The Innovation Arms Race*

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Abstract

Economists have long recognized that competition and innovation interact as key drivers of economic growth (Schumpeter, 1943; Arrow, 1962; Aghion and Howitt, 1992). Acknowledging this, regulators carefully scrutinize competitive behaviors that potentially affect innovation incentives, in particular in the field of M&A (Shapiro, 2012). Do acquisitions of innovative targets spur or stifle innovation? To address this question, we test the Innovation Arms Race hypothesis, providing a first large scale empirical investigation of M&A effects on acquirer rivals' incentives to innovate and the equilibrium outcome resulting from this competitive process. Our results are consistent with the Innovation Arms Race hypothesis predictions: acquisitions of innovative targets push acquirer rivals to invest more in innovation, both internally through research and development (R&D) and externally through acquisition of innovative targets (the correlated investment prediction) and this increase in innovation investment under pressure of rivals leads to a decrease in firm market valuation (the value decrease prediction). These results are robust to endogeneity and are driven by High-Technology and (to some extent) Healthcare industries. This arms race process appears stronger for leaders and (to some extent) firms under strong competitive pressure (so-called neck-and-neck firms). Initial patents and patent citations based evidence shows no sign of innovation investment efficiency decline, suggesting that the Innovation Arms Race generates a transfer of economic rent favorable to consumers.

Keywords: competition, innovation, mergers and acquisitions

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1. Introduction

Competition and innovation fuel economic growth and economists have long recognized their complex interactions (Schumpeter, 1943; Arrow, 1962; Aghion and Howitt, 1992). Accordingly, regulatory agencies in charge of competition supervision take into account competitive behavior side-effects on innovation when dealing with specific cases. This is particularly the case when reviewing mergers and acquisitions (M&A). The 2010 release of the Horizontal Merger Guidelines issued by the U.S. Department of Justice and Federal Trade Commission (DOJ/FTC)[1] dedicates Section 6.4 to the analysis of unilateral effects on innovation and product variety. As emphasized in Shapiro (2012), the M&A effects on innovation incentives have become an integral part of the DOJ/FTC review process.

The importance given in DOJ/FTC M&A review process to acquisition side-effects on innovation is in itself enough to motivate our study: knowing the typical effects of mergers on innovation incentives has policy implications. the regulatory agencies' point of view matters to the merging parties. Depending on whether M&A transactions foster or dampen acquirer's rivals' innovations, the DOJ/FTC may be indeed willing to adopt a more lenient or more restrictive attitude towards transactions filed for approval. More than that, however, the driver for the regulatory interest is the critical role that innovation incentives play in economic growth. Given the scale and breadth of acquisition activity, they can have broad implications for aggregate innovation.

Game theory provides the necessary theoretical foundation to study equilibrium outcomes of escalating competitive situations in which each party focuses on out-doing the others within the Arms Race game, initially introduced to study competition among countries. In a non-cooperative situation, each player's dominant strategy is to choose the "high" action and the resulting Nash equilibrium is worse for each one than if they had chosen "low" action (Osborne, 2003). The theory therefore provides clear and unambiguous predictions to test the Arms Race Hypothesis: (i) firms should invest more in innovation in response to rivals' investments in innovation (the correlated investments prediction) and (ii) the resulting outcome should be value destroying for the parties in competition, consistent with either a decline in innovation investment efficiency or a transfer of rents beneficial to consumers (the value decrease prediction). Interestingly, the combination of these two predictions identifies the Arms Race Hypothesis as an alternative to the classic Schumpeter (1943) Rent Dissipation hypothesis (that implies less investments in innovation in response to an increase in competitive pressure, not more) and Arrow's (1962) Competition Escape hypothesis (that implies a non value destroying, if not value creating, effect of

[1] https://www.ftc.gov/public-statements/2010/08/horizontal-merger-guidelines-united-states-department-justice-federal

firm investments in response to an increase in competitive pressure), as summarized in Figure 1. Whether the *Arms Race*, the Schumpeter *Rent Dissipation* or Arrow *Competition Escape* hypothesis provide a better depiction of competition in the field of innovation is an empirical issue and our empirical strategy is designed to confront their predictions with the facts.

While a large body of literature on innovation has developed in financial economics, only a limited number of recent contributions focus explicitly on interactions between M&A and innovation. Lerner, et al. (2011) show that leveraged buyouts do not reduce innovation at portfolio companies. Atanassov (2013) asks whether the threat of hostile takeovers stifle innovation and reports results inconsistent with such claim. Phillips and Zhdanov (2013) suggest that large firms, by their acquisitions, provide incentives to small firms to invest in innovation to become attractive targets and this task sharing could be socially efficient. Bena and Li (2014) investigate interactions between M&A and innovation and report that innovative firms are more likely to engage in M&A, that technological overlap between the merging parties increases the probability of a match, and that innovation-driven acquisitions create more value in the long run. Chen et al. (2016) adopt a different perspective and study the role of envy (generated by innovation awards obtained by rivals) in the willingness to make acquisitions. Their results suggest that behavioral factors play a role. Cunningham et al. (2020), studying the pharmaceutical industry, argue that acquisitions may be motivated by the willingness to kill potential innovation by rivals. In a similar vein, Kamepalli et al. (2020) study the impact of high-priced acquisitions of entrants by incumbents on incentives to innovate and argue that such acquisitions do not necessarily stimulate innovation. None on these contributions focus specifically on the effects of acquisitions on acquirer rivals' incentives to innovate and the resulting outcomes of this competitive process. This is our main endeavor.

Our study covers the period 1996 to 2017, constrained by the availability of the Hoberg and Phillips (2010) (HP henceforth) similarity scores. We follow all firms listed on the New-York Stock Exchange (NYSE), National Association of Securities Dealers Automated Quotations (NASDAQ), and American Stock Exchange (AMEX) during that period, excluding financial institutions (Standard Industrial Classification (SIC) codes 6,000 to 6,999) because of the lack of data on innovation. This panel data set is composed of 49,818 firm-year observations. We collect M&A transactions in the Thomson Reuter (now Refinitiv) SDC database. We include both horizontal and non-horizontal transactions because the definition of horizontal transactions is subject to industry classification limitations (Bhojra et al., 2003) and because M&A effects on acquirer rivals' incentives to innovate may not be limited to within industry transactions. We also keep acquisitions of unlisted targets in our sample because these firms are important players in the field of innovation (Gao et al., 2018). Our M&A sample includes 44,643 transactions.

Firms can invest in innovation organically by spending more on research and development (R&D) and externally by buying innovative targets. These will be the dependent variables used to test the correlated investment prediction. These variables are innovation inputs and should, therefore, capture firms' intention to react to rivals' moves. Capturing value effects of innovation investments to test the value decrease prediction is challenging because cash-flow consequences of these investments may take years before they materialize. Instead of relying on some operational performance measure, we follow Bloom et al. (2013) and select a market based measure of valuation. Stock prices react to the capitalized value of cash-flow consequences of investment decisions as soon as the information is available to investors. The anticipatory nature of the market-based value should therefore allow us to capture valuation effect of innovation investments. We borrow the firm valuation equation from Fama and French (1998). Our variable of interest is a measure of intensity of innovative acquisitions (IA) by firm rivals[2]. We start by identifying innovative targets in our M&A sample using R&D investment intensity in their 3-digit SIC industry[3]. Next, we collect the ten closest firm rivals ($10NN$) in the product market space using HP similarity scores. This set of firm rivals should be particularly relevant because it focuses on product market competition, similarly to the DOJ/FTC definition of the relevant market. Finally, we compute our measure of innovative target acquisition intensity for this $10NN$ set of firm rivals (rivals' IA henceforth). To test the Arms Race Hypothesis correlated investment prediction, we regress the firm's R&D (the R&D equation) and IA intensity (the IA equation) on this measure of rivals' IA. Testing the second Arms Race Hypothesis prediction (the value decrease prediction) entails studying the value effect of these investments. We do so by regressing the logarithm of one plus the difference between the market value and book value of total assets scaled by the book value of total assets (lnMTBA) on firm excess investments (defined as the difference between the current year investment and the three year historical average) in R&D and IA in response to rivals' IA. Our baseline analyses are performed at the intensive margin, keeping only firms whose rivals did perform acquisitions, to avoid producing results driven by firms never exposed to such rivals' moves and we report results at the extensive margin as a robustness check. Our regressions include firm and year fixed effects as well as time-varying covariates.

It is clearly apparent that R&D and innovative acquisitions are interdependent decisions. We control for this source of simultaneity bias potentially affecting our test of the correlated investment prediction using the conditional mean independence theorem (Stock and Watson, 2020). Because we perform a peer

[2] Our baseline results rest on a count-based measure and we report corresponding value based results in Appendix.

[3] Because our sample of M&A transactions include unlisted targets, we can't use HP similarity scores to collect targets' industry peers.

effect analysis (rivals are peers of the firm under focus and therefore subject to the same latent factors), we lag by one year our measure of IA by $10NN$ rivals to use a predetermined independent variable, which is one way to cure this source of endogeneity (Angrist and Pischke, 2009). However, the latent factors that we are concerned with can be persistent through time, reducing the effectiveness of our lagging strategy. Therefore, we check the robustness of our correlated investment prediction test with an instrumental variable approach. Specifically, as in Homberg and Mattray (2018), we use the U.S. R&D tax credits program implemented at the state level from 1982 to 2006 as an exogenous shock to incentives to allocate resources to internal innovation, at the expense of external innovation through acquisitions.

Our main results are clear: (i) firms react to an increase in their rivals' innovative acquisitions by investing more in innovation, both organically (R&D) and externally (IA), and (ii) these investments made under pressure from rivals' innovative acquisitions are negatively correlated with market valuation (lnMTBA). Taken together, these results support the Arms Race Hypothesis. Morevoer, economic effects are sizeable.

More specifically, we use a specification that controls for firm fixed effects, year fixed effects, time varying control variables (return on assets (ROA henceforth), leverage, cash, intangibility and equity market to book (MTB henceforth) ratios) to the test of the correlated investment prediction and find a positive and highly significant (p-values on the order of 0.1%) coefficient on one-year lagged rivals' innovative acquisitions in both the R&D and the IA equations. The economic effect is sizeable: a one standard deviation increase in rivals' IA (count based) increases R&D by 4.7 % and IA by 51.8 % with respect to their unconditional averages. These results control for simultaneity between R&D and innovative acquisition decisions thanks to the conditional mean independence theorem and are not sensitive to the inclusion of the IA and R&D in the R&D and IA equations respectively. We obtain comparable results working at the extensive margins (including all firms, whether or not their rivals did undertake IA), when limiting our M&A sample to change of control transactions, or to horizontal transactions (the acquirer and the target share the same 3-digit SIC code). However, if we limit our M&A sample to public target acquisitions, results are only partially consistent with the correlated investment prediction. This emphasizes the importance of taking into account small private targets to capture IA effects. Results obtained using our instrument and a two-stage least square estimator (2SLS) confirm that a causal interpretation of the correlated investment prediction results is warranted. Using a value-based measure of intensity of innovative acquisitions by firm rivals does not alter these conclusions.

Market value regressions that test the Arms Race's value decrease prediction display consistently negative and statistically significant coefficients for the interaction terms between rival IA investments and firm excess R&D and excess IA[4]. These results are obtained controlling again for firm fixed effects, year fixed effects and time varying control variables included in the Fama and French (1998) market valuation equation.

We next replicate our results by industry, using the Fama and French five industries classification[5]. The High-Technology and (to some extent) Healthcare industries are driving our results. This makes sense: an innovation arms race will occur in equilibrium if market conditions are such that there are enough incentives for both rivals to invest in innovation, and High-Technology and Healthcare industries satisfy these conditions as innovation intensive.

We also perform within industry investigations. We start by distinguishing industry leaders and laggards (firms above and below the industry median ROA and market share respectively). We anticipate that industry leaders are more likely to react to competitive pressure by investing more in innovation while industry laggards may be too financially constrained to follow this strategy (these arguments ground partially the Schumpeter (1943) rent dissipation and Arrow (1962) competition escape hypotheses[6]). Our results only partially support these predictions: industry leaders and laggards both react to rivals' IA by investing more in R&D and IA but industry leaders invest significantly more in IA than industry laggards. Excess investment in R&D and IA by industry leaders negatively impact firm market value, consistent with the Arms Race value decrease prediction. Aghion et al. (2005) argue that the relation between competition and innovation follows an inverted U shape, with neck-and-neck firms (firms in fierce competition against close rivals) having the highest incentives to invest in innovation. We follow Chen and Wu (2019) and use HP similarity scores to identify firm and neck-and-neck competition. Our results reveal that neck-and-neck firms are displaying a stronger R&D investment reaction to rivals' IA and that this behavior is value decreasing.

We finally investigate whether the loss of value generated by the Arms Race mechanism finds its roots in a decline in innovation efficiency or a transfer of rents beneficial to the consumer. Using the NBER Patent Citations data file (Hall et al., 2001) and measuring innovation output as the logarithm of the three years forward cumulated number of patents or patent citations, we don't find evidence of a decrease in innovation efficiency. Thus, this preliminary investigation appears to support a transfer of rents to the consumers, an outcome that should reduce regulatory authorities' concerns.

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[4] Results statistically significant at 1% or 5% level of confidence, depending on the specification.
[5] Available at http://mba.tuck.dartmouth.edu/pages/faculty/ken.french/data_library.html.
[6] The anticipation of lower benefits from innovation leading to less innovation is another channel through with the Schumpeter (1943) rent dissipation hypothesis may be at work.

Our contribution to the M&A regulation debate is twofold: the broad picture is that M&As spur investment in innovation but without increasing incumbents' rents, due to the arms race equilibrium outcome of this process. Our industry level and within-industry results emphasize the actual effect of any given M&A transaction on acquirer rivals' incentives to innovate is context dependent. Industry characteristics and the competitive position of involved industry players are key determinants here. Beyond this contribution to the M&A regulation debate, our results highlight the importance of firm interactions in shaping investment decisions in innovation, one more form of peer effects (eg. Foucault and Frésard, 2014; Bustamante and Frésard, 2020). Our results are also informative on the choice between organic and external innovative growth, showing the conditions under which these materialize in response to competitive pressure. Finally, given the scale and scope of acquisition activity, the analysis of how rivals' acquisitions impact a firm's innovation incentives have implications for the broader literature on the determinants of innovation.

We summarize the relevant literature in Section 2. Section 3 is dedicated to our empirical design and Section 4 to our main results. Robustness checks are summarized in Section 5, before we conclude.

2. Literature Review

2.1. Innovation in the Economic and Finance Literature

Innovation's role in economic growth makes it a research topic of first order importance and it has attracted significant attention. The academic literature is vast and giving a fair account of it is beyond the scope of this literature review. We will just mention two examples, representative of the key issues at stake. Romer (1990) develops a model of monopolistic competition that recognizes the endogenous nature of technological changes and its specificities (in particular, the one-time fixed costs of development with no cost of reuse). Aghion and Howitt (1992) incorporate technological obsolescence as a negative externality of innovation in their study of the relation between innovation and economic growth. The authors conclude that a *laisse-faire* policy (letting firms choose frequency and size of innovation) leads to too low economic growth. Unsurprisingly, innovation has also been actively studied in the management literature but the field is again too broad to be summarized here. A representative example is Knott (2008). In short, the author studies whether R&D efficiency is born (organizational IQ) or made (absorptive capacity). Using a large panel of U.S. industries over the 1981 to 2000 period and measuring innovation efficiency as elasticity from a Cobb-Douglas production function, the author concludes that organizational IQ dominates absorptive capacity.

The finance literature has followed this trend. Investigated questions bear among others on the relation between firm organizational form and innovation, the profile of innovators, and market valuation of innovation. Fulghieri and Sevilir (2009) study the impact of competition on the organization of innovation activities within the firm and its financing. Their theoretical analyses conclude that it is optimal for firms subject to competition shocks to choose external organizational structures, in collaboration with specialized start-ups, to hasten product innovation. Seru (2014) reports that single segment firms generate more patents and citations than multi-segments firms. The author claims that the relation is causal, addressing endogeneity using failed M&A attempts and a difference-in-differences identification strategy. Hirshleifer et al. (2012) take a behavioral approach and study the relation between CEO personality (overconfidence, using the Malmendier and Tate (2008) option-exercise based proxy of overconfidence, as well as press-based ones) and innovation. They conclude that overconfident CEOs more aggressively pursue innovation but that this does not necessarily create more value for shareholders. Cohen et al. (2013), and Hirshleifer et al. (2013, 2017) uncover systematic stock market miss-valuation of innovation activities. In Cohen et al. (2013), the authors show that, while successful R&D investment is to some extent predictable, investors seem to ignore this source of public information and that building a long-short trading strategy around this systematic source of pricing errors is valuable. Hirshleifer et al. (2013, 2017) show that innovation efficiency and originality are strong predictors of future stock returns.

2.2. Innovation and Competition

The classic Schumpeterian view (Schumpeter, 1943) of competition is that it erodes innovation. Increasing competition leads to a transfer of rents from producers to consumers (the Rent Dissipation hypothesis) and firms under pressure reduce their investments, including those in innovation. Arrow (1962) argues on the contrary that, under the pressure of competition, firms invest more aggressively in innovation to differentiate their products from competitors' ones and to better serve consumers (the Competition Escape hypothesis). Recently, the Competition Escape hypothesis has received some empirical support in Hoberg and Phillips (2016) whose empirical results based on Security Exchange Commission (SEC) 10K filings product descriptions lend support to endogenous product differentiation. To some extent, the Competition Escape hypothesis also grounds the contribution of Hombert and Matray (2018). The authors study whether more innovative U.S. manufacturing industries better resist the pressure of import competition from China. Controlling carefully for endogeneity, reported results confirm that this is the case. Aghion et al. (2005), on their side, argue that the relation between competition and innovation should exhibit an inverted-U shape. Firms in close competition (called neck-and-neck firms) have the strongest incentives to innovate to escape from rivals' pressure because pre-innovation rents are more strongly reduced by an increase in product market competition. Laggard firms on their side will suffer too much from an increase in competition to invest more in innovation while leader ones are shielded enough and don't invest in such a strategy. The authors report consistent empirical evidence on a U.K. panel data set over the period 1973 to 1994.

Another channel through with competition affects innovation is spillover effects among rival firms. Jaffe (1986) focuses on technological spillovers. The position of firms in the technological space is captured thanks to the use of a patent database. Using a sample of 432 firms and data collected over two periods (1972 to 1974 and 1978 to 1980), the author reports a positive spillover effect of rivals' investments in R&D on R&D productivity (measured by the ratio of patents per dollar investment in R&D), especially for high R&D firms, but mixed evidences for profit and market value spillovers (positive for high R&D firms and negative for low R&D firms). Bloom et al. (2013, 2017) disentangle the business spillover effect from the technological one. As in Jaffe (1986), technological spillover is based on the firm position in the technological space while business spillover weights rivals R&D by distances in the product space using 4-digit SIC codes. While technological spillover is about knowledge sharing, as in Jaffe (1986), a socially beneficial outcome, business spillover is introduced by the authors as competitive mechanism by which firms are damaged by loss of market share. The authors use tax-induced changes of R&D capital user cost to address endogeneity issues and report that the technological spillover effect dominates the business one.

2.3. Innovation and M&As

The literature has long recognized the risk that financial pressure induces short-termism and that this hampers innovation (see e.g. Stein, 1989, Holmstrom, 1989). Atanassov (2013) explores whether this applies to hostile takeovers. Results come from the analysis of a large sample of listed U.S. firms over the period 1976 to 2000, using business combination anti-takeover laws as exogenous shocks to the probability of hostile takeovers and a difference-in-differences approach as identification strategy. The author reports that innovation declines in the wake of business combination laws enactment and that this negative relation is mitigated in the presence of alternative governance mechanisms (large shareholders, leverage and product market competition in particular), results that are inconsistent with the threat of hostile acquisitions stifling innovation. Phillips and Zhdanov (2013) go one step farther. Their theoretical analysis, corroborated by empirical results, concludes that it may be optimal for large firms to acquire innovation in place of developing it internally. By doing so, these large firms provide incentives to small firms to invest more in innovation, the possibility of being acquired at a large premium acting as a strong stimulus. This incentive-based mechanism generates a positive relation between the intensity of the M&A activity and innovation in the economy, a socially desirable outcome. Recently, Kamepalli et al. (2020) challenge this view, arguing that highly priced acquisitions of new entrants by incumbents may reduce incentives to innovate in industries where customers face switching costs and benefit from network externalities.

Bena and Li (2014) focus on asset complementarities to study the motives and outcomes of acquisitions under the lens of innovation. Asset complementarity is measured by the technological overlap between merging parties (in particular, patent cross-citations and common knowledge base). Studying the 1984 to 2006 period, the authors report that more innovative firms are more likely to engage into acquisitions, that the degree of technological overlap increases the probability of merger and that innovation-driven acquisitions achieve better long-term real outcomes in terms of innovation output, operating and market-based performance.

Chen et al. (2016) adopt a behavioral perspective to study motivations to engage in the M&A market. The authors take the case of innovation awards granted by the R&D Magazine from 1965 to 2015, presented as the *Oscar of Innovation*, and use state-level trade-secret law adoptions under the Uniform Trade Secrets Act to break endogeneity. Results confirm that the propensity to acquire increases following R&D awards won by competitors, that this effect is magnified in the absence of financial constraints, by stronger technology competition and with more overconfident CEOs. Acquirers focus moreover on more innovative targets.

The relation between M&A and innovation is also certainly industry specific. Cunningham et al. (2020) focus on the pharmaceutical industry. Making use of very granular data on product and patent characteristics, the authors uncover strategies designed by incumbent firms to kill potentially threatening innovations by acquiring rivals in their early life cycle stage and stopping the development of new drugs. Haucap et al. (2019) develop a model interacting M&As and product innovation and test their prediction on a sample of European transactions also in the pharmaceutical industry, using a differences-in-differences specification as identification strategy. They report that average patenting and R&D of the merged entity and its rivals decline substantially in post-merger periods. Cunningham et al. (2020) and Haucap et al. (2019) results suggest that in the pharmaceutical industry, M&A transactions negatively impact innovation.

To summarize, the literature on innovation is vast and addresses essential questions such as economic growth, competition, and business strategies. Consequently, regulatory agencies in charge of competition supervision have increasingly incorporated side-effects on innovation incentives in their investigations (Shapiro, 2012). To the best of our knowledge, the Arms Race hypothesis has not been tested as such. As explained in introduction and clearly apparent in Figure 1, it generates two predictions (correlated investments and value decrease) that, taken together, allow us to differentiate it from the Schumpeter (1943) Rent Dissipation and Arrow (1962) Competition Escape hypotheses.

3. Data and Empirical Design

3.1. Data

We use all NYSE, NASDAQ, and AMEX firms for which the necessary information can be collected in the Compustat and CRSP (Center for Research in Security Prices) databases, excluding financial institutions (SIC codes 6,000 to 6,999). Few financial institutions report R&D and/or patents because their research activities do not meet the necessary criteria to do so (Frame and White, 2004). Our period of analysis is constrained by the availability of product similarity scores provided in the HP dataset[7] and therefore starts in 1996 and ends in 2017.

M&A transactions are collected from the SDC database. We select all completed transactions between 1996 and 2017 and keep public, private, and subsidiary targets. Transactions with missing values are also included in our sample (they account for 46% of the transactions). Our sample contains 44,643 transactions, among which are 815 acquisitions of certain assets, 1,543 acquisitions of majority interests, 3,802 acquisition of partial interests, 653 acquisitions of remaining interests, 28,689 acquisitions of assets, 13 acquisitions, and 9,128 mergers according to the SDC deal forms classification. We do not require a minimum percentage to be acquired (85.21% of acquisitions in our sample are full acquisitions). Note that we include both horizontal and non-horizontal transactions because the definition of horizontal transactions is subject to industry classification limitations (Bhojra et al., 2003) and because M&A effects on acquirer rivals' incentives to innovate may not be limited to within industry transactions. We also keep acquisitions of unlisted targets in our sample because these firms are important players in the field of innovation (Gao et al., 2018).

[7] Available at http://hobergphillips.tuck.dartmouth.edu/industryclass.htm.

This data collection process leads to a firm-year panel composed of 49,818 observations. Column 1 of Table 1 displays its evolution through time[8]. The peak number of firms is reached in 1998 (3,449 firms), then declines progressively to be cut in half by the end of the period (1,569 firms in 2017), a significant decline analyzed in Doidge et al. (2017). Also clearly apparent in the table is the well-known wave pattern displayed by aggregate M&A activity, with the peak observed at the end of nineties, the rebound of the market in between the Internet bubble burst and the 2008 financial crisis, and its restart during the last decade (Alexandridis, 2017). Table 1 Column 2 provides the corresponding number of unique acquirers. The activity of repetitive acquirers is clearly apparent: our 49,818 firm-year observations are generated by the M&A activity of 6,289 unique firms, confirming previous findings (eg.: Fuller et al., 2001). Columns 3 and 4 report the corresponding number of acquisitions and aggregate deal values. Comparing the corresponding cells in Columns 2 (the number of unique acquirers by year) and 3 (the number of acquisitions acquirers), it appears that, on average, acquirers undertake approximately two acquisitions per year.

3.2. Variables

Dependent Variable

To test the Arms Race correlated investment prediction, we select dependent variables that capture firm investment in innovation (in a classic revealed preferences approach). But measuring investments in innovation is challenging. Granja and Moreira (2019) is one of the very rare papers working at the product level, using barcodes information collected in the Nielsen Retail Measurement Services scanner dataset (Kilts-Nielsen Data Center at the University of Chicago Booth School of Business). This database provides highly valuable product level information but is limited to the consumer goods industry. However, to the best of our knowledge, there is no standardized electronic database that tracks innovation at the product level for a large cohort of firms representative of the U.S. economy and in the long run. A first classic firm level measure is R&D, either as a flow (R&D expenses) or a stock (some measure of cumulated R&D expenses, potentially applying a depreciation rate, such in Jaffe (1986), Bloom et al. (2013, 2017) or Hombert and Matray (2018). An R&D-based measure has well-documented shortcomings (not all innovation investments meet the necessary materiality requirements to be accounted for as R&D and

[8] The number of firm-year observations is zero for 1996 because we lag our independent variable by one year in all our analyses to mitigate sources of omitted variables due to the peer effect type of regression that we estimated (Angrist and Pischke, 2009).

R&D is available only for listed firms). However, it is a measure of financial resources committed to innovation within the firm (an innovation input), which is what we want to capture (the intention to innovate). Alternative measures, such patents and patent citations, to the collection of which considerable resources have been dedicated (Hall et al., 2001 and Lerner and Seru, 2017), are measures of innovation output, less suited to our analysis because we are interested in strategic choices: a firm can choose to invest in R&D, but cannot choose to successfully produce a patentable innovation (and further, not all innovations are patented due to fears of disclosing information to competitors). A recent trend is the use of text-based analysis techniques to develop alternative measures of innovation, such as Bellstam et al. (2017) or Bowen et al. (2019). The textual material may come from SEC filings (such as the SEC 10K filings) or from patent applications. These techniques open the doors to broader measures of innovation but are not currently available o as in Homberg and Mattray (2018)ver long periods for large samples of listed firms. We, therefore, use R&D expenses divided by total assets (labelled *R&D Intensity* henceforth) as our measure of within-firm investment in innovation, because it is broadly available for U.S. non-financial firms.

Innovation investments can alternatively take the form of acquisitions of innovative targets. Acquiring innovation is a major motivation to enter into the M&A market, as documented in numerous academic contributions (eg.: Phillips and Zhdanov, 2013). Like *R&D Intensity*, this is a measure of innovation input, not (or less) subject to delays like the patenting process, and it complements within firm innovation investment measures to take into account resources allocated to external acquisitions of innovation. Moreover, firm acquisitions can easily be collected over long periods and for large samples thanks to the SDC database. Building our measure of innovative target acquisitions (labelled *Innovative Acquisitions* or IA henceforth) requires us to classify targets as innovative or not. We design a simple procedure, based on the degree of investment in R&D in the target industry, suited to public and private targets and easily replicable. The procedure follows three steps:

- for each year and 3-digit SIC industry, we compute the sum of R&D expenses by all Compustat firms (listed firms, therefore) belonging to this industry according to CRSP historical SIC codes. We next divide the sum of R&D expenses by the sum of total assets of the corresponding firms. This provides us an industry-year measure of R&D intensity;
- in the next step, for each year, we sort 3-digit SIC industries by industry R&D intensity. Innovative industries are industries in the highest quartile of R&D intensity;
- finally, we classify targets as innovative targets when, according to the 3-digit SIC code collected in SDC, they belong to an innovative industry.

This process of identifying the innovative targets allows us to take into account the rise and fall of innovation activities in each industry over time. Importantly, this simple industry-based procedure allows us to classify both listed and unlisted targets (these are known to be a major source of innovation in our economies) and provides us our second dependent variables, IA, defined as the number of innovative target acquisitions divided by the number of acquisitions[9]. Table 1 provides descriptive statistics. Out of 44,642 M&A transactions in our sample, 9,220 target innovative firms (Column 5). This amounts to close to twenty-five percent of the sample, to some extent (but not necessarily) a mechanical consequence of our IA identification procedure (industries are classified as innovative if they rank in the highest quartile by R&D intensity). The percentage of IA is also clearly declining through time, from 23.9% (723 divided by 3,021) in 1996 to 12% (167 divided by 1,387) in 2017, a trend most probably due to the high representation of Internet-related companies in mergers at the end of the nineties. It is also noteworthy to compare the sample of all IA (Column 5) to the subset of listed ones (Columns 7): these accounts for only 14.7% of the transactions (1,355 divided by 9,220), stressing the importance of private targets inclusion in our sample.

The investigation of the Arms Race value decrease prediction requires some measure of economic rent obtained thanks to innovation investments. The main issue here is that these investments take years to materialize, the patenting process itself introducing long delays (Hall et al., 2001; Lerner and Seru, 2017). Using accounting based performance measures like ROA is therefore problematic because the cash-flows generated by innovation investments will only occur many years after the corresponding investments. This leads us to select a market valuation-based measure as the dependent variable, like Bloom et al. (2013), to test the value decrease prediction: investors react quickly to public information affecting future cash-flows and, under the efficient market hypothesis (Fama, 1991), changes in market value represent the current value of these anticipated cash-flow streams. Changes in market value contemporaneous to firm innovation investments should therefore indicate the value effect, if any, of these investment decisions as perceived by investors. More specifically, we use the logarithm of one plus the market valuation ratio used in Fama and French (1998), which is the difference between the market value and book value of total assets scaled by the book value of total assets, denoted henceforth lnMTBA. The log transform helps to control for the significant skewness of MTBA and allows direct interpretation of coefficients as percentage changes in MTBA of a unit change in the variable of interest.

Table 2 reports descriptive statistics on all variables used in our multivariate analyses. As indicated in Column 6, the number of observations varies depending on data availability. Panel A is dedicated to

[9] In the absence of an acquisition by the firm-year under focus, IA is set to zero. We report also results with a value based measure of IA, built using deal values reported in SDC, available for roughly half of our M&A sample.

variables used to test the correlated investment prediction and Panel B, the value decrease prediction. Variables are grouped into dependent, independent and control variables, so as to clarify their status and clearly identify where endogeneity is potentially an issue[10]. In our sample of 49,818 observations, R&D expense amounts on average to 4.7% of total assets. Resources allocated to R&D is however highly heterogeneous, with a standard deviation of 8.8%, and right-skewed (the median is a mere 0.4%), witnessing that internal investments in innovation is driven by a sub-sample of R&D intensive firms. These figures are comparable to numbers reported in the extant literature. For example, He and Tian (2013) report that firms' R&D expenses amount to 5% of total assets in their sample of 5,640 firm-year observations over the period 1998 to 2003. Chang et al. (2015) display a comparable 4% average on a sample of 25,860 firm-year observations over the period 1993 to 2005. We also provide in Table 2 the average number of IA by firm-year, which is 0.103. The distribution is again highly right skewed, as the third quartile is still 0. IA are in fact concentrated into the last decile of the distribution (untabulated). The average MTBA ratio is 0.269, a figure that can't be compared to Fama and French (1998) because the authors don't report descriptive statistics.

Independent Variables

To test the Arms Race correlated investment prediction, we are interested in the effect of rival's IA on the subject firm's incentives to innovate. Our variable of interest is therefore a measure of intensity of such acquisitions by firm rivals. We label this measure RICI for Rival Intensity of Innovative Acquisitions – Count Based[11] and obtain it using the following procedure:

- we start by identifying innovative targets in our M&A sample as described above;
- next, we collect firm rivals. To this end, we use HP similarity scores to obtain, year by year, the portfolio of the firm's ten nearest neighbors in the product market space (denoted $10NN_t$).
- we count the number of acquisitions by $10NN$ rivals in year t: $RAC_{it} = \sum_{j \in 10NN_{it}} AC_{ijt}$ where AC_{ijt} is the number of acquisitions by rival j of firm i in year t;
- we count the number of IA by $10NN$ rivals in year t: $RIAC_{it} = \sum_{j \in 10NN_{it}} IAC_{ijt}$ where IAC_{ijt} is the number of IA by rival j of firm i in year t;
- $RICI$ for firm i in year t is finally defined as the ratio of $RIAC_{it}$ to RAC_{it}:

[10] By conditional mean independence, coefficients of independent variables can be given a causal interpretation even if some control variables are endogenous as long as, conditionally on these control variables, the variables of interest are exogenous (Stock and Watson, 2020, Section 6.8).

[11] We develop a similar measure for value based analyses reported in Appendix under the acronym *RIVI* for Rival Intensity of Innovative Acquisitions – Valued Based.

$$RICI_{it} = \frac{RIAC_{it}}{RAC_{it}} \text{ if } RAC_{it} > 0 \text{ and } 0 \text{ otherwise} \quad (1)$$

where i is the firm subscript and t is the year subscript.

RICI depends on the use of HP similarity scores to identify rivals. Similarity scores are refreshed each year based on product descriptions reported in SEC 10-K filings and therefore, our $10NN$ rivals portfolio compositions are themselves updated every year, providing a dynamic depiction of firms' competitive environment. Moreover, because HP similarity scores are built on product description similarities, identified rivals are firms that produce products most similar to the product portfolio of the firm under focus. This corresponds to concept of the relevant market described in the DOJ/FTC Horizontal Mergers Guidelines. The main limitation of RICI is that it captures only acquisition activities by listed rivals, while we know that the M&A market has witnessed a rise in private buyers' activities during the analyzed period (Eckbo et al., 2018).

Table 2, Panel A reports that, on average 17.8% of $10NN$ rivals acquisitions are innovative, with a highly right skewed distribution, more than half of the sample undertaking no innovative acquisitions (the median is 0). Indeed, the skewness reflects the fact that innovative acquisitions cluster (consistent with the Arms Race hypothesis), so that conditional on there being one innovative acquisition, on average 48.9% of rival acquisitions are innovative.

The value decrease prediction of the Arms Race hypothesis is a statement on the value effect of firm decisions to make innovative investments (whether as R&D expenses or buying innovative targets) under the pressure of IA by rivals. Therefore, our independent variables of interest will be the interaction of firm innovative investments and RICI. To capture the firm response specific to rivals pressure, we control for the firm historical innovation investment policy by decomposing the current R&D and IA into the three years historical R&D and IA averages and the current excess R&D and IA. This procedure generates the historical and excess R&D intensity and IA interactions with RICI, our two independent variables of interest to test the value decrease prediction:

$$RICI_{it} \times R\&D_{it}^{histo} = RICI_{it} \times \left(\frac{1}{3} \sum_{\tau=1}^{3} R\&D_{it-\tau}\right) \quad (2)$$

$$RICI_{it} \times IA_{it}^{histo} = RICI_{it} \times \left(\frac{1}{3} \sum_{\tau=1}^{3} IA_{it-\tau}\right) \quad (3)$$

$$RICI_{it} \times R\&D_{it}^{excess} = RICI_{it} \times \left(R\&D_{it} - \frac{1}{3} \sum_{\tau=1}^{3} R\&D_{it-\tau}\right) \quad (4)$$

$$RICI_{it} \times IA_{it}^{excess} = RICI_{it} \times (IA_{it} - \frac{1}{3}\sum_{\tau=1}^{3} IA_{it-\tau}) \tag{5}$$

where $R\&D_{it}^{excess}$ is the firm i excess R&D intensity in year t, IA_{it}^{excess} the excess IA in year t and $R\&D_{it}^{histo}$ and IA_{it}^{histo} the corresponding historical values.

Previous academic contributions have introduced more sophisticated measures of excess or investments, notably to test the empire building hypothesis (Baumol, 1959). For example, Frattaroli (2020) controls for firm age, sales, the presence of state ownership, ROA, book-to-market, and market leverage, in addition to industry and year fixed effects, to study the impact of the 2018 French Alstom Decree[12] on investment (see Table 7 differences-in-differences specification). The variations control for the normal level of investments and allow one to isolate the effect of the treatment on the excess (or abnormal) investments. By doing so, Frattaroli (and similar approaches) focuses on the fraction of investments that can be considered as abnormal with respect to a reference model of normal investments. We do not adopt such a strategy because we are interested in the change of firm investment behavior through time in response to an increase in competition. Using the historical firm behavior as reference allows us to isolate this change of behavior without any assumptions on a model of normal investment.

Table 2, Panel B, confirms that, on the sample used to test the value decrease prediction, RICI is also close to 17%, with a highly right-skewed distribution. Excess R&D intensity is on average close to zero, as it should be if R&D intensity isn't trending during the analyzed time period in our sample, but is highly heterogeneous, with a standard deviation (3.3%) close to the average R&D intensity in the sample (4%). We observe also a high heterogeneity for excess IA, all three quartiles being equal to zero, while the standard deviation is huge with respect of the average (the untabulated coefficient of variation is -32.73).

Control Variables

To test the correlated investment prediction, in addition to firm and year fixed-effects, we include in our multivariate specifications a set of time-varying firm level control variables. Specifically, we control for firm size (the natural logarithm of total assets), profitability (ROA, defined as the ratio of operating income before depreciation to total assets), capital structure (leverage, defined as the ratio of long term

[12] The 2018 French Alstom Decree designates energy, water supply, transportation, electronic communications and public health industries as strategic to the country's interest and enables the French public authorities to veto acquisition attempts of French firms active in these fields by foreign acquirers. Frattoroli (2020) shows that the adaptation of this new legislation has significantly reduced the probability of being acquired for firms active in these industries.

debt and debt in current liabilities to total assets), liquidity (cash ratio, defined as the ratio of cash position to total assets), the nature of assets (intangible ratio, defined as the ratio of intangible assets to total assets) and valuation (MTB, the ratio of market value of equity to book value equity, with book equity computed as in Davis et al., 2000). Descriptive statistics are provided in Table 2. The average size of our firms is $3,956 million (with a median of $417 million– untabulated – highlighting the strong right skewness of the distribution of firm size), with a corresponding ROA of 8.5%, leverage of 20.3%, cash ratio of 12.8%, intangible ratio of 16.2% and MTB of 3.06. Compared to descriptive statistics reported for similar samples (Cheng et al. 2015), the numbers are in the order of magnitude of what we expect to find. For example, the authors report an average ROA of 10% and leverage of 22%. When testing the robustness of our results to endogeneity, we also use a measure of firm level R&D tax incentive as instrumental variable, following Bloom and al. (2013), but we defer its description until Section 5.1.

Tests of the value decrease prediction rely on the Fama and French (1998) regression approach (Equation 1). The authors include a set of explanatory variables that include past, current, and future values of dividends, interest, earnings, investment, and R&D expenditures, respectively denoted D_{it}, I_{it}, E_{it}, dA_{it} and RD_{it}. Additional notations are used for two year leads and lags: dX_{it} is the two year change in X_{it} ($dX_{it} = X_{it} - X_{it-2}$) and dX_{it}/A_{it} is the two year change in X_{it} scaled by total assets. We replicate these variables following the description in their Section 1. The inclusion of scaled two year leads and lags of dividends, interest, earnings, investment, and R&D expenditures aim to control for investor anticipations. The set of control variables is listed in Table 2, Panel B, with corresponding descriptive statistics. As the authors do not provide descriptive statistics, we are not in a position to compare to them. Note also that adding the control variables used to test the correlated investment prediction (firm size, ROA, leverage, liquidity, intangible ratio) does not alter our results (untabulated).

3.3. Econometric Specification

The Correlated Investment Prediction

The decisions to allocate resources to innovation internally, in the form of R&D expenses, and/or externally, to acquire innovative targets, are clearly interdependent. To account for this source of correlation, our baseline specification is a system of two simultaneous equations, one for R&D Intensity and the other for Innovative Acquisitions:

$$R\&D_{it} = \alpha_i + \beta_t + \gamma\, RICI_{it-1} + \delta\, IA_{it} + \boldsymbol{Controls'}_{\boldsymbol{it-1}}\, \boldsymbol{\mu} + \epsilon_{it} \tag{6}$$

$$IA_{i,t} = \alpha_i + \beta_t + \gamma\, RICI_{it-1} + \delta\, R\&D_{i,t} + \boldsymbol{Controls'}_{\boldsymbol{it-1}}\, \boldsymbol{\mu} + \eta_{it} \tag{7}$$

where $R\&D_{it}$ and $IA_{i,t}$ are our dependent variables, α_i are the firm fixed-effects, β_t are the year fixed-effects, $RICI_{i,t-1}$ is the lagged value of our independent variable, $\boldsymbol{Controls'}_{\boldsymbol{i,t-1}}$ is the lagged values of our vector of control variables (we use bold notation for vectors), $\epsilon_{i,t}$ and $\eta_{i,t}$ are the errors terms. Under the correlated investment prediction of the Arms Race hypothesis, we expect that γ is positive in Equations 6 and 7.

Keeping in mind that the variable of interest is RICI, the presence of IA at the right-hand side of Equation 6 and R&D at the right-hand side of Equation 7 allows us to control for one source of endogenous omitted variable bias due to the omission of these variables thanks to the Conditional Mean Independence Theorem (Stock and Watson, 2020, Section 6.8)[13]. We defer the treatment of potential endogeneity of RICI itself, our independent variable for which a causal interpretation is relevant, to the robustness check Section 5.1. We also report results without R&D and IA as right-hand side variables to check whether our results are affected by the bad controls issue (Angrist and Pischke, 2009).

The Value Decrease Prediction

The test of the Arms Race hypothesis' value decrease prediction relies on expanded versions of the Fama and French (1998) regression specification:

$$lnMTBA_{it} = \alpha_i + \beta_t + \gamma\, RICI_{it} + \delta\, R\&D_{it} + \tau\, (RICI_{it} \times R\&D_{it}^{excess}) + \theta\, \left(RICI_{it} \times R\&D_{it}^{histo}\right) + \mu\, IA_{it} + \boldsymbol{Controls'}_{\boldsymbol{it}}\, \boldsymbol{\nu} + \epsilon_{it} \tag{8}$$

$$lnMTBA_{it} = \alpha_i + \beta_t + \gamma\, RICI_{it} + \delta\, IA_{it} + \tau\, (RICI_{it} \times IA_{it}^{excess}) + \theta\, \left(RICI_{it} \times IA_{it}^{histo}\right) + \mu\, R\&D_{it} + \boldsymbol{Controls'}_{\boldsymbol{it}}\, \boldsymbol{\nu} + \eta_{it} \tag{9}$$

where $\boldsymbol{Controls}$ is the vector of Fama and French (1998) explanatory variables, namely E_{it}/A_{it}, dE_{it}/A_{it}, dE_{it+2}/A_{it}, dA_{it}/A_{it}, dA_{it+2}/A_{it}, RD_{it}/A_{it}, dRD_{it}/A_{it}, dRD_{it+2}/A_{it}, I_{it}/A_{it}, dI_{it}/A_{it}, dI_{it+2}/A_{it}, D_{it}/A_{it}, dD_{it}/A_{it}, dD_{it+2}/A_{it} and dV_{it+2}/A_{it}. We use voluntarily contemporaneous dependent and independent variables because we expect investors to react quickly to public information of firm innovation investments. Under the value decrease prediction, we expect τ to be negative in

[13] Coefficients of the IA and R&D can however not be given any causal interpretation as the rank and order conditions for identification are not met.

Equation 8 and in Equation 9. These equations are estimated by ordinary least squares and standard errors are clustered at the firm-year level, to account for the panel structure of our dataset (Petersen, 2009).[14]

As emphasized in Figure 1, it is the combination of positive γ in Equations 6 and 7 (correlated investment) and negative τ in Equations 8 and 9 that discriminate the Arms Race hypothesis from the Schumpeter (1943) Rent Dissipation and the Arrow (1962) Competition Escape hypotheses.

4. Results

4.1. The Arms Race Hypothesis – Grand Average Results

We start by reporting average results obtained for the whole cohort of firms (49,818 firm-year observations for the correlated investment prediction and 29,890 for the value decrease prediction) and over the whole 1996 to 2017 period. Table 3 reports six specifications: the first four ones report results for the correlation investment prediction and the last two, for the value decrease prediction. Columns 1 and 2 contain estimates of Equations 6 and 7 respectively (that rely on conditional mean independence to control for simultaneity of decisions between R&D investments and innovative target acquisitions) and Columns 3 and 4, estimates of Equations 6 and 7 excluding R&D and IA as right-hand side variables (to check the robustness of our results to the potential bad control issues). Columns 5 and 6 present estimates of Equations 8 and 9.

The results show a clear picture: in Columns 1 to 4, the coefficient of RICI is positive and highly significant, consistent with the correlated investment prediction: lagged innovative acquisitions by rivals drives firms to invest more in R&D and IA. Moreover, these effects are economically sizable: a one standard deviation increase in RICI increases R&D by 4.7 % and IA by 51.8 % with respect to their unconditional averages. Notably, the RICI coefficient estimates are almost unchanged between Columns 1 and 2 and Columns 3 and 4: the interdependence between R&D and innovative acquisitions does not affect firm reactions to rival moves, as measured by RICI, and our results are not biased by a bad control issue. In Column 5, the coefficient of the interaction term between RICI and excess R&D is negative and significant at the 5% confidence level, while in Column 6, the coefficient of the interaction term between

[14] One may worry that the simulateneous presence of the MTB ratio as a control variable in investment Equations 6 and 7 and the contemporaneous lnMTBA as dependent variables in value Equations 8 and 9 generates some form of circularity or one more bad control issue (Angrist and Pischke, 2009). In our view, this is unlikely because the investment and value equations are separate specifications and, moreover, the MTB ratio is lagged by one year in the investment equations. Notwistanding, we replicate our results excluding the MTB ratio from the investment equation and obtained similar results (unreported).

RICI and excess IA is negative at the 1% confidence level, in support to the value decrease prediction. The economic effects are smaller than for the correlated investment prediction but yet sizeable: a one standard deviation increase in rivals' IA (count based) combined with a one standard deviation increase in firm excess R&D leads to a lnMTBA decline between 0.5% and 1%. A similar result is observed in case of one standard deviation increase in firm excess IA. The combination of Columns 1 to 4 results (correlated investment prediction test) and Columns 5 to 6 results (value decrease test) bring strong support to the Arms Race Hypothesis: M&A transactions focused on innovative targets trigger more resource allocation to innovation by acquirer rivals, not less, and these investments in innovation negatively affect the firm's value. One implication of the finding that these acquisitions spur innovation is that, on average, regulatory agencies in charge of M&A supervision should worry less about adverse effects of M&A activities on innovation.

We report in Appendix I.A.1 Table 3 estimates with the full set of control variables. Some control variables display noteworthy coefficient estimates, even if we must refrain from any causal interpretation. In Column 1, firm size is negatively correlated with R&D investment, like ROA and leverage. As we control for firm fixed-effects, these estimates indicate that increase in size, profitability, and leverage are correlated with less R&D spending at the firm level. Similar conclusions hold for innovative acquisition's correlation with leverage and asset tangibility (Column 2). On the contrary, an increase in growth opportunities and/or firm valuation (MTB) is positively correlated with innovative acquisition undertakings. This last result is at first sight consistent with the positive correlation reported in the literature between lagged firm valuation and future M&A activity (eg., Rhodes-Kropf et al., 2005), but the negative relation between firm value and a specific type of acquisition (contemporaneous excess innovation acquisitions under the pressure of rivals) (Column 6) highlights that interactions between these variables are probably more complex. Point estimates of Fama and French (1998) explanatory variable coefficients are significantly different from estimates reported by the authors (see authors Table 2), as to be expected taking account the difference in estimation strategy (Fama and French (1998) use a Fama-MacBeth regression approach while our results rest on a fixed-effects panel data estimator) and analyzed periods (Fama and French (1998) study the 1965 to 1992 period). Notwithstanding, restricting our attention to statistically significant coefficients, nine out of the fourteen variables display a similar sign, namely E_{it}/A_{it}, dE_{it+2}/A_{it}, dA_{it}/A_{it}, dA_{it+2}/A_{it}, dRD_{it+2}/A_{it}, I_{it}/A_{it}, D_{it}/A_{it}, dD_{it+2}/A_{it} and dV_{it+2}/A_{it}, a result highlighting the robustness of the Fama and French (1998) study.

We next focus on three alternative M&A and firm samples: change of control transactions (we restrict our M&A sample to cases where the acquirer holds less than 50% before the transaction and more than

50% after, a subsample of 38,296 transactions), acquisitions of public targets (a subsample of 7,005 transactions) and horizontal M&A transactions (the acquirer and the target share the same 3-digit SIC code, a subsample of 22,150 transactions). Results are reported in Table 4 and are obtained with the inclusion of R&D and IA as right-hand side variables to control for simultaneity between R&D and innovative acquisition decisions, like in Table 3 Columns 1 and 2. Table 4 structure is otherwise similar to Table 3 to ease comparison of results. The main take-aways from Table 4 can be summarized as follows:

- Change of control transactions (Table 4, Panel A): in Columns 1 and 2 (the correlated investment prediction test), coefficient estimates of lagged RICI remain positive and highly significant in both the R&D and the IA equations. In both cases, the point estimates are similar to point estimates reported in Table 3. In Columns 3 and 4 (the value decrease prediction test), coefficient estimates of the interaction terms between RICI and excess R&D and RICI and excess IA are negative, significant at the 10% confidence level in Column 3 and 1% confidence level in Column 4, with coefficient point estimates that are again close to the ones reported in Table 3. Restricting our sample to change of control transactions does not alter significantly our results;
- Acquisitions of public targets (Table 4, Panel B): almost all coefficients of interest lose their significance (only in Column 1, in the *R&D* equation, the coefficient on lagged RICI is positive and statistically significant, but the point estimate is significantly smaller than in Table 3). The Arms Race Hypothesis predictions do not find support using this sub-sample restricted to public targets. This is consistent with private firms playing an important role in innovation in the economy (Gao et al., 2018) but also with a loss of statistical power of our tests due to a drastic M&A sample restriction (from 44,602 transactions to 7,005);
- Horizontal transactions (Table 4, Panel C): finally, restricting our M&A sample to horizontal transactions also does not affect our results. Like for control transactions, results are consistent with the Arms Race Hypothesis predictions, with coefficient points estimates on the order of magnitude of estimates reported in Table 3. This is a noteworthy result because it has regulatory implications: the positive effect of rivals' innovative acquisitions on the firm incentives to invest in innovation is confirmed for transactions specifically subject to regulatory scrutiny.

4.2. The Arms Race Hypothesis – Industry Level Results

Average results mask potentially significant industry heterogeneity, even if our inclusion of firm fixed-effects should absorb a large part of it[15]. As such, we conduct industry level analyses next. Investigations at the industry level must balance granularity against statistical power: the finer grained the chosen industry classification, the more homogenous are the industry characteristics, a desirable property to investigate innovation incentives. But the finer grained the industry classification, the lower the statistical power of our regressions because the number of firm-year observations is drastically reduced. This is particularly problematic because our goal is to identify whether the Arms Race Hypothesis process is at work. A low power test would lead us to erroneously fail to reject the null hypothesis of no effect of rivals IA on incentives to innovate and firm value (a type II error) for many industries, an outcome particularly problematic in the light of our research question: in the absence of negative effects on incentives to innovate, the case for regulatory agencies to come into play to regulate these transactions clearly weakens. We decide therefore to favor statistical power and to adopt the Fama and French five industries classification[16]: Fama and French provide a matching table that allows us to group SIC industries into Consumer, Manufacturing, High-Technology, Healthcare, and Others. We use historical SIC codes collection in the CRSP database to place firm-year observations into the corresponding Fama and French industries.

Table 5 reports our results. Each panel is organized as Table 3 to ease comparison, except that Table 3 Columns 3 and 4 are dropped because our results are clearly unaffected by the issue of the bad control (see Section 4.1). Panel A focuses on the Consumer Industry (10,427 and 6,547 firm-year observations, respectively for the correlated investment prediction test and the value decrease prediction test). Like for the sub-sample of public targets, the Arms Race Hypothesis predictions find no support. We reach a similar conclusion for the Manufacturing Industry (with sub-samples of 12,291 and 7,960 firm-year observations). In contrast, results for the High-Technology Industry (Panel C) bring support to both the correlated investment and the value decrease predictions (except in Column 3, where the coefficient of the RICI times excess R&D interaction terms is negative but not statistically significant). Noteworthy, point estimates of RICI coefficients (0.012 and 0.199 in Columns 1 and 2) are higher than the corresponding point estimates reported in Table 3 for the whole sample of firms (0.009 and 0.141 respectively: the effect of an increase in rivals IA on innovation investments appear to be stronger in the High-Technology Industry. These results are obtained with sub-samples of 13,912 and 7,969 firm-year observations). Panel

[15] Firm level SIC code updates are infrequent updated and therefore, SIC industry dummies are mostly time-constant variables

[16] Available at http://mba.tuck.dartmouth.edu/pages/faculty/ken.french/data_library.html

D (Healthcare Industry) results bring weaker support to the Arms Race Hypothesis predictions: the coefficient of RCI in Column 1 (the R&D part of the correlated investment prediction) is positive (with a point estimate similar to the one reported in Table 3) and statistically significant at the 5% confidence level and the coefficient of the interaction term between RICI and excess R&D is negative in Column, in support with the value decrease prediction. But rivals IA appear to have no significant effect on the firm IA (Column 2) and value (Column 4). Sub-samples of firm-year observations are here smaller (5,066 and 3,023 respectively). As expected for the Others Industry, which is a catch all for unrelated industries not grouped into the other 4 sectors, coefficients not significant (except marginally in Column 2), most probably significant because rivals are poorly identified here.

While we can't exclude that part of these conclusions are due to a lack of power to reject the null hypothesis of no effect (sample sizes are drastically reduced as emphasized hereabove), the dependence of our results to the industry is intuitive: innovation is certainly a powerful driver of competition in the High-Technology and Health-Care industries and therefore, these industries offer conditions favorable to the emergence of arms races between competitors.

4.3. The Arms Race Hypothesis – Within-Industry Results

The dependence of firms' response to competitive shocks to its within industry situation is rooted in Schumpeter (1943) and Arrow (1962). Schumpeter argues that competition erodes producer rents. Under this rent-dissipation hypothesis, an increase in competition puts producers under financial pressure and leads them to cost cutting strategies, including cutting innovation investments. This should be especially the case for weaker industry participants (industry laggards henceforth), as these are already constrained before the increase in competition. On the other hand, Arrow argues that in response to an increase in competition, firms will invest more in innovation to restore their quasi-monopoly rents (the competition-escape hypothesis). Strong industry participants (industry leaders henceforth) are in the best position to follow this strategy because they have sufficient financial resources. The Schumpeterian rent-dissipation and Arrow escape-competition hypotheses provide mechanisms explaining the dependence between industry participants' competitive position and their willingness to invest in innovation in reaction to competitive shocks. More recently, Aghion et al. (2005) argue that the relation between innovation and competition follows an inverted-U relation. So called neck-and-neck firms (firms in fierce competition with rivals) are the most willing to invest in innovation because returns of these investments are the greater for them. In this section, we explore the relation between firm R&D and innovative IA investments, their valuation consequences, rivals' IA (the competitive shock), and firm within industry position.

We start with the Schumpeterian rent-dissipation and Arrow escape-competition hypotheses. Our first step is to identify industry leaders and laggards. We build an empirical proxy based on profitability (ROA) and market shares (sales based). For each year and each 3-digit SIC industry, we sort firms by ROA and market shares. Industry leaders are firms that are in the highest quartile of ROA and in the highest quartile of market shares (the most profitable and largest industry players). Industry laggards are symmetrically obtained: they are firms in the lowest quartile of ROA and in the lowest quartile of market shares (the least profitable and smallest industry players).

We next augment Equations 6 and 7 with interaction terms to test whether firms' within industry position affect the relation between subject firm R&D and IA and rivals IA (the correlated investment prediction) :

$$R\&D_{it} = \alpha_i + \beta_t + \gamma_0 \left(Leaders_{it} \times RICI_{it-1}\right) + \gamma_1 \left(Laggards_{it} \times RICI_{it-1}\right) + \gamma_2 \left(Others_{it} \times RICI_{it-1}\right) + \delta\, IA_{it} + \boldsymbol{Controls'}_{\boldsymbol{it-1}}\, \boldsymbol{\omega} + \epsilon_{it} \quad (10)$$

$$IA_{it} = \alpha_i + \beta_t + \gamma_0 \left(Leaders_{it} \times RICI_{it-1}\right) + \gamma_1 \left(Laggards_{it} \times RICI_{it-1}\right) + \gamma_2 \left(Others_{it} \times RICI_{,t-1}\right) + \delta\, R\&D_{,t} + \boldsymbol{Controls'}_{\boldsymbol{it-1}}\, \boldsymbol{\omega} + \eta_{it} \quad (11)$$

where $Leaders_{it}$ is a dummy variable equal to one if the firm i is an industry leader in year t, $Laggards_{it}$ is a dummy variable equal to one if it is an industry laggard, $Others_{it}$ is a dummy variable equal to one otherwise[17]. Other notations are as in Equations 6 and 7. We are in particular interested in coefficients $\gamma_0$and γ_1, that capture interactions between within industry position and competition shocks due to rivals' IA.

We similarly augment Equations 8 and 9 with interactions terms to test whether firms' within industry positive affect the relation between firm value and the interaction between rivals IA and firm excess R&D and firm excess IA (the value decrease prediction)[18]:

[17] Note that we do not include the variable $RICI_{it-1}$ because it would be perfectly colinear with the combinations of $(Leaders_{it} \times RICI_{it-1})$, $(Laggards_{it} \times RICI_{it-1})$ and $(Others_{it} \times RICI_{it-1})$. Equations 10 and 11 regression specifications allows us the decompose the effect of $RICI_{it-1}$ on the dependent variable between industry leaders, laggards and other firms.
[18] The interaction terms $(RICI_{it} \times R\&D_{it}^{excess})$ and $(RICI_{it} \times IA_{it}^{excess})$ are excluded to avoid again perfect multicolinarity.

$$lnMTBA_{it} = \alpha_i + \beta_t + \gamma\, RICI_{it} + \delta\, R\&D_{it} + \tau_0\,(Leaders_{it} \times RICI_{it} \times R\&D_{it}^{excess}) + \tau_0\,(Laggards_{it} \times RICI_{it} \times R\&D_{it}^{excess}) + \tau_0\,(Others_{it} \times RICI_{it} \times R\&D_{it}^{excess}) + \theta\left(RICI_{it} \times R\&D_{it}^{histo}\right) + \mu\, IA_{it} + \boldsymbol{Controls'_{it}\,\nu} + \epsilon_{it} \qquad (12)$$

$$lnMTBA_{it} = \alpha_i + \beta_t + \gamma\, RICI_{it} + \delta\, IA_{it} + \tau_0\,(Leaders_{it} \times RICI_{it} \times IA_{it}^{excess}) + \tau_0\,(Laggards_{it} \times RICI_{it} \times IA_{it}^{excess}) + \tau_0\,(Others_{it} \times RICI_{it} \times IA_{it}^{excess}) + \theta\left(RICI_{it} \times IA_{it}^{histo}\right) + \mu\, R\&D_{it} + \boldsymbol{Controls'_{it}\,\nu} + \eta_{it} \qquad (13)$$

Table 6, Panel A reports our results, again organized as Table 3 to ease comparison. In addition to the standard set of statistics, we report heteroskedastic robust Fisher tests of coefficient equality between $Laggards_{it} \times RICI_{it-1}$ and $Laggards_{it} \times RICI_{it-1}$ interaction terms (Columns 1 and 2) and $Leaders_{it} \times RICI_{it} \times R\&D_{it}^{excess}$ and $Laggards_{it} \times RICI_{it} \times R\&D_{it}^{excess}$ interaction terms (Columns 3 and 4) at the bottom of the table. Both industry leaders and industry laggards invest significantly in R&D under the pressure of rivals IA (correlated investment prediction) but, while the difference between leaders and laggards is not statistically significant for R&D (Column 1), it is highly so for IA (Column 2): in reaction to an increase of rivals' competitive pressure, industry leaders are more willing (or more able) to pursue innovative acquisitions than the average firm in the industry. Concerning the value effects of these investments (the value decrease prediction), we observe negative and significant coefficients of industry leaders for excess R&D (Column 3) and excess IA (Column 4). Moreover, the difference between leaders and laggards is statistically significant for excess R&D, as indicated by the Fisher test reported in Column 3. The Arms Race Hypothesis predictions clearly get stronger support for industry leaders than industry laggards, especially on the IA side.

We next turn to the Aghion et al. (2005) inverted-U relationship. We follow Chen and Wu (2019) and use HP similarity scores to create our neck-and-neck competition indicator variable, denoted $Neck\&Neck_{it}$, and its complement, denoted $Others_{it}$. For each year and each firm, we collect the three closest rivals in the product market space and compute their average similarity score. Firms in neck-and-neck competitions are the ones belonging to the highest quartile of the yearly distribution of these average similarity scores. Next, we replace in Equations 10 to 13 interaction terms with $Leaders_{it}$, $Laggards_{it}$and $Others_{it}$dummy variables by interaction terms with $Neck\&Neck_{it}$ and $Others_{it}$ dummy variables.

Results are reported in Panel B of Table 6. The Arms Race Hypothesis predictions are clearly confirmed for neck-and-neck firms: under the pressure of rivals IA, these firms increase R&D and IA more (correlated investment prediction, Columns 1 and 2) but these excess investments negatively affect their market valuation (value decrease prediction, Columns 3 and 4). However, the difference with non neck-and-neck firms (denoted others) is not so clear-cut as the difference between industry leaders and laggards: with the exception of the negative value effect of excess IA on the market value that is not statistically significant (Column 3), the results are also consistent with the Arms Race Hypothesis predictions for this subsample of firms.

Taken together, these results show that within industry position affects firm level reactions to an increase in competitive pressure due to rivals' innovative acquisitions. Interestingly, our results remain compatible with the grand average reported in Table 3: whether for industry leaders and laggards (Panel A) or for industry neck-and-neck firms (Panel B), all coefficients of interaction terms with RICI are positive in Columns 1 and 2, consistent with the correlated investment prediction, and all coefficients of interaction terms with RICI times excess R&D and RICI times excess IA are negative for the value equations, consistent with the value decrease prediction.

5. Additional investigations and Robustness checks

5.1. Rivals Innovative Acquisition Endogeneity

While it seems improbable that our test of the correlated investment prediction (Equations 6 and 7) are exposed to some simultaneity or reverse causality sources of bias (we lag our independent variable RICI by one year and therefore, future firm innovation investment decisions would have to drive past rivals innovative acquisitions), potential endogenous omitted variables remain a concern. The issue is of importance because giving a causal interpretation to our results supporting our correlated investment prediction has clear regulatory implications: if rivals' IA drive higher firm investments in R&D and IA, regulators should not be concerned about adverse side-effects of these M&A transactions on innovation.

We control for time constant latent factors thanks to the inclusion of firm fixed-effects, time varying latent factors common to all firms thanks to year fixed-effects and a set of firm level time varying characteristics (profitability, capital structure, liquidity, nature of assets, and valuation). Nonetheless, one may argue that some additional time varying latent factors correlated to both past rivals' innovative acquisitions and a firm's decision to invest in R&D and to acquire innovative targets are at play. Therefore, we decide to test the validity of the causal interpretation of our results using an instrumental variable approach.

We select state-wide R&D tax credits as an instrument for rivals' innovative acquisitions. The U.S. federal R&D tax credit was introduced in 1981 and progressively implemented in U.S. states afterwards.

This staggered adoption led 32 U.S. states to provide R&D tax credits by 2006. Hombert and Matray (2018) emphasize that these state R&D policies generate significant exogenous decrease in the user cost of R&D across states and time. Therefore, firms benefit from these incentives to invest in R&D depending on the location of their R&D activities. We use the Hall-Jorgenson user cost of R&D as instrument, replicating the procedure described in Bloom et al. (2013) Internet Appendix B.3.1. Valid instruments must satisfy the relevance, exclusion, and independence assumptions. We argue that these are satisfied with the tax credits:

- Relevance: R&D tax credits increase firm incentives to invest in R&D and, to the extent to which firms face funding constraints, we expect that increased incentives to invest in R&D should lower incentives to acquire innovative targets. This is a testable assumption;
- Exclusion: The instrument works through another state's tax change that affects rivals located in that state, but not the subject firm located in a different state. As such, these out-of-state tax-credit changes should not directly affect the firm's own decisions to invest in innovation (whether organically through R&D or externally through innovative acquisitions). The correlation between the firm innovation investment decisions and the rivals R&D incentives takes place through the change in competitive pressure that the rivals' behavior generates. As is typical, this exclusion restriction is not testable per se but it appears to us reasonable in the present case;
- Independence: Bloom and al. (2013) suggest that the introduction and level of U.S. tax credits were largely unrelated to the economic environment into which firms operate and Hombert and Matray (2018) provide additional results consistent with this claim.

Because our independent variable of interest is computed for the firm $10NN$ rivals portfolio, we collect the Hall-Jorgenson user cost of R&D for these same firm rivals, use them to predict rival firm level investment in R&D due to tax credits incentives and finally, take the average of these predicted values (denoted $R\&DUC_{i,t}^{10NN}$) to obtain our instrument for $RICI_{i,t}$. We anticipate that the average $10NN$ user cost of R&D will be negatively correlated with $RICI_{i,t}$ because, as explained above, increased incentives to invest in R&D should lower incentives (at least relatively speaking) to acquire innovation externally.

We obtain our instrumental variable estimates using 2SLS. In the first stage, we regress $RICI_{i,t}$ on $R\&DUC_{i,t}^{10NN}$ and all other control variables:

$$RICI_{i,t} = \alpha_i + \beta_t + \gamma \; R\&DUC_{i,t}^{10NN} + \; \delta \; IA_{it} + \; \boldsymbol{Controls'}_{\boldsymbol{i,t-1}} \, \boldsymbol{\mu} + \; \epsilon_{i,t} \tag{14}$$

or

$$RICI_{i,t} = \alpha_i + \beta_t + \gamma \; R\&DUC_{i,t}^{10NN} + \; \delta \; \; R\&D_{i,t} + \; \boldsymbol{Controls'}_{\boldsymbol{i,t-1}} \, \boldsymbol{\mu} + \; \epsilon_{i,t} \tag{15}$$

We next regress $R\&D_{i,t}$ and $IA_{i,t}$ and the lagged fitted values of $RICI_{i,t}$ (denoted $RICI_{i,t-1}^{fit,1}$ using Equation 14 and $RICI_{i,t-1}^{fit,2}$ using Equation 15) and the firm own user cost of R&D (denoted $R\&DUC_{i,t}$):

$$R\&D_{i,t} = \alpha_i + \beta_t + \gamma\, RICI_{i,t-1}^{fit,1} + \delta\, R\&DUC_{i,t} + \mu\, IA_{it} + \boldsymbol{Controls'}_{\boldsymbol{i,t-1}}\, \boldsymbol{\nu} + \epsilon_{i,t} \tag{16}$$

$$IA_{i,t} = \alpha_i + \beta_t + \gamma\, RICI_{i,t-1}^{fit,2} + \delta\, R\&DUC_{i,t} + \mu\, R\&D_{i,t} + \boldsymbol{Controls'}_{\boldsymbol{i,t-1}}\, \boldsymbol{\nu} + \eta_{i,t} \tag{17}$$

We use the standard two-stage least square estimator, standard errors are clustered at the firm level and adjusted to take into account the two-stage nature of this procedure. The presence of $R\&DUC_{i,t}$ as a right-hand side variable in Equations 16 and 17 is particularly important because $R\&DUC_{i,t}$ and $R\&DUC_{i,t}^{10NN}$ are potentially correlated and we have therefore to partial out the firm own R&D user cost incentives to invest in R&D to obtain an unbiased estimate of γ, the coefficient of interest. We limit the period under investigation to 1996-2010 because the latest U.S. states to adopt R&D tax credits in the Wilson (2009) dataset did so in 2006 [19].

Results are displayed in Table 7. Columns 1 and 2 are dedicated to the R&D part of the correlated investment prediction (corresponding to Column 1 in Table 3), reporting the first stage and second stage estimation results respectively and Columns 3 and 4 to the IA part of the correlated investment prediction (corresponding to Column 2 in Table 2), reporting likewise first and second stages estimation results respectively. Let us first comment on the first stage estimates. As anticipated, the coefficient of R&DUC^{10NN} is negative and highly statistically significant in Columns 1 and 3 (the t-stat is above 13 with a corresponding Fisher statistic above 30): increased incentives to invest in R&D reduce rivals' innovative acquisition intensity. The coefficient on lagged instrumented RICI is positive and statistically significant both in the R&D equation (Column 2) and the innovative acquisition equation (Column 4). One may worry about the point estimates (respectively 0.101 and 1.574), that could appear very high with respect to point estimates reported in Table 3 (respectively 0.009 and 0.141). Jiang (2017) points out indeed that this can signal a fist stage weak instrument issue but our first stage test of significance indicates that this is not the case. However, as clarified in Angrist and Pischke (2009), the Local Average Treatment Effect theorem tells us that the instrumental variable estimate is valid only for compliers (the subsample of rival

[19] We obtain similar (but marginally less statistically significant) results limiting the investigated period to 2008 and 2012 (unreported results).

firms that decrease their innovative acquisitions due to R&D tax credits, in our case). This subsample of firms is potentially significantly different from firms do not change their acquisition strategies regardless of the tax credits they are offered (e.g.: firms that do not undertake any acquisition or never-takers in Angrist and Pischke terminology). These instrumental variable based results confirm therefore that the positive relation between rivals' IA and firm R&D and innovative acquisitions is not an artifact due to the action of some latent factors but do not provide an estimate of the magnitude of the causal relation for the whole cohort of firms that we track.

5.2. Innovation Investments Efficiency

Our results are consistent with the value decrease prediction of the Arms Race Hypothesis:a negative relation between the firm market value and the interaction between the rivals IA (RICI) and excess investments in innovation (R&D and IA) can be driven by a sub-optimal investment policy, generating a decline in innovation investment efficiency, or by a transfer of economic rents beneficial to consumers. We explore in this section whether a decline in innovation investment efficiency is observable using information collected in the NBER Patent Citation Data file Hall et al., 2001. Our measures of innovation outputs are the logarithm of the three years forward cumulated number of patents or citations. Due to data availability constraint (the NBER data are available only up to 2006) and the three year window over which patents and patents citations are cumulated, our analyzed period ends in 2003. Our results are therefore obtained for a limited subsample of 4,147 observations and, from that perspective, remain exploratory. The estimated econometric specification parallels the one used to test the value decrease prediction of the Arms Race Hypothesis (Equations 8 and 9), substituting our measures of innovation output for the lnMBTA dependent variables and our standard set of control variables (ROA, leverage, cash, intangibility and equity MTB ratios) for the Fama and French (1998) explanatory variables.

Results are reported in Table 8, Panel A for patents and Panel B for patents citations. In each case, Column 1 focuses on excess R&D and Column 2 on excess IA, like in Table 3. A clear message emerges from these estimates: no decline in innovation investment efficiency is observable. The only coefficient of interest that is statistically significant appears in Column 2 of Panel B (the coefficient of RICI and excess IA interaction term), but it is positive. These initial results seem therefore to indicate that observable decline in firm market value in the wake of excess innovation investments under pressure of rivals indicates a transfer of rents beneficial to consumers. Such a tentative conclusion, if confirmed on larger datasets, would be one more reason for regulatory authorities not to be concerned about the M&A side-effects on innovation incentives.

We also used the Kogan et al. (2017) dataset that covers our entire sample period to replicate the above reported NBER Patent Citation Data file based analyses and obtained similar results (unreported).

5.3. Analyses on the Extensive Margin

As mentioned in the introduction, up to now our analyses are performed on the intensive margin, keeping only firms whose rivals did perform acquisitions, to avoid producing results driven by firms never exposed to such rivals' moves. But one might be concerned that our inferences are muddled by focusing only on firms that are exposed to rival pressure. For example, it could be that firms with no rival pressure are also taking the same innovation actions, increasing the case for an omitted driver. In this section, therefore, we replicate our baseline analyses (Table 3) on the extensive margin, that is keeping all firms, whether or not their $10NN$ rivals undertook some acquisitions. This leads to the addition of roughly 30,000 firm-year observations to our sample.

Table 9 reports the results. The two predictions of the Arms Race Hypothesis are again strongly supported. Moreover, the coefficient point estimates are close to the ones reported in Table 3 (analyses on the intensive margin). Thus, our results are not a byproduct of the exclusion of firms never exposed to rivals' IA from our sample.

5.4. Value Based Analysis

Our measure of rivals' IA, RICI, is count based (see Equation 1). A corresponding value based measure of rivals' IA can easily be constructed by simply weighting each acquisition by its deal value as reported in the SDC database. Two potential shortcomings of such approach are that the M&A transactions for which the SDC database doesn't report the deal value will be excluded from the analysis and, taking into account the extreme right skewness of the M&A deal value distribution, a limited number of large transactions may drive the generated results. Notwithstanding these issues, we replicate our results using this value based measure of rivals IA (denoted RIVI) and report the results in Appendices 2 to 8.

To summarize, the results are mostly unchanged. This is the case for baseline results (Table IA.2 and for analyses by subsamples (Table I.A.3), except that when restricting the sample to public targets, the Arms Race Hypothesis predictions find more support (some indication that the arms race mechanism may be more at work for large transactions). Analyses by industry (Table I.A.4) confirm that the High-Technology Industry and, to a lesser extent, the Healthcare Industry are driving the results. Within industry analyses (Table I.A.5) confirm the role of industry leaders. Instrumental variable based results (Table I.A.6) are again statistically significant, both at the first stage (rejecting the null hypothesis of weak instrument) and at the second stage, confirming the causal interpretation of the relation between rivals' IA and the intensity of firm investments in innovation (the correlated investment prediction). Finally, innovation investment efficiency shows no sign of decline (Table I.A.7) and results obtained on the extensive margin are consistent with results obtained on the intensive margin (Table I.A.8).

6. Conclusion

The Arms Race Hypothesis predicts that investment in innovation increase under the pressure of rivals (the correlated investment prediction), generating a decline in firm valuation (the value decrease prediction). Tracking a large cohort of firms over the 1996 to 2017 periods and using the Hoberg and Phillips (2010) similarity scores to identify firm rivals in the product market space, our results strongly support these predictions. Additional analyses emphasize the importance of taking into account M&A transactions targeting private firms to study these incentives mechanisms, the driving role of the High-Technology Industry (and, to a lesser extent, the Healthcare one) and the within industry heterogeneity of behaviors, depending on the competitive position of firms (industry leaders appear to be more prone to engage into an innovation arms race). Moreover, our results warrant a causal interpretation of the relation between rivals' innovative acquisitions and the firm innovative investment response and hold whether we work at the intensive or extensive margin. These results have significant policy implications: while each case is different, in general, regulatory authorities should less aggressively intervene in the M&A market out of concern for negative side-effects on innovation incentives.

Some of the analyses performed in this work remain exploratory and open the door to interesting future research. In particular, within industry heterogeneity of firm response to rival pressures certainly deserve additional work, including refining our leaders, laggards and neck-and-neck classifications. Also, effects on innovation investment efficiency are at best tentative at this stage and should be backed by results obtained on a larger cohort of firms and longer period of time.

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Figure 1 – Hypothesis and Predictions

Figure 1 put in relation the increase in rival innovation investments, the firm innovation investment reaction and its valuation consequence under the Innovation Arms Race hypothesis, the Schumpeter (1943) Rent Dissipation hypothesis and the Arrow (1962) Competition Escape hypothesis.

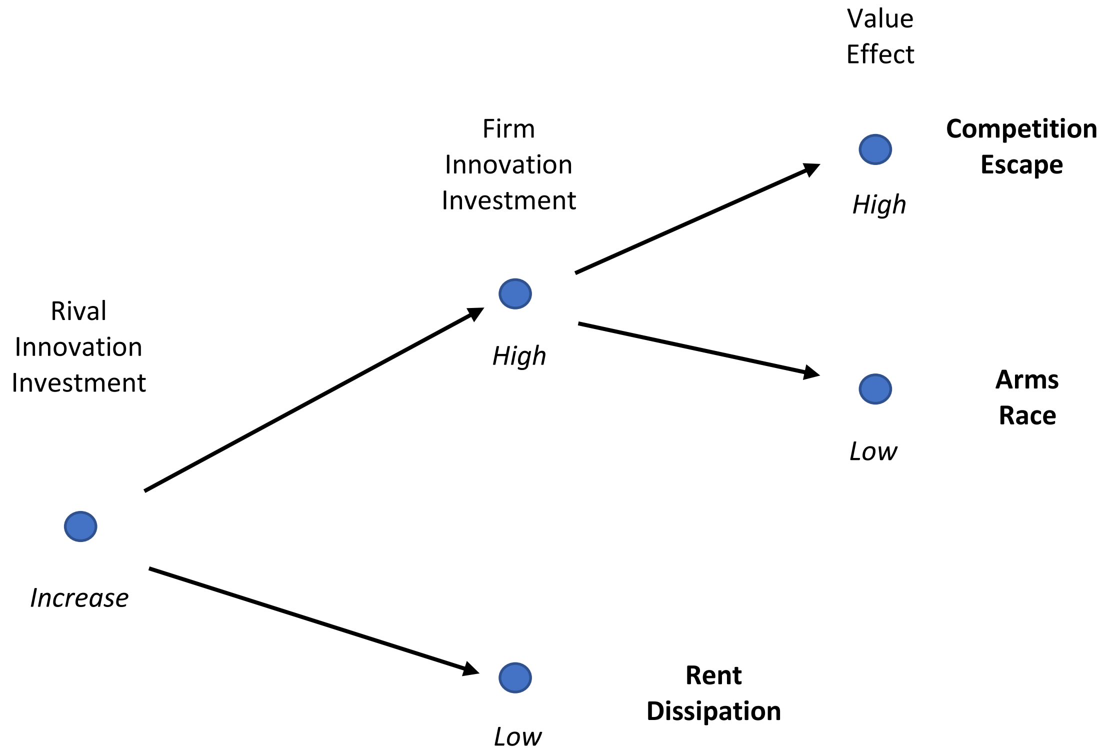

Table 1 – Sample and M&A transactions

Table 1 presents sample statistics by year. In Column 1, we report the number of firm-year observations. In Column 2, the number of unique acquirers in the M&A sample is provided. Columns 3 and 4 display the number of M&A transactions and the corresponding aggregate deal value respectively. Columns 5 and 6 show the number of innovative target acquisitions (see Section 3.1 for innovative acquisition definition) and the corresponding aggregate deal value respectively while Columns 7 and 8 provide the corresponding statistics of listed targets only.

Year	Firm-year Obs.	Unique Acquirers	All M&A Deals		All Innovative Targets		Public Innovative Targets	
			Numbers	Dollar Value [In Billions]	Numbers	Dollar Value [In Billions]	Numbers	Dollar Value [In Billions]
	1	2	3	4	5	6	7	8
1996			3,021	291.56	723	29.32	156	16.82
1997	2,952	1,460	3,620	464.48	747	38.04	123	22.98
1998	3,449	1,533	3,869	693.73	961	92.81	137	47.63
1999	3,298	1,386	3,350	822.53	898	239.80	158	197.81
2000	3,046	1,260	2,738	861.01	918	166.50	132	79.52
2001	2,754	1,002	1,865	336.24	566	37.17	97	18.09
2002	2,627	900	1,584	176.49	465	31.08	76	11.52
2003	2,543	878	1,557	160.35	451	40.35	63	22.35
2004	2,509	966	1,752	269.50	536	56.13	42	13.98
2005	2,627	994	1,961	493.51	567	97.67	32	19.91
2006	2,517	1,046	2,033	490.76	241	74.02	34	37.22
2007	2,369	970	2,003	476.11	255	76.42	43	35.89
2008	2,263	858	1,675	294.31	210	31.18	42	23.86
2009	1,915	668	1,264	426.79	225	139.04	45	49.79
2010	1,844	771	1,519	326.50	199	29.49	24	10.47
2011	2,040	820	1,610	399.76	218	68.35	27	32.26
2012	1,993	820	1,655	300.96	193	50.56	25	23.20
2013	1,921	769	1,477	315.74	177	26.23	16	14.76
2014	1,970	894	1,711	714.58	187	99.81	23	72.06
2015	1,849	819	1,541	882.19	155	104.75	27	83.06
2016	1,763	761	1,451	632.79	161	66.85	19	45.04
2017	1,569	753	1,387	543.94	167	63.07	14	38.19
Total	49,818	6,289	44,643	10,082	9,220	1,659	1,355	916

Table 2 – Descriptive Statistics

The table reports descriptive statistics for the set of variables used in our multivariate analyses. Panel A focuses on the correlated investment prediction tests and Panel B, on the value decrease tests. Columns 1 and 2 provides the arithmetic average and the standard deviation, Columns 3 to 5 the first, second and third quartiles of the distribution and Column 6, the number of observations. All variable definitions and data sources are provided in Section 3.2.

Variable Name	Mean	Stdev.	25th Pctl.	Median	75th Pctl.	Observations
	1	2	3	4	5	6
Panel A - Correlated Investment Tests						
Dependent Variables						
R&D Intensity	0.047	0.088	0.000	0.004	0.060	49818
Innovative Acquisition	0.103	0.494	0.000	0.000	0.000	49818
Variables of Interest						
RICI	0.178	0.301	0.000	0.000	0.250	49818
Control Variables						
Firm Size	6.140	2.026	4.656	6.036	7.505	49818
ROA	0.085	0.166	0.056	0.111	0.164	49818
Leverage	0.203	0.186	0.015	0.177	0.332	49818
Liquidity	0.128	0.145	0.023	0.076	0.181	49818
Intangible Ratio	0.162	0.190	0.003	0.087	0.263	49818
MTB	3.064	3.984	1.202	1.955	3.381	49818
Panel B - Value decrease Tests						
Dependent Variables						
lnMTBA	0.269	0.641	-0.163	0.192	0.636	29890
Variables of Interest						
RICI	0.170	0.292	0.000	0.000	0.250	29890
Excess R&D	-0.001	0.033	-0.001	0.000	0.000	29890
Excess Innovative Acquisition	-0.015	0.491	0.000	0.000	0.000	29890
Control Variables						
R&D Intensity	0.040	0.074	0.000	0.004	0.053	29890
Innovative Acquisition	0.108	0.493	0.000	0.000	0.000	29890
Historical R&D	0.041	0.073	0.000	0.004	0.055	29890
Historical Innovative Acquisition	0.123	0.439	0.000	0.000	0.000	29890
E_{it}/A_{it}	0.030	0.163	0.018	0.057	0.090	29890
dE_{it}/A_{it}	0.003	0.209	-0.025	0.010	0.041	29890
dE_{it+2}/A_{it}	0.012	0.263	-0.029	0.009	0.049	29890
dA_{it}/A_{it}	0.104	0.368	-0.016	0.122	0.273	29890
dA_{t+2}/A_{t}	0.214	0.641	-0.049	0.105	0.305	29890
dRD_{it}/A_{it}	0.004	0.044	0.000	0.000	0.004	29890
dRD_{it+2}/A_{it}	0.007	0.061	0.000	0.000	0.004	29890
I_{it}/A_{it}	0.012	0.014	0.001	0.009	0.019	29890
dI_{it}/A_{it}	0.001	0.011	-0.002	0.000	0.003	29890
dI_{it+2}/A_{it}	0.002	0.021	-0.002	0.000	0.003	29890
D_{it}/A_{it}	0.011	0.037	0.000	0.000	0.014	29890
dD_{it}/A_{it}	0.002	0.040	0.000	0.000	0.001	29890
dD_{it+2}/A_{it}	0.002	0.039	0.000	0.000	0.002	29890
dV_{it+2}/A_{it}	0.354	1.920	-0.203	0.134	0.617	29890

Table 3 - Innovation Arms Race Correlated Investment and Value decrease Predictions Test

Table 3 reports results of Innovation Arms Race Predictions (see Figure 1). Columns 1 to 4 are dedicated to The Correlated Investment Prediction (incentives to innovate). The dependent variables are *R&D Intensity* in Columns 1 and 3, defined as R&D expenses divided by total assets and *Innovative Acquisition* in Columns 2 and 4, defined as the number of innovative target acquisitions divided by the number of acquisitions by subject firm. The variable of interest is *RICI,* defined as the number of innovative target acquisitions divided by the total number of acquisitions by rival firms per year (see Equation 1). In Columns 1 and 2, *Innovative Acquisition* and *R&D Intensity* are included as control variable and in Columns 3 and 4, they are excluded as a robustness check. Columns 5 and 6 display tests of the Value decrease Prediction . The dependent variable is natural logarithm of one plus the ratio of the difference between the market value and the book value of assets scaled by the book value of assets, as in Fama and French (1992). The variables of interest are the interaction between *RICI* and *Excess R&D* or *Excess Innovative Acquisition*. *Excess R&D* is defined as the difference between *R&D Intensity* of the subject firm and its historical *R&D Intensity* (the average *R&D Intensity* over the last three years), and *Excess Innovative Acquisition* is the difference between *Innovative Acquisition* of the subject firm and its historical *Innovative Acquisition* (the average *Innovative Acquisition* over the last three years). Column 5 reports the results for the interaction between *RICI* and *Excess R&D* and Column 6, the results for the interaction between *RICI* and *Excess Innovative Acquisition*. Estimates are obtained using a fixed-effect regression model. Standard errors are clustered at the firm level (p-value is reported below the coefficient estimate). The inclusion of fixed effects and control variables are indicated in the last rows of the table. All variable definitions are provided in Appendix Table A.1. Statistical significance at 10%, 5%, and 1% is indicated by *, **, and ***, respectively.

Subject Firms'	R&D Intensity	Innovative Acquisition	R&D Intensity	Innovative Acquisition	Firm Value	
	1	2	3	4	5	6
RICI	0.009***	0.141***	0.009***	0.141***	0.048**	0.081***
	0.001	0.001	0.001	0.001	0.021	0.006
RICI x Excess R&D					-0.489**	
					0.047	
RICI x Historical R&D					0.291	
					0.206	
RICI x Excess Innovative Acquisition						-0.069***
						0.001
RICI x Historical Innovative Acquisition						-0.055***
						0.005
Innovative Acquisition	0.000				0.025***	0.059***
	0.375				0.008	0.000
R&D Intensity		-0.071			1.589***	1.544***
		0.354			0.000	0.000
Control Variables	Yes	Yes	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Firm Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	49,818	49,818	49,818	49,818	29,890	29,890
Adjusted R^2	0.83	0.20	0.83	0.20	0.737	0.737

Table 4 – Innovation Arms Race Correlated Investment and Value decrease Predictions Test – Subsample Analyses

Table 4 replicates Table 3 tests of the Innovation Arms Race predictions (see Figure 1) and tests are performed for sub-samples of M&A transactions. In Panel A, the M&A sample is restricted to change of control transactions. Panel B reports the results when we take into account the innovative acquisitions of public target only and in Panel C, we limit our sample to horizontal transactions. In each panel, Columns 1 and 2 are dedicated to The Correlated Investment Prediction (incentives to innovate). The dependent variables are *R&D Intensity* in column 1, defined as R&D expenses divided by total assets and *Innovative Acquisition* in Column 2*,* defined as the number of innovative target acquisitions divided by the number of acquisitions by subject firm. Columns 3 and 4 display tests of the Value decrease Prediction . The dependent variable is natural logarithm of one plus the ratio of the difference between the market value and the book value of assets scaled by the book value of assets, as in Fama and French (1992). The variables of interest are the interaction between *RICI* and *Excess R&D* or *Excess Innovative Acquisition*. *RICI* is defined as the number of innovative target acquisitions divided by the total number of acquisitions by rival firms per year (see Equation 1). *Excess R&D* is defined as the difference between *R&D Intensity* of the subject firm and its historical *R&D Intensity* (the average *R&D Intensity* over the last three years), and *Excess Innovative Acquisition* is the difference between *Innovative Acquisition* of the subject firm and its historical *Innovative Acquisition* (the average *Innovative Acquisition* over the last three years). Column 3 reports the results for the interaction between *RICI and Excess R&D* and Column 4, the results for the interaction between *RICI* and *Excess Innovative Acquisition*. Estimates are obtained using a fixed-effect regression model. Standard errors are clustered at the firm level (p-value is reported below the coefficient estimate). The inclusion of fixed effects and control variables are indicated in the last rows of the table. All variable definitions are provided in Appendix Table A.1. Statistical significance at 10%, 5%, and 1% is indicated by *, **, and ***, respectively.

Panel A - Change of Control Transactions

Subject Firms'	R&D Intensity	Innovative Acquisition	Firm Value	
	1	2	3	4
RICI	0.009***	0.132***	0.047**	0.080***
	0.001	0.001	0.022	0.004
RICI x Excess R&D			-0.441*	
			0.069	
RICI x Historical R&D			0.311	
			0.153	
RICI x Excess Innovative Acquisition				-0.075***
				0.000
RICI x Historical Innovative Acquisition				-0.056***
				0.008
Innovative Acquisition	-0.001		0.022**	0.059***
	0.256		0.020	0.000
R&D Intensity		-0.081	1.570***	1.539***
		0.241	0.000	0.000
Control Variables	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes
Firm Fixed Effects	Yes	Yes	Yes	Yes
Observations	48738	48738	29282	29282
Adjusted R^2	0.83	0.19	0.74	0.74

Panel B - Acquisitions of Public Targets Only

Subject Firms'	R&D Intensity	Innovative Acquisition		Firm Value
	1	2	3	4
RICI	0.004**	0.005	-0.019	0.004
	0.039	0.270	0.359	0.794
RICI x Excess R&D			-0.770	
			0.132	
RICI x Historical R&D			0.238	
			0.355	
RICI x Excess Innovative Acquisition				-0.026
				0.586
RICI x Historical Innovative Acquisition				-0.025
				0.784
Innovative Acquisition	0.000		-0.001	0.009
	0.870		0.967	0.769
R&D Intensity		0.003	1.603***	1.575***
		0.872	0.000	0.000
Control Variables	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes
Firm Fixed Effects	Yes	Yes	Yes	Yes
Observations	49818	49818	29890	29890
Adjusted R^2	0.83	0.06	0.74	0.74

Panel C - Horizontal Transactions

Subject Firms'	R&D Intensity	Innovative Acquisition		Firm Value
	1	2	3	4
RICI	0.009***	0.116***	0.033*	0.044*
	0.001	0.000	0.067	0.082
RICI x Excess R&D			-0.546*	
			0.063	
RICI x Historical R&D			0.128	
			0.559	
RICI x Excess Innovative Acquisition				-0.059***
				0.001
RICI x Historical Innovative Acquisition				-0.030*
				0.067
Innovative Acquisition	-0.001*		0.012	0.054***
	0.088		0.140	0.001
R&D Intensity		-0.100	1.731***	1.658***
		0.108	0.000	0.000
Control Variables	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes
Firm Fixed Effects	Yes	Yes	Yes	Yes
Observations	40649	40649	24387	24387
Adjusted R^2	0.82	0.20	0.73	0.73

Table 5 – Innovation Arms Race Correlated Investment and Value decrease Predictions Test – Industry Level Analyses

Table 5 replicates Table 3 tests of the Innovation Arms Race predictions (see Figure 1) and test s are performed by industry. We use the Fama-French 5 industry classification, based on the correspondence table with 4-digit SIC codes provided by the authors. Panel A focuses on the *consumer* industry, Panel B on the *manufacturing* industry, Panel C on the *high-tech* industry, Panel D on the *Healthcare* industry and Panel E on *Other* industry. In each panel, Columns 1 and 2 are dedicated to The Correlated Investment Prediction (incentives to innovate). The dependent variables are *R&D Intensity* in column 1, defined as R&D expenses divided by total assets and *Innovative Acquisition* in Column 2, defined as the number of innovative target acquisitions divided by the number of acquisitions by subject firm. Columns 3 and 4 display tests of the Value decrease Prediction . The dependent variable is natural logarithm of one plus the ratio of the difference between the market value and the book value of assets scaled by the book value of assets, as in Fama and French (1992). The variables of interest are the interaction between *RICI* and *Excess R&D* or *Excess Innovative Acquisition*. The variable of interest is *RICI* is defined as the number of innovative target acquisitions divided by the total number of acquisitions by rival firms per year (see Equation 1). *Excess R&D* is defined as the difference between *R&D Intensity* of the subject firm and its historical *R&D Intensity* (the average *R&D Intensity* over the last three years), and *Excess Innovative Acquisition* is the difference between *Innovative Acquisition* of the subject firm and its historical *Innovative Acquisition* (the average *Innovative Acquisition* over the last three years). Column 3 reports the results for the interaction between *RICI and Excess R&D* and Column 4, the results for the interaction between *RICI* and *Excess Innovative Acquisition*. Estimates are obtained using a fixed-effect regression model. Standard errors are clustered at the firm level (p-value is reported below the coefficient estimate). The inclusion of fixed effects and control variables are indicated in the last rows of the table. All variable definitions are provided in Appendix Table A.1. Statistical significance at 10%, 5%, and 1% is indicated by *, **, and ***, respectively.

Panel A – Consumer Industry

Subject Firms'	R&D Intensity	Innovative Acquisition	Firm Value	
	1	2	3	4
RICI	0.001	-0.009	0.038	0.022
	0.649	0.546	0.247	0.474
RICI x Excess R&D			-2.171*	
			0.082	
RICI x Historical R&D			-1.051	
			0.232	
RICI x Excess Innovative Acquisition				-0.037
				0.551
RICI x Historical Innovative Acquisition				-0.078
				0.222
Innovative Acquisition	-0.001		0.037*	0.050*
	0.410		0.064	0.060
R&D Intensity		-0.200	3.244***	2.979***
		0.429	0.001	0.002
Control Variables	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes
Firm Fixed Effects	Yes	Yes	Yes	Yes
Observations	10427	10427	6547	6547
Adjusted R^2	0.81	0.16	0.779	0.778

Panel B - Manufacturing Industry

Subject Firms'	R&D Intensity	Innovative Acquisition		Firm Value
	1	2	3	4
RICI	0.001	0.006	-0.005	0.004
	0.483	0.784	0.880	0.876
RICI x Excess R&D			-0.368	
			0.650	
RICI x Historical R&D			0.539	
			0.607	
RICI x Excess Innovative Acquisition				-0.029
				0.565
RICI x Historical Innovative Acquisition				0.089
				0.361
Innovative Acquisition	0.000		0.028**	0.033**
	0.639		0.044	0.032
R&D Intensity		0.122	3.204***	3.180***
		0.642	0.002	0.001
Control Variables	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes
Firm Fixed Effects	Yes	Yes	Yes	Yes
Observations	12291	12291	7960	7960
Adjusted R^2	0.82	0.16	0.75	0.75

Panel C - High-Tech Industry

Subject Firms'	R&D Intensity	Innovative Acquisition		Firm Value
	1	2	3	4
RICI	0.012***	0.199***	0.019	0.064**
	0.000	0.002	0.542	0.025
RICI x Excess R&D			-0.088	
			0.717	
RICI x Historical R&D			0.303	
			0.217	
RICI x Excess Innovative Acquisition				-0.040**
				0.023
RICI x Historical Innovative Acquisition				-0.051*
				0.072
Innovative Acquisition	-0.001		0.005	0.031**
	0.337		0.481	0.012
R&D Intensity		-0.137	0.896***	0.936***
		0.315	0.005	0.004
Control Variables	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes
Firm Fixed Effects	Yes	Yes	Yes	Yes
Observations	13912	13912	7969	7969
Adjusted R^2	0.76	0.21	0.72	0.72

Panel D - Health Industry

Subject Firms'	R&D Intensity	Innovative Acquisition		Firm Value
	1	2	3	4
RICI	0.014**	0.059	0.069*	0.095***
	0.011	0.142	0.098	0.006
RICI x Excess R&D			-0.853*	
			0.082	
RICI x Historical R&D			0.085	
			0.780	
RICI x Excess Innovative Acquisition				-0.040
				0.326
RICI x Historical Innovative Acquisition				-0.059
				0.150
Innovative Acquisition	0.000		0.012	0.035
	0.827		0.484	0.231
R&D Intensity		-0.035	2.398***	2.166***
		0.827	0.000	0.000
Control Variables	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes
Firm Fixed Effects	Yes	Yes	Yes	Yes
Observations	5066	5066	3023	3023
Adjusted R^2	0.81	0.21	0.74	0.74

Panel E - Other Industry

Subject Firms'	R&D Intensity	Innovative Acquisition		Firm Value
	1	2	3	4
RICI	0.001	0.074*	0.120**	0.099*
	0.614	0.061	0.048	0.084
RICI x Excess R&D			-0.435	
			0.769	
RICI x Historical R&D			0.002	
			0.998	
RICI x Excess Innovative Acquisition				-0.004
				0.953
RICI x Historical Innovative Acquisition				0.161
				0.133
Innovative Acquisition	-0.003*		0.148***	0.144***
	0.067		0.000	0.000
R&D Intensity		-0.725	0.344	0.303
		0.103	0.716	0.715
Control Variables	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes
Firm Fixed Effects	Yes	Yes	Yes	Yes
Observations	7741	7741	4273	4273
Adjusted R^2	0.91	0.13	0.75	0.75

Table 6 – Innovation Arms Race – Within-Industry Results

Table 6 reports the results of the Innovation Arms Race predictions (see Figure 1) depending on the characteristics of industry participants. Panel A reports the results for Leader and Laggard firms and Panel B reports the results for Neck-to-Neck firms. In each panel, Columns 1 and 2 are dedicated to The Correlated Investment Prediction (incentives to innovate). The dependent variables are *R&D Intensity* in column 1, defined as R&D expenses divided by total assets and *Innovative Acquisition* in Column 2, defined as the number of innovative target acquisitions divided by the number of acquisitions by subject firm. The variables of interest are the interaction between *RICI* and Leader or Laggard in panel A and the interaction between *RICI* and *Neck-to-Neck* firms in panel B. *RICI* is defined as the number of innovative target acquisitions divided by the total number of acquisitions by rival firms per year (see Equation 1). *Leader (Laggard)* is an indicator variable which is equal to 1 if the firm is in the *highest (lowest)* quartile of ROA and market shares. *Neck-to-Neck Firms* is an indicator variable which is equal to 1 if the rival firm is in the highest quartile of the yearly distribution of HP similarity score. In each panel, Columns 3 and 4 display tests of the Value decrease Prediction . The dependent variable is natural logarithm of one plus the ratio of the difference between the market value and the book value of assets scaled by the book value of assets, as in Fama and French (1992). The variables of interest are the interaction between *RICI and Excess R&D*/*Excess Innovative Acquisition* and *Leader*/*Laggard* in Panel A and the interaction between *RICI and Excess R&D*/*Excess Innovative Acquisition* and *Neck-to-Neck* firms in Panel B. *Excess R&D* is defined as the difference between *R&D Intensity* of the subject firm and its historical *R&D Intensity* (the average *R&D Intensity* over the last three years), and *Excess Innovative Acquisition* is the difference between *Innovative Acquisition* of the subject firm and its historical *Innovative Acquisition* (the average *Innovative Acquisition* over the last three years). Estimates are obtained using a fixed-effect regression model. Standard errors are clustered at the firm level (p-value is reported below the coefficient estimate). The inclusion of fixed effects and control variables are indicated in the last rows of the table. All variable definitions are provided in Appendix Table A.1. Statistical significance at 10%, 5%, and 1% is indicated by *, **, and ***, respectively.

Panel A – Industry Leaders and Laggards

Subject Firms'	R&D Intensity	Innovative Acquisition	Firm Value	
	1	2	3	4
RICI			0.050**	0.081***
			0.017	0.006
RICI x Leader	0.009***	0.236***		
	0.001	0.001		
RICI x Laggard	0.015***	0.068***		
	0.001	0.003		
RICI x Others	0.005**	0.119***		
	0.040	0.002		
RICI x Excess R&D x Leader			-1.477*	
			0.051	
RICI x Excess R&D x Laggard			-0.068	
			0.762	
RICI x Excess R&D x Others			-0.712	
			0.144	
RICI x Excess IA x Leader				-0.072***
				0.000
RICI x Excess IA x Laggard				-0.072
				0.170
RICI x Excess IA x Others				-0.061**
				0.024
RICI x Historical IA			0.241	
			0.272	
RICI x Historical R&D				-0.055***
				0.006
Innovative Acquisition	0.000		0.025***	0.060***
	0.407		0.008	0.000
R&D Intensity		-0.065	1.598***	1.545***
		0.388	0.000	0.000
Control Variables	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes
Firm Fixed Effects	Yes	Yes	Yes	Yes
Observations	49773	49773	29888	29888
Adjusted R^2	0.83	0.20	0.74	0.74
F-tests				
$\beta_{RICI\times Leader} - \beta_{RICI\times Laggard} \neq 0$	2.714	10.24***		
	0.115	0.005		
$\beta_{RICI\times Excess\ R\&D\times Leader} - \beta_{RICI\times Excess\ R\&D\times Laggard} \neq 0$			4.151*	
			0.059	
$\beta_{RICI\times Excess\ IA\times Leader} - \beta_{RICI\times Excess\ IA\times Laggard} \neq 0$				0.0003
				0.986

Panel B – Neck-to-Neck Firms

Subject Firms'	R&D Intensity	Innovative Acquisition	Firm Value	
	1	2	3	4
RICI			0.048**	0.081***
			0.021	0.006
RICI x Neck-to-Neck	0.021**	0.127***		
	0.011	0.001		
RICI x Others	0.008***	0.144***		
	0.000	0.001		
RICI x Excess R&D x Neck-to-Neck			-1.010*	
			0.063	
RICI x Excess R&D x Others			-0.329	
			0.236	
RICI x Excess Innovative Acquisition x Neck-to-Neck				-0.089**
				0.042
RICI x Excess Innovative Acquisition x Others				-0.068***
				0.001
RICI x Historical Innovative Acquisition				-0.055***
				0.006
RICI x Historical R&D			0.297	
			0.221	
Innovative Acquisition			0.025***	0.060***
	0.000		0.008	0.000
R&D Intensity	0.381		1.594***	1.547***
		-0.070	0.000	0.000
Control Variables	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes
Firm Fixed Effects	Yes	Yes	Yes	Yes
Observations	49773	49773	29888	29888
Adjusted R^2	0.83	0.20	0.74	0.74
F-tests				
$\beta_{RICI \times Leader} - \beta_{RICI \times Laggard} \neq 0$	4.107*	0.220		
	0.056	0.644		
$\beta_{RICI \times Excess\ R\&D \times Leader} - \beta_{RICI \times Excess\ R\&D \times Laggard} \neq 0$			1.227	
			0.284	
$\beta_{RICI \times Excess\ IA \times Leader} - \beta_{RICI \times Excess\ IA \times Laggard} \neq 0$				0.406
				0.533

Table 7 – The Arms Race Hypothesis Correlated Investment Prediction – Instrumental Variable Estimates

Table 9 replicates Table 3 tests of the Innovation Arms Race Correlated Investment using an instrumental variable approach. The dependent variables are *R&D Intensity* in column 2, defined as R&D expenses divided by total assets and *Innovative Acquisition* in Column 4*,* defined as the number of innovative target acquisitions divided by the number of acquisitions by subject firm. The variable of interest is *RICI,* defined as the number of innovative target acquisitions divided by the total number of acquisitions by rival firms per year (see Equation 1) and is instrumented by *Rival's Tax Induced R&D* (it is the predicted value of firm-level investment in R&D due to tax credit incentives and is obtained by from the Hall-Jorgenson user cost of R&D and replicating the procedure described in Bloom et al. (2013) Internet Appendix B.3.1, denoted $R\&DUC^{10NN}$). R&DUC is the firm tax induced used cost. Columns 1 and 3 report the results obtained from first stage regression and Columns 1 and 4 display the results from second stage regression. Estimates are obtained using 2SLS regression model. Standard errors are clustered at the firm level (p-value is reported below the coefficient estimate). The inclusion of fixed effects and control variables are indicated in the last rows of the table. All variable definitions are provided in Appendix Table A.1. Statistical significance at 10%, 5%, and 1% is indicated by *, **, and ***, respectively.

	1st Stage	*2nd Stage*	*1st Stage*	*2nd Stage*
	RICI	R&D Intensity	RICI	Innovative Acquisition
	1	2	3	4
$R\&DUC^{10NN}$	-0.025***		-0.026***	
	0.001		0.001	
RICI		0.101**		1.574**
		0.043		0.020
Innovative Acquisition	0.039***	-0.005**		
	0.000	0.033		
R&D Intensity			0.367***	-0.680**
			0.000	0.014
R&DUC	***-0.024	0.015***	***-0.026	0.047
	0.000	0.000	0.000	0.159
Joint test of excluded instruments F(9,6860)	37.87		36.86	
Prob >F	0.000		0.000	
Control Variables	Yes	Yes		Yes
Year Fixed Effects	Yes	Yes		Yes
Firm Fixed Effects	Yes	Yes		Yes
Observations	37557		37557	
Overall R^2	0.388		0.050	
Chi^2	662.32		101.60	

Table 8 - M&A and Rivals' Incentives to Innovate – Innovation Efficiency

Table 8 reports results the effects of Innovation Arms Race on innovation efficiency. The dependent variables are *Number of Patents* in Columns 1 and 2 of panel A, defined as log of one plus number of patents, and *Number of Citations* in Columns 1 and 2 of panel B, defined as log of one plus number of citations. In both the panels, the variables of interest are the interaction between *RICI* and *Excess R&D* or *Excess Innovative Acquisition*. *RICI* is defined as the number of innovative target acquisitions divided by the total number of acquisitions by rival firms per year (see Equation 1). *Excess R&D* is defined as the difference between *R&D Intensity* of the subject firm and its historical *R&D Intensity* (the average *R&D Intensity* over the last three years), and *Excess Innovative Acquisition* is the difference between *Innovative Acquisition* of the subject firm and its historical *Innovative Acquisition* (the average *Innovative Acquisition* over the last three years). Column 1 reports the results for the interaction between *RICI and Excess R&D* and Column 2, the results for the interaction between *RICI* and *Excess Innovative Acquisition*. Estimates are obtained using a fixed-effect regression model. Standard errors are clustered at the firm level (p-value is reported below the coefficient estimate). The inclusion of fixed effects and control variables are indicated in the last rows of the table. All variable definitions are provided in Appendix Table A.1. Statistical significance at 10%, 5%, and 1% is indicated by *, **, and ***, respectively.

Panel A – Patents based

Subject Firms'	Number of Patents	
	1	2
RICI	0.000	0.025
	0.985	0.275
RICI x Excess R&D	0.280	
	0.247	
RICI x Historical R&D	0.250	
	0.208	
RICI x Excess Innovative Acquisition		-0.003
		0.818
RICI x Historical Innovative Acquisition		-0.001
		0.861
Innovative Acquisition	0.006	0.007
	0.235	0.211
R&D Intensity	-0.099	0.044
	0.509	0.758
Control Variables	Yes	Yes
Year Fixed Effects	Yes	Yes
Firm Fixed Effects	Yes	Yes
Observations	4147	4147
Adjusted R^2	0.92	0.92

Panel B – Citation based

Subject Firms'	Number of Citations	
	1	2
RICI	-0.037	-0.027
	0.425	0.432
RICI x Excess R&D	0.028	
	0.912	
RICI x Historical R&D	0.109	
	0.586	
RICI x Excess Innovative Acquisition		0.039**
		0.026
RICI x Historical Innovative Acquisition		0.016
		0.406
Innovative Acquisition	-0.002	-0.023**
	0.777	0.043
R&D Intensity	0.361	0.378*
	0.109	0.055
Control Variables	Yes	Yes
Year Fixed Effects	Yes	Yes
Firm Fixed Effects	Yes	Yes
Observations	6212	6212
Adjusted R^2	0.76	0.76

Table 9 – Innovation Arms Race Correlated Investment and Value decrease Predictions Test – Extensive Margin Analyses

Table 4 displays results of Innovation Arms Race Predictions (see Figure 1). In contrast with Table 3, tests are performed at the extensive margin (the sample of firms include firms that are not subject to rival innovative acquisition pressure) Columns 1 and 2 are dedicated to The Correlated Investment Prediction (incentives to innovate). The dependent variables are *R&D Intensity* in column 1, defined as R&D expenses divided by total assets and *Innovative Acquisition* in Column 2*,* defined as the number of innovative target acquisitions divided by the number of acquisitions by subject firm. The variable of interest is *RICI,* defined as the number of innovative target acquisitions divided by the total number of acquisitions by rival firms per year (see Equation 1). Columns 3 and 4 display tests of the Value decrease Prediction . The dependent variable is natural logarithm of one plus the ratio of the difference between the market value and the book value of assets scaled by the book value of assets, as in Fama and French (1992). The variables of interest are the interaction between *RICI* and *Excess R&D* or *Excess Innovative Acquisition*. *Excess R&D* is defined as the difference between *R&D Intensity* of the subject firm and its historical *R&D Intensity* (the average *R&D Intensity* over the last three years), and *Excess Innovative Acquisition* is the difference between *Innovative Acquisition* of the subject firm and its historical *Innovative Acquisition* (the average *Innovative Acquisition* over the last three years). Column 3 reports the results for the interaction between *RICI and Excess R&D* and Column 4, the results for the interaction between *RICI* and *Excess Innovative Acquisition*. Estimates are obtained using a fixed-effect regression model. Standard errors are clustered at the firm level (p-value is reported below the coefficient estimate). The inclusion of fixed effects and control variables are indicated in the last rows of the table. All variable definitions are provided in Appendix Table A.1. Statistical significance at 10%, 5%, and 1% is indicated by *, **, and ***, respectively.

Subject Firms'	R&D Intensity	Innovative Acquisition	Firm Value	
	1	2	3	4
RICI	0.007**	0.112***	0.057***	0.088***
	0.016	0.001	0.003	0.001
RICI x Excess R&D			-0.500***	
			0.006	
RICI x Historical R&D			0.232	
			0.170	
RICI x Excess Innovative Acquisition				-0.072***
				0.000
RICI x Historical Innovative Acquisition				-0.059***
				0.004
Innovative Acquisition	-0.001		0.027***	0.062***
	0.171		0.003	0.000
R&D Intensity		-0.065	1.333***	1.284***
		0.151	0.000	0.000
Control Variables	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes
Firm Fixed Effects	Yes	Yes	Yes	Yes
Observations	76520	76520	43353	43353
Adjusted R^2	0.82	0.21	0.714	0.714

Appendix Table A.1:

The table provides the definition of the set of variables used in our multivariate analyses. Panel A focuses on the variables used in correlated investment prediction tests and Panel B, on the variables used in value decrease tests.

Variable Name	Definitions
Panel A - Correlated Investment Tests	
Dependent Variables	
R&D Intensity	It is defined as R&D expenses divided by total assets (*Source: Compustat and CRSP*).
Innovative Acquisition	It is defined as the number of innovative target acquisitions divided by the number of acquisitions by subject firm (*Source: SDC*).
Variables of Interest	
RICI	It is defined as the number of innovative target acquisitions divided by the total number of acquisitions by rival firms per year (*Source: SDC*).
Control Variables	
Firm Size	It is defined as the natural logarithm of total assets (*Source: Compustat and CRSP*).
ROA	It is defined as the ratio of operating income before depreciation to total assets (*Source: Compustat and CRSP*).
Leverage	It is defined as the ratio of long-term debt and debt in current liabilities to total assets (*Source: Compustat and CRSP*).
Liquidity	It is a cash ratio and is defined as the ratio of cash position to total assets (*Source: Compustat and CRSP*).
Intangible Ratio	It is defined as the ratio of intangible assets to total assets (*Source: Compustat and CRSP*).
MTB	It is defined as the ratio of market value of equity to book value equity, with book equity computed as in Davis et al., 2000 (*Source: Compustat and CRSP*).
Panel B - Value decrease Tests	
Dependent Variables	
Firm Value	It is the logarithm of one plus the market valuation ratio introduced in Fama and French (1998), which is the difference between the market value and book value of total assets scaled by the book value of total assets (*Source: Compustat and CRSP*).
Variables of Interest	
RICI	It is defined as the number of innovative target acquisitions divided by the total number of acquisitions by rival firms per year (*Source: SDC*).
Excess R&D	It is defined as the difference between R&D Intensity of the subject firm and its historical R&D Intensity (the average R&D Intensity over the last three years) (*Source: Compustat and CRSP*).
Excess Innovative Acquisition	It is defined as the difference between Innovative Acquisition of the subject firm and its historical Innovative Acquisition (the average Innovative Acquisition over the last three years) (*Source: SDC*).
Control Variables	

R&D Intensity	It is defined as R&D expenses divided by total assets (*Source: Compustat and CRSP*).
Innovative Acquisition	It is defined as the number of innovative target acquisitions divided by the number of acquisitions by subject firm (*Source: SDC*).
Historical R&D	It is defined as (the average R&D Intensity over the last three years) (*Source: Compustat and CRSP*).
Historical Innovative Acquisition	It is defined as the average Innovative Acquisition over the last three years (*Source: SDC*).
E_{it}/A_{it}	It is the current earnings variable and is defined as earnings in year *t* scaled by book value of assets in year *t* (*Source: Compustat and CRSP*).
dE_{it}/A_{it}	It is the past earnings variable and is defined as change in earnings (E_{it} - E_{it-2}) scaled by book value of assets in year *t* (*Source: Compustat and CRSP*).
dE_{it+2}/A_{it}	It is the future earnings variable and is defined as change in earnings (E_{it+2} - E_{it}) scaled by book value of assets in year *t* (*Source: Compustat and CRSP*).
dA_{it}/A_{it}	It is the past changes in assets and is defined as change in assets (A_{it}- A_{it-2}) scaled by book value of assets in year *t* (*Source: Compustat and CRSP*).
dA_{t+2}/A_{t}	It is the future changes in assets and is defined as change in assets (A_{it+2} - A_{it}) scaled by book value of assets in year *t* (*Source: Compustat and CRSP*).
dRD_{it}/A_{it}	It is the past changes in research and development expenses and is defined as change in assets (RD_{it}- RD_{it-2}) scaled by book value of assets in year *t* (*Source: Compustat and CRSP*).
dRD_{it+2}/A_{it}	It is the future changes in research and development expenses and is defined as change in assets (RD_{it+2} - RD_{it}) scaled by book value of assets in year *t* (*Source: Compustat and CRSP*).
I_{it}/A_{it}	It is the current interest variable and is defined as interest expense in year t scaled by book value of assets in year *t* (*Source: Compustat and CRSP*).
dI_{it}/A_{it}	It is the past interest variable and is defined as change in interest expenses (I_{it} - I_{it-2}) scaled by book value of assets in year *t* (*Source: Compustat and CRSP*).
dI_{it+2}/A_{it}	It is the future interest variable and is defined as change in interest expenses (I_{it+2} - I_{it}) scaled by book value of assets in year *t* (*Source: Compustat and CRSP*).
D_{it}/A_{it}	It is the current dividend variable and is defined as dividends in year t scaled by book value of assets in year t (*Source: Compustat and CRSP*).
dD_{it}/A_{it}	It is the past dividend variable and is defined as change in dividend (D_{it} - D_{it-2}) scaled by book value of assets in year *t* (*Source: Compustat and CRSP*).
dD_{it+2}/A_{it}	It is the future dividend variable and is defined as change in dividend expenses (D_{it+2} - D_{it}) scaled by book value of assets in year *t* (*Source: Compustat and CRSP*).
dV_{it+2}/A_{it}	It the future firm value variable and is defined as change in market value (MV_{it+2} - MV_{it}) scaled by book value of assets in year *t* (*Source: Compustat and CRSP*).

Internet Appendix

This internet appendix reports additional results to accompany the paper "*Innovation Arms Race*".

The contents are as follows:

Table I.A. 1 reports the baseline results from the Table 3 in the paper and shows the coefficients of all the respective control variables used in each regression model.

Table I.A. 2 reports the baseline results from Table 3 in the paper, with the variable interest based on value of transactions (*RIVI)*.

Table I.A. 3 reports the baseline results from Table 4 in the paper, with the variable interest based on value of transactions (*RIVI)*.

Table I.A. 4 reports the baseline results from Table 5 in the paper, with the variable interest based on value of transactions (*RIVI)*.

Table I.A. 5 reports the baseline results from Table 6 in the paper, with the variable interest based on value of transactions (*RIVI)*.

Table I.A. 6 reports the baseline results from Table 7 in the paper, with the variable interest based on value of transactions (*RIVI)*.

Table I.A. 7 reports the baseline results from Table 8 in the paper, with the variable interest based on value of transactions (*RIVI)*.

Table I.A. 8 reports the baseline results from Table 9 in the paper, with the variable interest based on value of transactions (*RIVI)*.

Table I.A. 1 - Innovation Arms Race

Table I.A. 1 reports results of Innovation Arms Race Predictions (see Figure 1). In contrast with Table 3 in the paper, the table displays the results with full set of controls we include in respective regression models. Columns 1 to 4 are dedicated to The Correlated Investment Prediction (incentives to innovate). The dependent variables are *R&D Intensity* in Columns 1 and 3, defined as R&D expenses divided by total assets and *Innovative Acquisition* in Columns 2 and 4, defined as the number of innovative target acquisitions divided by the number of acquisitions by subject firm. The variable of interest is *RICI,* defined as the number of innovative target acquisitions divided by the total number of acquisitions by rival firms per year (see Equation 1). In Columns 1 and 2, *Innovative Acquisition* and *R&D Intensity* are included as control variable and in Columns 3 and 4, they are excluded as a robustness check. Columns 5 and 6 display tests of the Value decrease Prediction . The dependent variable is natural logarithm of one plus the ratio of the difference between the market value and the book value of assets scaled by the book value of assets, as in Fama and French (1992). The variables of interest are the interaction between *RICI* and *Excess R&D* or *Excess Innovative Acquisition*. *Excess R&D* is defined as the difference between *R&D Intensity* of the subject firm and its historical *R&D Intensity* (the average *R&D Intensity* over the last three years), and *Excess Innovative Acquisition* is the difference between *Innovative Acquisition* of the subject firm and its historical *Innovative Acquisition* (the average *Innovative Acquisition* over the last three years). Column 5 reports the results for the interaction between *RICI* and *Excess R&D* and Column 6, the results for the interaction between *RICI* and *Excess Innovative Acquisition*. Estimates are obtained using a fixed-effect regression model. Standard errors are clustered at the firm level (p-value is reported below the coefficient estimate). The inclusion of fixed effects and control variables are indicated in the last rows of the table. All variable definitions are provided in Appendix Table A.1. Statistical significance at 10%, 5%, and 1% is indicated by *, **, and ***, respectively.

Subject Firms'	R&D Intensity	Innovative Acquisition	R&D Intensity	Innovative Acquisition		Firm Value
	1	2	3	4	5	6
RICI	0.009***	0.141***	0.009***	0.141***	0.048**	0.081***
	0.001	0.001	0.001	0.001	0.021	0.006
RICI x Excess R&D					-0.489**	
					0.047	
RICI x Historical R&D					0.291	
					0.206	
RICI x Excess Innovative Acquisition						-0.069***
						0.001
RICI x Historical Innovative Acquisition						-0.055***
						0.005
Innovative Acquisition	0.000				0.025***	0.059***
	0.375				0.008	0.000
R&D Intensity		-0.071			1.589***	1.544***
		0.354			0.000	0.000
Control Variables						
Firm Size	-0.010***	-0.006	-0.010***	-0.025*		
	0.000	0.539	0.000	0.060		
ROA	-0.081***	0.040	-0.079***	0.102*		
	0.000	0.216	0.000	0.076		
Leverage	-0.013***	-0.106***	-0.012***	-0.186***		
	0.003	0.000	0.005	0.005		
Liquidity	0.003	-0.004	0.003	-0.020		
	0.413	0.892	0.548	0.718		
Intangible Ratio	-0.006	-0.215***	-0.006	-0.411***		

	0.179	0.000	0.200	0.000		
MTB	0.000	0.003**	0.000	0.004**		
	0.240	0.041	0.164	0.030		
E_{it}/A_{it}					0.609***	0.612***
					0.001	0.001
dE_{it}/A_{it}					-0.006	-0.007
					0.801	0.795
dE_{it+2}/A_{it}					0.146***	0.146***
					0.008	0.008
dA_{it}/A_{it}					0.144***	0.148***
					0.000	0.000
dA_{it+2}/A_{it}					0.255***	0.255***
					0.000	0.000
dRD_{it}/A_{it}					0.126	0.079
					0.272	0.495
dRD_{it+2}/A_{it}					0.701***	0.708***
					0.003	0.003
I_{it}/A_{it}					-3.312***	-3.265***
					0.000	0.000
dI_{it}/A_{it}					-0.191	-0.247
					0.755	0.694
dI_{it+2}/A_{it}					-0.923	-0.931
					0.206	0.203
D_{it}/A_{it}					1.684***	1.693***
					0.000	0.000
dD_{it}/A_{it}					-0.215*	-0.217*
					0.093	0.090
dD_{it+2}/A_{it}					0.800***	0.807***
					0.005	0.004
dV_{it+2}/A_{it}					-0.078***	-0.078***
					0.000	0.000
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Firm Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	49818	49818	49818	49818	29890	29890
Adjusted R^2	0.83	0.20	0.83	0.20	0.737	0.737

Table I.A. 2 - Innovation Arms Race

Table I.A. 2 reports results of Innovation Arms Race Predictions (see Figure 1). In contrast with Table 3 in the paper, the variable of interest is based on the dollar value of transaction. Columns 1 to 4 are dedicated to The Correlated Investment Prediction (incentives to innovate). The dependent variables are *R&D Intensity* in Columns 1 and 3, defined as R&D expenses divided by total assets and *Innovative Acquisition* in Columns 2 and 4, defined as the number of innovative target acquisitions divided by the number of acquisitions by subject firm. The variable of interest is *RIVI,* defined as the dollar value of innovative target acquisitions divided by the total dollar value of acquisitions by rival firms per year (see Equation 1). In Columns 1 and 2, *Innovative Acquisition* and *R&D Intensity* are included as control variable and in Columns 3 and 4, they are excluded as a robustness check. Columns 5 and 6 display tests of the Value decrease Prediction . The dependent variable is natural logarithm of one plus the ratio of the difference between the market value and the book value of assets scaled by the book value of assets, as in Fama and French (1992). The variables of interest are the interaction between *RIVI* and *Excess R&D* or *Excess Innovative Acquisition*. *Excess R&D* is defined as the difference between *R&D Intensity* of the subject firm and its historical *R&D Intensity* (the average *R&D Intensity* over the last three years), and *Excess Innovative Acquisition* is the difference between *Innovative Acquisition* of the subject firm and its historical *Innovative Acquisition* (the average *Innovative Acquisition* over the last three years). Column 5 reports the results for the interaction between *RIVI* and *Excess R&D* and Column 6, the results for the interaction between *RIVI* and *Excess Innovative Acquisition*. Estimates are obtained using a fixed-effect regression model. Standard errors are clustered at the firm level (p-value is reported below the coefficient estimate). The inclusion of fixed effects and control variables are indicated in the last rows of the table. All variable definitions are provided in Appendix Table A.1. Statistical significance at 10%, 5%, and 1% is indicated by *, **, and ***, respectively.

Subject Firms'	R&D Intensity	Innovative Acquisition	R&D Intensity	Innovative Acquisition		Firm Value
	1	2	3	4	5	6
RIVI	0.007***	0.173***	0.007***	0.172***	0.048**	0.081***
	0.001	0.005	0.001	0.005	0.021	0.006
RIVI x Excess R&D					-0.489**	
					0.047	
RIVI x Historical R&D					0.291	
					0.206	
RIVI x Excess Innovative Acquisition						-0.069***
						0.001
RIVI x Historical Innovative Acquisition						-0.055***
						0.005
Innovative Acquisition	0.000				0.025***	0.059***
	0.284				0.008	0.000
R&D Intensity		-0.156			1.589***	1.544***
		0.279			0.000	0.000
Control Variables	Yes	Yes	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Firm Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	44800	44800	44800	44800	29890	29890
Adjusted R^2	0.83	0.17	0.83	0.17	0.737	0.737

Table I.A. 3 - Innovation Arms Race – Subsample Analyses

Table I.A. 4 replicates Table 3 tests of the Innovation Arms Race Predictions (see Figure 1) and tests are performed for sub-samples of M&A transactions. In contrast to Table 5 in the paper, the variable of interest is based on the dollar value of transaction. In Panel A, the M&A sample is restricted to change of control transactions. Panel B reports the results when we take into account the innovative acquisitions of public target only and in Panel C, we limit our sample to horizontal transactions. In each panel, Columns 1 and 2 are dedicated to The Correlated Investment Prediction (incentives to innovate). The dependent variables are *R&D Intensity* in column 1, defined as R&D expenses divided by total assets and *Innovative Acquisition* in Column 2*,* defined as the number of innovative target acquisitions divided by the number of acquisitions by subject firm. Columns 3 and 4 display tests of the Value decrease Prediction . The dependent variable is natural logarithm of one plus the ratio of the difference between the market value and the book value of assets scaled by the book value of assets, as in Fama and French (1992). The variables of interest are the interaction between *RIVI* and *Excess R&D* or *Excess Innovative Acquisition*. *RIVI* is defined as the dollar value of innovative target acquisitions divided by the total dollar value of acquisitions by rival firms per year (see Equation 1). *Excess R&D* is defined as the difference between *R&D Intensity* of the subject firm and its historical *R&D Intensity* (the average *R&D Intensity* over the last three years), and *Excess Innovative Acquisition* is the difference between *Innovative Acquisition* of the subject firm and its historical *Innovative Acquisition* (the average *Innovative Acquisition* over the last three years). Column 3 reports the results for the interaction between *RIVI and Excess R&D* and Column 4, the results for the interaction between *RIVI* and *Excess Innovative Acquisition*. Estimates are obtained using a fixed-effect regression model. Standard errors are clustered at the firm level (p-value is reported below the coefficient estimate). The inclusion of fixed effects and control variables are indicated in the last rows of the table. All variable definitions are provided in Appendix Table A.1. Statistical significance at 10%, 5%, and 1% is indicated by *, **, and ***, respectively.

Panel A - Change of Control Transactions

Subject Firms'	R&D Intensity	Innovative Acquisition	Firm Value	
	1	2	3	4
RIVI	0.007***	0.165***	0.022	0.060**
	0.001	0.005	0.254	0.012
RIVI x Excess R&D			-0.416	
			0.171	
RIVI x Historical R&D			0.362	
			0.111	
RIVI x Excess Innovative Acquisition				-0.027***
				0.001
RIVI x Historical Innovative Acquisition				-0.026**
				0.012
Innovative Acquisition	0.000		0.003	0.017***
	0.332		0.368	0.005
R&D Intensity		-0.144	1.548***	1.536***
		0.325	0.000	0.000
Control Variables	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes
Firm Fixed Effects	Yes	Yes	Yes	Yes
Observations	43423	43423	26155	26155
Adjusted R^2	0.83	0.16	0.74	0.74

Panel B - Acquisitions of Public Targets Only

Subject Firms'	R&D Intensity	Innovative Acquisition		Firm Value
	1	2	3	4
RIVI	0.005**	0.034*	0.027	0.057**
	0.026	0.068	0.147	0.022
RIVI x Excess R&D			-0.518*	
			0.095	
RIVI x Historical R&D			0.346	
			0.145	
RIVI x Excess Innovative Acquisition				-0.019*
				0.056
RIVI x Historical Innovative Acquisition				-0.024
				0.246
Innovative Acquisition	0.000		-0.005	0.007
	0.761		0.346	0.293
R&D Intensity		0.029	1.587***	1.543***
		0.763	0.000	0.000
Control Variables	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes
Firm Fixed Effects	Yes	Yes	Yes	Yes
Observations	44800	44800	26941	26941
Adjusted R^2	0.83	0.03	0.74	0.74

Panel C - Horizontal Transactions

Subject Firms'	R&D Intensity	Innovative Acquisition		Firm Value
	1	2	3	4
RIVI	0.009***	0.214***	0.013	0.041*
	0.000	0.002	0.478	0.084
RIVI x Excess R&D			-0.549*	
			0.078	
RIVI x Historical R&D			0.278	
			0.242	
RIVI x Excess Innovative Acquisition				-0.019
				0.106
RIVI x Historical Innovative Acquisition				-0.017
				0.124
Innovative Acquisition	0.000		-0.002	0.012
	0.225		0.516	0.204
R&D Intensity		-0.159	1.716***	1.686***
		0.225	0.000	0.000
Control Variables	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes
Firm Fixed Effects	Yes	Yes	Yes	Yes
Observations	32787	32787	19697	19697
Adjusted R^2	0.82	0.17	0.73	0.73

Table I.A. 4 – Innovation Arms Race – Industry Level Results

Table I.A. 5 replicates Table 3 tests of the Innovation Arms Race Predictions (see Figure 1) and tests are performed by industry. In contrast to Table 6 in the paper, the variable of interest is based on the dollar value of transaction. We use the Fama-French 5 industry classification, based on the correspondence table with 4-digit SIC codes provided by the authors. Panel A focuses on the *consumer* industry, Panel B on the *manufacturing* industry, Panel C on the *high-tech* industry, Panel D on the *Healthcare* industry and Panel E on *Other* industry. In each panel, Columns 1 and 2 are dedicated to The Correlated Investment Prediction (incentives to innovate). The dependent variables are *R&D Intensity* in column 1, defined as R&D expenses divided by total assets and *Innovative Acquisition* in Column 2, defined as the number of innovative target acquisitions divided by the number of acquisitions by subject firm. Columns 3 and 4 display tests of the Value decrease Prediction . The dependent variable is natural logarithm of one plus the ratio of the difference between the market value and the book value of assets scaled by the book value of assets, as in Fama and French (1992). The variables of interest are the interaction between *RIVI* and *Excess R&D* or *Excess Innovative Acquisition*. *RIVI* is defined as the dollar value of innovative target acquisitions divided by the total dollar value of acquisitions by rival firms per year (see Equation 1). *Excess R&D* is defined as the difference between *R&D Intensity* of the subject firm and its historical *R&D Intensity* (the average *R&D Intensity* over the last three years), and *Excess Innovative Acquisition* is the difference between *Innovative Acquisition* of the subject firm and its historical *Innovative Acquisition* (the average *Innovative Acquisition* over the last three years). Column 3 reports the results for the interaction between *RIVI and Excess R&D* and Column 4, the results for the interaction between *RIVI* and *Excess Innovative Acquisition*. Estimates are obtained using a fixed-effect regression model. Standard errors are clustered at the firm level (p-value is reported below the coefficient estimate). The inclusion of fixed effects and control variables are indicated in the last rows of the table. All variable definitions are provided in Appendix Table A.1. Statistical significance at 10%, 5%, and 1% is indicated by *, **, and ***, respectively.

Panel A – Consumer Industry

Subject Firms'	R&D Intensity	Innovative Acquisition	Firm Value	
	1	2	3	4
RIVI	-0.001	0.021	0.007	-0.003
	0.183	0.471	0.790	0.893
RIVI x Excess R&D			-1.758*	
			0.094	
RIVI x Historical R&D			-0.952	
			0.176	
RIVI x Excess Innovative Acquisition				-0.008
				0.608
RIVI x Historical Innovative Acquisition				-0.087**
				0.018
Innovative Acquisition	0.000		0.014**	0.017**
	0.674		0.029	0.021
R&D Intensity		-0.302	3.369***	3.063***
		0.684	0.001	0.002
Control Variables	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes
Firm Fixed Effects	Yes	Yes	Yes	Yes
Observations	8761	8761	5511	5511
Adjusted R^2	0.82	0.08	0.78	0.78

Panel B - Manufacturing Industry

Subject Firms'	R&D Intensity	Innovative Acquisition		Firm Value
	1	2	3	4
RIVI	0.000	-0.031	-0.006	0.008
	0.956	0.435	0.859	0.678
RIVI x Excess R&D			-0.358	
			0.673	
RIVI x Historical R&D			0.459	
			0.561	
RIVI x Excess Innovative Acquisition				0.005
				0.790
RIVI x Historical Innovative Acquisition				0.014
				0.725
Innovative Acquisition	0.000		0.007	0.006
	0.393		0.273	0.298
R&D Intensity		0.564	3.403***	3.362***
		0.412	0.001	0.000
Control Variables	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes
Firm Fixed Effects	Yes	Yes	Yes	Yes
Observations	11199	11199	7266	7266
Adjusted R^2	0.82	0.11	0.74	0.74

Panel C - High-Tech Industry

Subject Firms'	R&D Intensity	Innovative Acquisition		Firm Value
	1	2	3	4
RIVI	0.010***	0.264***	-0.010	0.046*
	0.000	0.002	0.737	0.073
RIVI x Excess R&D			-0.146	
			0.646	
RIVI x Historical R&D			0.401	
			0.133	
RIVI x Excess Innovative Acquisition				-0.031***
				0.004
RIVI x Historical Innovative Acquisition				-0.032**
				0.024
Innovative Acquisition	-0.001		-0.003	0.016**
	0.169		0.457	0.015
R&D Intensity		-0.375	0.880***	0.944***
		0.174	0.009	0.004
Control Variables	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes
Firm Fixed Effects	Yes	Yes	Yes	Yes
Observations	13119	13119	7537	7537
Adjusted R^2	0.76	0.18	0.72	0.72

Panel D - Health Industry

Subject Firms'	R&D Intensity	Innovative Acquisition	Firm Value	
	1	2	3	4
RIVI	0.009**	0.153	0.038	0.082**
	0.030	0.112	0.318	0.020
RIVI x Excess R&D			-0.723	
			0.129	
RIVI x Historical R&D			0.148	
			0.587	
RIVI x Excess Innovative Acquisition				-0.023
				0.100
RIVI x Historical Innovative Acquisition				-0.043**
				0.020
Innovative Acquisition	0.000		0.001	0.017*
	0.604		0.879	0.078
R&D Intensity		-0.201	2.471***	2.278***
		0.612	0.000	0.000
Control Variables	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes
Firm Fixed Effects	Yes	Yes	Yes	Yes
Observations	4671	4671	2815	2815
Adjusted R^2	0.81	0.20	0.75	0.75

Panel E - Other Industry

Subject Firms'	R&D Intensity	Innovative Acquisition	Firm Value	
	1	2	3	4
RIVI	0.001	0.074	0.168***	0.115**
	0.437	0.236	0.006	0.043
RIVI x Excess R&D			-1.188	
			0.340	
RIVI x Historical R&D			-1.235	
			0.166	
RIVI x Excess Innovative Acquisition				0.031
				0.471
RIVI x Historical Innovative Acquisition				0.147*
				0.068
Innovative Acquisition	-0.002**		0.046**	0.029
	0.033		0.034	0.125
R&D Intensity		-1.234*	0.880	0.434
		0.071	0.359	0.607
Control Variables	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes
Firm Fixed Effects	Yes	Yes	Yes	Yes
Observations	6658	6658	3681	3681
Adjusted R^2	0.90	0.07	0.75	0.75

Table I.A. 5 – Innovation Arms Race – Within-Industry Results

Table I.A. 6 reports the results of the Innovation Arms Race predictions (see Figure 1) depending on the characteristics of industry participants. Panel A reports the results for Leader and Laggard firms and Panel B reports the results for Neck-to-Neck firms. In each panel, Columns 1 and 2 are dedicated to The Correlated Investment Prediction (incentives to innovate). The dependent variables are *R&D Intensity* in column 1, defined as R&D expenses divided by total assets and *Innovative Acquisition* in Column 2, defined as the number of innovative target acquisitions divided by the number of acquisitions by subject firm. The variables of interest are the interaction between *RIVI* and Leader or Laggard in panel A and the interaction between *RIVI* and *Neck-to-Neck* firms in panel B. *RIVI* is defined as the dollar value of innovative target acquisitions divided by the total dollar value of acquisitions by rival firms per year (see Equation 1). *Leader (Laggard)* is an indicator variable which is equal to 1 if the firm is in the *highest (lowest)* quartile of ROA and market shares. *Neck-to-Neck Firms* is an indicator variable which is equal to 1 if the rival firm is in the highest quartile of the yearly distribution of HP similarity score. In each panel, Columns 3 and 4 display tests of the Value decrease Prediction . The dependent variable is natural logarithm of one plus the ratio of the difference between the market value and the book value of assets scaled by the book value of assets, as in Fama and French (1992). The variables of interest are the interaction between *RIVI and Excess R&D*/*Excess Innovative Acquisition* and *Leader*/*Laggard* in Panel A and the interaction between *RIVI and Excess R&D*/*Excess Innovative Acquisition* and *Neck-to-Neck* firms in Panel B. *Excess R&D* is defined as the difference between *R&D Intensity* of the subject firm and its historical *R&D Intensity* (the average *R&D Intensity* over the last three years), and *Excess Innovative Acquisition* is the difference between *Innovative Acquisition* of the subject firm and its historical *Innovative Acquisition* (the average *Innovative Acquisition* over the last three years). Estimates are obtained using a fixed-effect regression model. Standard errors are clustered at the firm level (p-value is reported below the coefficient estimate). The inclusion of fixed effects and control variables are indicated in the last rows of the table. All variable definitions are provided in Appendix Table A.1. Statistical significance at 10%, 5%, and 1% is indicated by *, **, and ***, respectively.

Panel A – Industry Leaders and Laggards

Subject Firms'	R&D Intensity	Innovative Acquisition	Firm Value	
	1	2	3	4
RIVI			0.024	0.058**
			0.186	0.018
RIVI x Leader	0.006***	0.311***		
	0.006	0.003		
RIVI x Laggard	0.010***	0.081***		
	0.005	0.007		
RIVI x Others	0.003	0.118**		
	0.115	0.024		
RIVI x Excess R&D x Leader			-1.361**	
			0.046	
RIVI x Excess R&D x Laggard			-0.051	
			0.850	
RIVI x Excess R&D x Others			-0.446	
			0.430	
RIVI x Excess Innovative Acquisition x Leader				-0.005
				0.173
RIVI x Excess Innovative Acquisition x Laggard				-0.021
				0.189
RIVI x Excess Innovative Acquisition x Others				-0.006
				0.444
RIVI x Historical Innovative Acquisition				-0.012
				0.196
RIVI x Historical R&D			0.336	
			0.127	
Innovative Acquisition	0.000		0.000	0.000
	0.219		0.190	0.383
R&D Intensity		-0.174	1.579***	1.563***
		0.212	0.000	0.000
Control Variables	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes
Firm Fixed Effects	Yes	Yes	Yes	Yes
Observations	49773	49773	29888	29888
Adjusted R^2	0.83	0.17	0.74	0.74
F-tests				
$\beta_{RICI\times Leader} - \beta_{RICI\times Laggard} \neq 0$	1.716	8.145***		
	0.205	0.010		
$\beta_{RICI\times Excess\ R\&D\times Leader} - \beta_{RICI\times Excess\ R\&D\times Laggard} \neq 0$			4.405*	
			0.052	
$\beta_{RICI\times Excess\ IA\times Leader} - \beta_{RICI\times Excess\ IA\times Laggard} \neq 0$				1.085
				0.313

Panel B – Neck-to-Neck Firms

Subject Firms'	R&D Intensity	Innovative Acquisition	Firm Value	
	1	2	3	4
RIVI			0.023	0.058**
			0.198	0.018
RIVI x Neck-to-Neck	0.018**	0.201***		
	0.016	0.008		
RIVI x Others	0.005***	0.169***		
	0.003	0.005		
RIVI x Excess R&D x Neck-to-Neck			-0.577	
			0.377	
RIVI x Excess R&D x Others			-0.347	
			0.232	
RIVI x Excess Innovative Acquisition x Neck-to-Neck				-0.008
				0.262
RIVI x Excess Innovative Acquisition x Others				-0.006**
				0.023
RIVI x Historical Innovative Acquisition			-0.012	
			0.202	
RIVI x Historical R&D				0.371
				0.115
Innovative Acquisition	0.000		0.000	0.000
	0.200		0.192	0.434
R&D Intensity		-0.181	1.572***	1.559***
		0.194	0.000	0.000
Control Variables	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes
Firm Fixed Effects	Yes	Yes	Yes	Yes
Observations	49773	49773	29888	29888
Adjusted R^2	0.83	0.17	0.74	0.74
F-tests				
$\beta_{RICI \times Leader} - \beta_{RICI \times Laggard} \neq 0$	4.752**	0.219		
	0.041	0.645		
$\beta_{RICI \times Excess\ R\&D \times Leader} - \beta_{RICI \times Excess\ R\&D \times Laggard} \neq 0$			0.128	
			0.725	
$\beta_{RICI \times Excess\ IA \times Leader} - \beta_{RICI \times Excess\ IA \times Laggard} \neq 0$				0.073
				0.791

Table I.A. 6 - M&A and Rivals' Incentives to Innovate – Instrumental Variable Estimates

Table I.A. 8 replicates Table 3 tests of the Innovation Arms Race Correlated Investment using an instrumental variable approach. The dependent variables are *R&D Intensity* in column 2, defined as R&D expenses divided by total assets and *Innovative Acquisition* in Column 4, defined as the number of innovative target acquisitions divided by the number of acquisitions by subject firm. The variable of interest is *RIVI,* defined as the dollar value of innovative target acquisitions divided by the total dollar value of acquisitions by rival firms per year (see Equation 1) and is instrumented by *Rival's Tax Induced R&D* (it is the predicted value of firm-level investment in R&D due to tax credit incentives and is obtained by from the Hall-Jorgenson user cost of R&D and replicating the procedure described in Bloom et al. (2013) Internet Appendix B.3.1). Columns 1 and 3 report the results obtained from first stage regression and Columns 1 and 4 display the results from second stage regression. Estimates are obtained using 2SLS regression model. Standard errors are clustered at the firm level (p-value is reported below the coefficient estimate). The inclusion of fixed effects and control variables are indicated in the last rows of the table. All variable definitions are provided in Appendix Table A.1. Statistical significance at 10%, 5%, and 1% is indicated by *, **, and ***, respectively.

	1st Stage	*2nd Stage*	*1st Stage*	*2nd Stage*
	RIVI	R&D Intensity	RIVI	Innovative Acquisition
	1	2		2
Rival's Tax Induced R&D	-0.025***		-0.026***	
	0.001		0.001	
RIVI		0.101**		1.574**
		0.043		0.020
Innovative Acquisition	0.039***	-0.005**		
	0.000	0.033		
R&D Intensity			0.367***	-0.680**
			0.000	0.014
Tax Induced R&D	***-0.024	0.015***	***-0.026	0.047
	0.000	0.000	0.000	0.159
Joint test of excluded instruments F(9,6860)	37.87		36.86	
Prob >F	0.000		0.000	
Control Variables	Yes	Yes		Yes
Year Fixed Effects	Yes	Yes		Yes
Firm Fixed Effects	Yes	Yes		Yes
Observations	37557		37557	
Overall R^2	0.388		0.050	
Chi^2	662.32		101.60	

Table I.A. 7 - M&A and Rivals' Incentives to Innovate – Innovation Efficiency

Table I.A. 7 reports the effects of Innovation Arms Race on innovation efficiency. The dependent variables are *Number of Patents* in Columns 1 and 2 of panel A, defined as log of one plus number of patents, and *Number of Citations* in Columns 1 and 2 of panel B, defined as log of one plus number of citations. In both the panels, the variables of interest are the interaction between *RIVI* and *Excess R&D* or *Excess Innovative Acquisition*. *RIVI* is defined as the dollar value of innovative target acquisitions divided by the total dollar value of acquisitions by rival firms per year (see Equation 1). *Excess R&D* is defined as the difference between *R&D Intensity* of the subject firm and its historical *R&D Intensity* (the average *R&D Intensity* over the last three years), and *Excess Innovative Acquisition* is the difference between *Innovative Acquisition* of the subject firm and its historical *Innovative Acquisition* (the average *Innovative Acquisition* over the last three years). Column 1 reports the results for the interaction between *RIVI and Excess R&D* and Column 2, the results for the interaction between *RIVI* and *Excess Innovative Acquisition*. Estimates are obtained using a fixed-effect regression model. Standard errors are clustered at the firm level (p-value is reported below the coefficient estimate). The inclusion of fixed effects and control variables are indicated in the last rows of the table. All variable definitions are provided in Appendix Table A.1. Statistical significance at 10%, 5%, and 1% is indicated by *, **, and ***, respectively.

Panel A – Patents based

Subject Firms'	Number of Patents	
	1	2
RIVI	-0.025	0.007
	0.251	0.701
RIVI x Excess R&D	0.431*	
	0.070	
RIVI x Historical R&D	0.321	
	0.119	
RIVI x Excess Innovative Acquisition		-0.008
		0.195
RIVI x Historical Innovative Acquisition		-0.004
		0.697
Innovative Acquisition	0.001	0.006
	0.701	0.152
R&D Intensity	-0.171	0.046
	0.282	0.746
Control Variables	Yes	Yes
Year Fixed Effects	Yes	Yes
Firm Fixed Effects	Yes	Yes
Observations	3772	3772
Adjusted R^2	0.92	0.92

Panel B – Citation based

Subject Firms'	Number of Citations	
	1	2
RIVI	-0.031	-0.012
	0.254	0.671
RIVI x Excess R&D	-0.090	
	0.738	
RIVI x Historical R&D	0.217	
	0.206	
RIVI x Excess Innovative Acquisition		0.024**
		0.031
RIVI x Historical Innovative Acquisition		0.013
		0.234
Innovative Acquisition	-0.006*	-0.019**
	0.091	0.016
R&D Intensity	0.396*	0.385*
	0.088	0.060
Control Variables	Yes	Yes
Year Fixed Effects	Yes	Yes
Firm Fixed Effects	Yes	Yes
Observations	5771	5771
Adjusted R^2	0.76	0.76

Table I.A. 8 - Innovation Arms Race – Extensive Margin Analyses

Table I.A. 3 displays results of Innovation Arms Race Predictions (see Figure 1) and tests are performed at the extensive margin (the sample of firms include firms that are not subject to rival innovative acquisition pressure). In contrast to Table 4 in the paper, the variable of interest is based on the dollar value of transaction. Columns 1 and 2 are dedicated to The Correlated Investment Prediction (incentives to innovate). The dependent variables are *R&D Intensity* in column 1, defined as R&D expenses divided by total assets and *Innovative Acquisition* in Column 2, defined as the number of innovative target acquisitions divided by the number of acquisitions by subject firm. The variable of interest is *RIVI,* defined as the dollar value of innovative target acquisitions divided by the total dollar value of acquisitions by rival firms per year (see Equation 1). Columns 3 and 4 display tests of the Value decrease Prediction . The dependent variable is natural logarithm of one plus the ratio of the difference between the market value and the book value of assets scaled by the book value of assets, as in Fama and French (1992). The variables of interest are the interaction between *RICI* and *Excess R&D* or *Excess Innovative Acquisition*. *Excess R&D* is defined as the difference between *R&D Intensity* of the subject firm and its historical *R&D Intensity* (the average *R&D Intensity* over the last three years), and *Excess Innovative Acquisition* is the difference between *Innovative Acquisition* of the subject firm and its historical *Innovative Acquisition* (the average *Innovative Acquisition* over the last three years). Column 3 reports the results for the interaction between *RIVI and Excess R&D* and Column 4, the results for the interaction between *RIVI* and *Excess Innovative Acquisition*. Estimates are obtained using a fixed-effect regression model. Standard errors are clustered at the firm level (p-value is reported below the coefficient estimate). The inclusion of fixed effects and control variables are indicated in the last rows of the table. All variable definitions are provided in Appendix Table A.1. Statistical significance at 10%, 5%, and 1% is indicated by *, **, and ***, respectively.

Subject Firms'	R&D Intensity	Innovative Acquisition	Firm Value	
	1	2	3	4
RIVI	0.005**	0.148***	0.028*	0.066***
	0.031	0.003	0.090	0.003
RIVI x Excess R&D			-0.417**	
			0.042	
RIVI x Historical R&D			0.318*	
			0.055	
RIVI x Excess Innovative Acquisition				-0.029***
				0.003
RIVI x Historical Innovative Acquisition				-0.031***
				0.003
Innovative Acquisition	-0.001		0.005*	0.020***
	0.113		0.089	0.003
R&D Intensity		-0.133	1.316***	1.293***
		0.113	0.000	0.000
Control Variables	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes
Firm Fixed Effects	Yes	Yes	Yes	Yes
Observations	76520	76520	43353	43353
Adjusted R^2	0.82	0.17	0.713	0.713