814***	-1.210***
	(-20.27)	(-20.00)	(-16.04)	(-28.78)	(-15.63)	(-28.89)	(-13.99)	(-25.83)
Country F.E.?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry F.E.?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year F.E.?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	22675	34578	15000	64186	13563	65623	21532	44716
adj. R-sq	0.274	0.289	0.271	0.276	0.275	0.276	0.263	0.254

Table 6: Asset HHI robustness check

	(1) Full sample TobinQ	(2) Developing TobinQ	(3) Developed TobinQ
Medium Competition Dummy	-0.0233**	0.0135	-0.0367***
	(-2.00)	(0.56)	(-2.68)
Low Competition Dummy	-0.0235*	-0.0209	-0.0268*
	(-1.76)	(-0.70)	(-1.76)
High Competition Dummy* R&D Intensity	4.259***	0.913	4.236***
	(21.82)	(1.34)	(20.92)
Medium Competition Dummy* R&D Intensity	4.124***	0.692	4.109***
	(23.84)	(0.66)	(22.88)
Low Competition Dummy* R&D Intensity	4.928***	4.318***	4.894***
	(22.09)	(3.38)	(21.02)
Log of MV	0.168***	0.228***	0.155***
	(60.79)	(36.03)	(49.40)
Blockholding	0.274***	0.155***	0.285***
	(12.85)	(3.44)	(11.39)
Capex	1.115***	0.0207	1.449***
	(12.39)	(0.15)	(12.56)
Leverage	-1.145***	-1.105***	-1.135***
	(-33.29)	(-15.88)	(-28.75)
Country F.E.?	Yes	Yes	Yes
Industry F.E.?	Yes	Yes	Yes
Year F.E.?	Yes	Yes	Yes
N	82086	14612	64305
adj. R-sq	0.266	0.271	0.275