Working Papers | 81

1.7.2020

Killers on the Road of Emerging Start-ups

IMPLICATIONS FOR MARKET ENTRY AND VENTURE CAPITAL FINANCING

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Suggested citation:
Koski, Heli, Kässi, Otto & Braesemann, Fabian (1.7.2020). "Killers on the Road of Emerging Start-ups – Implications for Market Entry and Venture Capital Financing".

ETLA Working Papers No 81.
http://pub.etla.fi/ETLA-Working-Papers-81.pdf

Abstract

This paper empirically studies the effect of acquisitions made by the large US-based technology companies on the entry dynamics and venture capital financing in different product markets. We use data from 742 product markets globally, distinguishing the US and European markets, for the years 2003–2018. The estimation results based on the difference-in-differences estimation suggest that the technology giants' buyouts subsequently reduced market entry rates and decreased available venture capital funding in the target product markets of tech giants' acquisitions. In other words, the acquisitions of technology giants seem to generate the so-called kill zone effect. Our empirical analysis further suggests that this effect was strengthened during the 2010s when large technology companies gained increasing access to user data. Furthermore, we find that technology giants' acquisitions of platform companies have decreased market entry in non-platform markets. In the US, unlike in the EU area, also available venture capital financing has declined in such non-platform markets from which technology giants have acquired companies.

Tiivistelmä

Teknologiajättien yritysostojen vaikutus yritysten markkinoille tuloon ja pääomasijoituksiin

Tämä tutkimus tarkastelee suurten yhdysvaltalaisten teknologiajättien yritysostojen vaikututusta yritysten markkinoille tuloon ja niiden saamiin pääomasijoituksiin. Tutkimuksen aineisto kattaa 742 tuotemarkkinaa globaalisti, erottaen Yhdysvaltojen ja Euroopan markkina-alueet, vuosina 2003–2018. Aineistoanalyysimme viittaa siihen, että teknologiajättien yritysostot ovat vähentäneet selvästi uusien yritysten markkinoille tuloa ja pääomasijoituksia sekä Yhdysvalloissa että Euroopassa tuotemarkkinoilla, joilta teknologiajätit ovat ostaneet yrityksiä. Toisin sanoen, teknologiajättien yritysostot näyttävät luovan nk. kuolemanlaakso -vaikutuksen markkinoilla. Löydämme myös näyttöä siitä, että kuolemanlaakso-vaikutus on vahvistunut 2010-luvulla teknologiajättien käytettävissä olevan henkilödatan määrän kasvun myötä. Teknologiajättien alustayritysostot ovat vähentäneet uusien yritysten markkinoille tuloa myös muilla kuin alustamarkkinoilla. Yhdysvalloissa, toisin kuin EU-alueella, seurauksena on ollut myös yritysten saamien pääomasijoitusten määrän pieneneminen ei-alustamarkkinoilla, joilta teknologiajätit ovat ostaneet yrityksiä.

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KTT **Heli Koski** on Elinkeinoelämän tutkimuslaitoksen tutkimusjohtaja ja Aalto-yliopiston tutkimusjohtaja.

VTT **Otto Kässi** on Elinkeinoelämän tutkimuslaitoksen tutkija.

Ph.D. (Econ) **Fabian Braesemann** on tutkija ja data-analyytikko Oxfordin yliopiston Saïd Business Schoolissa.

Acknowledgement: This report has been drafted as a part of the BRIE-Etla 2019–2022 – Shaping the Future in the Era of Intelligent Tools: AI and Beyond research project funded by Business Finland.

Kiitokset: Tämä raportti on osa BRIE-Etla 2019–2020 – Älykkäät teknologiat, globaalit ICT-toimijat ja markkinoiden toimivuus -tutkimusprojektia, jonka on rahoittanut Business Finland.

Keywords: Acquisitions, Venture capital funding, Competition, Technology giants

Asiasanat: Yritysostot, Pääomasijoittaminen, Kilpailu, Teknologiajätit

JEL: G24, G34, L1, L41

1. Introduction

The US-based technology giants' recent billion or even multi-billion deals to acquire technology companies have caught plenty of attention in the media and public discussion. Such examples include Google's USD 1.6 billion deal with a video sharing platform YouTube in 2006 and Microsoft's acquisition of professional social media platform LinkedIn for over USD 26 billion deal with LinkedIn in 2016. In addition to the tech giants' buyouts of platform companies of which large and increasing user bases are likely to reinforce lock-in effects arising from network externalities, the technology giants have regularly acquired smaller technology companies. Recent studies suggest that the expanding proliferation of technology companies outside of their core business areas has enabled them to accumulate more sharable inputs, data, and software algorithms that can be used to exploit the data (see, e.g., Koski and Pantzar, 2019). By the end of 2018, the six US-based technology giants' (Google, Apple, Microsoft, Amazon, Facebook, and IBM) total number of acquisitions amounted to over 950, of which almost 70 percent took place during the past ten years.

The increasing market power of the largest technology companies has raised competitive concerns (see, e.g., Cremer et al. 2019).[4] Large companies' buyouts of companies that could potentially grow to be their future rivals have further raised the question of whether the contemporary antitrust enforcement tools are adequate in digital markets (see, e.g., Argentesi et al., 2019; Cabral, 2020).[5] This paper aims to study the effect of acquisitions of the large US-based technology companies on entry dynamics and venture capital financing in different product markets. Building on previous literature, we hypothesize that acquisitions by the large incumbent companies lead to decreased entry and venture capital funding for other active firms in the market. Moreover, we suggest that this so-called kill zone effect may spill over from the tech giants' acquisitions in platform markets to non-platform markets in which they are active. This may happen as the acquisitions of platform companies increase the volume and variety of personal data tech giants have access to and strengthen their market dominance in non-platform markets. Furthermore, we hypothesize that the kill zone effect of tech giants' acquisitions has increased over time due to the increased volumes of consumer data they have access.

We use data for the years 2002-2018 extracted from Crunchbase, a global database of start-up companies, which provides detailed information on the market entry of technology companies and the amounts of venture capital funding attained by companies. A particular advantage of the Crunchbase dataset is that all

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4 For instance, in Europe, both the EU and the United Kingdom have appointed expert panels concentrating on digital competition (see European Commission (2019) and HM Treasury (2018) reports). Some recently published policy papers such as Bourreau and de Steel (2019) and Hylton (2019) assess the costs and benefits of platform acquisitions.

5 For a thorough discussion on the merger control for digital markets from a legal perspective, see Holmström et al. (2019). For more general discussion of the topic in the media, see, e.g., The Economist (2018) "American tech giants are making life tough for start-ups" (https://www.economist.com/business/2018/06/02/american-tech-giants-are-making-life-tough-for-startups accessed 2020-03-10).

companies are classified according to their main products into 744 product categories. This data feature allows us to capture the sample firms' product portfolios with a high resolution and to identify the major product markets in which companies are active. We employ a difference-in-differences estimation method to explore whether and how the large US-based technology giants' acquisitions have subsequently affected the entry dynamics and venture capital financing in different product markets in the United States and EU compared to product markets without acquisitions.

We find that the large technology companies' buyouts generally lead to substantially lower market entry rates and less venture capital funding in the target product markets both in the US and Europe. Our empirical analysis further suggests that this effect was strengthened during the 2010s when large technology companies gained increasing access to user data. Furthermore, we find that technology giants' acquisitions of platform companies have decreased market entry in non-platform markets. In the US, unlike in the EU area, also available venture capital financing has declined in such non-platform markets from which technology giants have acquired companies.

We organize the remainder of the paper as follows. In section 2, we present a literature review and discuss hypotheses stemming from the literature. Section 3 introduces the data and discusses its strengths and limitations. We present the empirical model and estimation results in Section 4. Section 5 concludes.

2. Competitive impacts of acquisitions

Economic literature provides controversial views on whether the large companies' acquisitions of start-ups tend to be pro-competitive or have adverse effects on competition. On the one hand, mergers between established firms and start-ups may facilitate the transfer of technologies bringing about substantial synergies and efficiencies. While the start-up may contribute innovative ideas and new products, the established firm may possess the competencies, assets, and financial resources needed to deploy those ideas and products further and commercialize them. According to Schumpeter's seminal work (1934, 1942), monopoly is a mechanism to attain efficiency in the markets. A competitive threat from newcomers keeps incumbents innovating and prevents them from charging monopoly profits. Simultaneously, the chance to be acquired by larger companies may motivate market entrants' innovation (see, e.g., Phillips and Zhdanov, 2013). Furthermore, it is an essential element of venture capital markets: it is among the main exit routes for investors, and it provides an incentive for the private financing of high-risk innovation (see, e.g., Crémer et al., 2019).

On the other hand, the economic literature suggests that the large companies' acquisitions of newly established companies may have detrimental effects on competition and consumers as they eliminate potential (future) competition. The incumbent companies have an incentive to undertake pre-emptive actions such as patenting new technologies before their rivals and acquiring their potential competitors leading to the persistence of their dominant position (Gilbert and Newbery, 1982). Recently, Cunningham et al. (2019), demonstrate that under imperfect competition, whenever the acquirer's and entrant's product portfolios overlap, the acquirer can earn monopoly profits by acquiring an entrant. These types of acquisitions are dubbed "killer acquisitions", where an incumbent acquires its potential competitor in the early stage of development in its innovative project, and after the acquisition terminates the project. In other words, the incumbent preempts potential future competition to avoid the risk of a replacement effect and potential future threat to its market position. Cunningham et al. (2019) find empirical support for this theory using data from the pharmaceutical industry.

Bryan and Hovenkamp (2019) make a similar argument: they discuss a model where entrants can choose what technology they invent, which makes them biased toward leading company's technology rather than those which help the laggard incumbent catch up. Shapiro (2018) further emphasizes that large incumbent firms' acquisitions of highly capable firms operating in an adjacent space – i.e., firms that might form future threats to incumbents – may not have an immediate impact on competition, but may lessen future competition.

In the context of digital markets, Kamepalli et al. (2019), argue that in the presence of network externalities and switching costs, similar market dynamics can occur. They build a model where the prospect of acquisition deters entry. In their model, early adopters choose the technologically best product, where the unsophisticated followers flock to. The early adopters, however, face switching costs. Since an acquisition transfers the entrant's technology to the incumbent, it reduces the early adopter's payoff from choosing a technology. Such acquisitions of the incumbents reduce the future payoffs to new market entrants and thus make new start-ups not worth funding to venture capitalists. To start-ups, the incumbents' acquisitions may thus generate the so-called "kill zone" due to inadequate availability of venture capital funding. In addition to deterring entry, this effect might also reduce venture capital and angel investments, and thereby shorten the lifetime of newly established companies (see, e.g., Kerr et al., 2014). Kamepalli et al. (2019) use data from seven software company acquisitions conducted by Facebook and Google from 2016 to 2018. Their empirical results suggest that these acquisitions significantly reduced venture capital investments into companies with substitute products to the acquired companies.

Competition in digital - and particularly in two- or multi-sided platform markets - differs from the competition in the traditional markets as digital technologies and services are subject to network effects and extreme returns to scale (see, e.g., Koski and Kretschmer, 2004). Additionally, exclusive access to large quantities of individual-specific data may enhance incumbents' competitive advantage. Such data can be used, e.g., for better understand customer preferences and willingness to pay for price discrimination (i.e., algorithmic pricing) and further for obtaining advertising revenues. Furthermore, consumer data is a sharable and re-usable input that can be utilized in developing and producing a variety of different digital services and products. Consequently, there are economies of scope related to (personal) data assets that may provide large incumbents with an incentive for conglomerate acquisitions (i.e., the acquisitions of companies active in seemingly unrelated markets providing non-substitutable products with the acquirer).[6]

Prufer and Schottmüller (2017) base their theoretical model on the assumption that consumer data decreases a firm's marginal cost of innovation, which they define as "data-driven indirect network effect". Their model suggests that when a dominant firm in one market can exploit its consumer data outside its primary market, it tends to become dominant in the 'connected markets' it enters. Tipped markets provide low incentives for innovation and may deter the market entry of new firms. Consequently, large technology incumbents may not only increase their market power and generate entry barriers by acquiring companies in their core markets. When the dominant company with large consumer data assets acquires a firm outside of its primary markets, it may generate a kill zone for potential market entrants. Relatedly, Prat and Valletti (2019) suggest that the concentration of online platforms may reduce market entry in retail product markets as large platform companies have an incentive to reduce the supply of targeted advertising to reduce competitive retailers' access to consumers.

The existence of network effects has been empirically studied since the 1990s (see, e.g., Gandal, 1994; Saloner and Shepard, 1995; Koski, 1999; Kim et al., 2014). More recently, the economic literature has provided some empirical evidence on data-driven effects or how data size affects firm performance. The few empirical studies so far suggest that more data does not seem to result in better search engine results (Chiou and Tucker, 2017), better demand forecasts (Bajari et al. 2018), nor better demographic forecasts (Neumann et al. 2018). However, we note that the aforementioned papers' empirical context refers to the marginal effects of data on performance within a specific context or certain market. Prufer and Schottmüller, on the other hand, discuss the effects of data exploitation across connected markets. Limited scope and specific settings of previous empirical studies do not allow us to make far-reaching conclusions on the impacts of data exploitation on the competition.

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[6] Other sharable inputs that can be widely utilized in developing and producing new digital products include, e.g., software and algorithms, as well as talents and knowledge concerning general-purpose technologies such as artificial intelligence. Accumulation of these inputs may provide one motivation for the incumbents' acquisitions.

In summary, previous economic studies suggest that large incumbents' acquisitions may generate a kill zone effect reducing market entry and venture capital investments. We construct and empirically test the following hypotheses arising from the literature:

Hypothesis 1: *Large incumbents' acquisitions of firms in a product market tend to decrease the entry of new firms to the product market.*

Hypothesis 2: *Large incumbents' acquisitions of firms in a product market tend to decrease venture capital investments in firms active in the product market.*

We further propose that the incumbent' acquisitions of platform companies increasing their access to large quantities of consumer data, may cause markets to tip and generate a kill zone for market entrants and newly established companies even in non-digital or traditional markets. We formulate the following hypothesis to test this proposition:

Hypothesis 3: *Large incumbents' platform company acquisitions tend to decrease market entry and venture capital investments in non-platform markets in which large incumbents acquire companies.*

Given the discussion above, we postulate that the marginal effect of tech companies' acquisitions on market entry and venture capital investments may have increased with data accumulation. Our fourth hypothesis is, therefore:

Hypothesis 4: *Large incumbents' increased accumulation of consumer data has increased the negative impact of acquisitions on market entry and venture capital funding.*

3. Data and descriptive findings

3.1 Data

Our dataset is extracted from Crunchbase, a global database of start-up companies. Crunchbase sources its data in various ways: a partner program where venture capital companies provide information on their portfolio companies in exchange for data access and crowdsourced data from companies verified by the in-house data team.

Since the data on Crunchbase collates its data without a specific sampling frame, the representativeness of real financial activity and entry data is challenging to assess. Nonetheless, due to the way that the data is collected, we argue that the coverage of Crunchbase among young technology companies - the subsector of the economy that most competes with data giants – is well represented in the data we observe. Dalle et al. (2017) compared Crunchbase data to the OECD Entrepreneurship Financing Database, which is assembled from surveys from national private equity and venture capital associations in each of its member countries and is presumably closer to being representative. Reassuringly for our argument, they show that the two data sets give highly correlated measures. Moreover, while the representativeness of the data from Crunchbase might be questionable, it is undoubtedly the most significant global database of start-ups and technology companies.

The significant advantage of Crunchbase database, compared to the datasets using traditional industrial classification (e.g., NACE codes), is that the companies are classified on a highly granular level according to their main products. The taxonomy within Crunchbase consists of 744 product categories, which are further grouped under 46 product category groups. Any company can be classified into an arbitrary collection of product categories based on its core business activities in product markets.[7] This level of firm's classification into product markets corresponds rather well to the competition law definition of a relevant market according to product factors, i.e., product markets of all products or services that can be regarded substitutable.

The Crunchbase data extract does not follow a standard panel data format that our analyses would necessitate. We have transformed the data into a panel format using the following steps. First, we have excluded all observations that are not companies from the data. After that, we have excluded all companies whose closing date has occurred before 2002. For each year 2002-2018, we calculated the annual number of new companies, the annual number of acquired companies, and a stock of companies whose founding date is in the past, and the opening date is either empty or has not occurred.

Our definition of technology giants comprises the following companies: Amazon, Apple, Facebook, Google, Microsoft, and IBM. We chose these six companies as the first five of the listed companies are commonly included in "big tech" which are "impossible to live without"[8]. We added IBM to the group of technology giants as the study of Koski and Pantzar (2019) shows that IBM is a major global player in digital markets with vast health databases and moreover, among the six companies, IBM has bought the highest number of companies in the two highly data-intensive sectors, financial services, and health. The six companies and their subsidiaries have been among the most active acquirers of technology companies, according to Crunchbase data.

Our primary dependent variables concern market entry and venture capital investments. We operationalize the market entry rate measure as the number of new firms in each product category divided by the stock of

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[7] As a concrete example, category group “Gaming” includes the following twelve categories: Casual Games, Console Games, Contests, Fantasy Sports, Gambling, Gamification, Gaming, MMO Games, Online Games, PC Games, Serious Games, Video Games.
[8] See, e.g., "It’s almost impossible to function without the big five tech giants”, *The Guardian,* February 17, 2019 (https://www.theguardian.com/commentisfree/2019/feb/17/almost-impossible-to-function-without-big-five-tech-giants, accessed 2020-06-02).

companies in the product category at a given year. As a measure of funding, we use the natural logarithm of total millions of USD awarded annually in all types of funding rounds to companies within the product category. The left panel of Figure 1 plots the total number of new companies and the stock of companies during the period 2002-2018. As is evident, the yearly number of founded companies peaked in 2014 and has declined since. The right panel in Figure 1 plots the total amount of venture capital funding by year according to Crunchbase data. In stark contrast to the entry of new companies, venture capital funding shows a positive trend throughout our observation period, with an average growth rate of over 25%.

Our unit of analysis is a product market, as defined by the 744 Crunchbase product categories. This analysis level allows us to compare entry rates and venture capital funding between product markets in which the technology giants have made acquisitions to those of product markets in which the technology giants have not bought any companies. We undertake analysis separately for the product markets in the United States and among the EU countries.

To explore the effects of data giants' platform company acquisitions, we define an acquired firm to belong to the group of platform companies if its primary products comprise at least one that can be categorized under the platform products. Such product categories in Cruchbase include the following ones: social network, trading platform, twitter, video-on-demand, video streaming, ad exchange, ad network, developer platform, e-commerce platforms, funding platform, google, mobile advertising, mobile payments, music streaming, playstation, professional networking, ride-sharing, search engine, sharing economy, social media, social media advertising, and video advertising.

The dependent variables and the main independent variables are summarized in Table 1.

Incomplete data on firm entry might further introduce concerns about measurement error affecting some of our estimates. Nonetheless, we note that the measurement error is on the left-hand side of our regression models, which implies that possible attenuation bias is not a problem. Moreover, using the entry rate rather than the number of entries as the dependent variable can mitigate the measurement errors on the dependent variable if the number of entries and stocks is not strongly correlated.

3.2 Acquisition patterns of data giants

The acquisition history of the global technology giants indicates that they have widely expanded their operations to new product and geographical market areas. It is credible that these acquisitions, and particularly those concerning platform companies, have contributed to the volume and variety of consumer data technology giants possess. Figure 2 visualizes the geographical acquisition patterns of the digital giants. Each circle represents the headquarter of an acquisition made by the digital giant in 2002-2010, each triangle the headquarters of the companies bought between 2011 and 2018. The large circle represents the headquarter of each digital giant. The headquarter locations of the six data giants and the acquisitions are connected with a line. The overall geographical pattern in North America, Europe, and the rest of the world is displayed as shares of acquisitions in larger bubbles.

Figure 2 reveals clear commonalities in the acquisition patterns of the GAFAMI companies. Most of the acquisitions have taken place in North America, most of them in the tech-intensive coastal regions of California, Washington, and on the East Coast. For all six giants, 70% or more of all acquisitions are focused on North American companies. Another crucial geographical focus is Western Europe, with most acquisitions made in the London Metropolitan Area. However, only 17% to 27% of all acquisitions took place in Europe. Other relevant areas of acquisitions are Israel and Australia. Data giants have conducted some acquisitions in India, New Zealand, China, Hongkong, and Singapore, but the total share of acquisitions outside of Europe and North America accumulates to just 4% to 8%. In summary, the figure shows the common acquisition strategy of digital giants. They all focus clearly on their home market, and they have expanded into European markets.

While figure 2 reveals the digital giants' geographical acquisition patterns, it does not allow for a fine-grained analysis of time patterns. Figure 3 investigates this dimension in more detail. The circular heat map visualizes the expansion of the digital giant's scope into increasing category groups from 2002 to 2018. Each cell represents a category group-year combination. The total circle contains 828 cells, i.e., 18 years x 46 category groups. The cells in the centre represent the categories in 2002; those at the periphery show the categories in 2018. Three grey circles represent orientation (2002, 2010, 2018). If a digital giant is not present in a given category, the cell is empty. The more firms a giant acquires, the darker the cells become. Each cell shows the total number of firms acquired by a giant in a given category.

The colors represent clusters of related categories. On the total dataset of all companies represented on CrunchBase (binary matrix of 685,663 companies x 46 categories: the value of one is assigned for each category that is present for a given company and a zero otherwise), we have applied a hierarchical clustering to identify groups of similar categories. The algorithm identified six main clusters (the dendrogram clustering shown in the appendix). We have further split the "Services, Finance" cluster to isolate "Data & Analytics" categories and "IT, Software, Internet" to form a separate "Mobile & Platforms" cluster.

The figure, overall, shows the similarities and differences in the acquisition patterns of the digital giants. For example, while Amazon is focused strongly on E-Commerce, Consumer, Services, and Entertainment early on, Apple entered into these markets later and to a lower degree. In contrast, Apple has started as a company focused on Software, Hardware, and Media. With the start of its mobile phone branch, the firm went more intensively into Mobile & Platforms, as well as Data & Analytics. In recent years, Apple also made its way into Services & Finance, accompanying its mobile payment solutions.

The lower panel reveals a clear focus on services, software, and mobile for Google, IBM, and Microsoft. Apart from such differences, the figure shows the overall expansion into the majority of categories. The numbers on the left of each heat map show the total number of categories the giants have made acquisitions to by 2002, 2010 and 2018. By 2018, the giants have entered the vast majority of categories.

4. Empirical approach and estimation results

We employed the difference-in-differences model to explore how the entry rates of firms and venture capital investments in the markets to which the technology giants have entered via acquisitions have developed as compared to the entry rates of those markets in which technology giants have not acquired any companies. We used the fixed effects approach to estimate the following equation:

$$Y_{it} = \alpha_i + \delta_1 \times post_{it} + \delta_2 \; x \; Treated_i \times post_{it} \times Acq_{it-1} + \mathrm{e}_{it},$$

where Y_{it} captures the number of firms entering into product market i divided by the total stock of companies, or venture capital investments (measured in logged millions of USD), in the product market i at time t. Treated is a dummy variable that takes value one if data giants have acquired at least one firm in product market category i by 2018 and 0 otherwise. The variable $post_{it}$ gets value 1 for the years after the data giants have entered the product market. The variable Acq_{it-1} is the cumulative number of acquisitions of data giants in markets for product i at time t-1.[9] The estimated coefficient δ_2 is of our major interest; it captures the impact of the intensity of data giants' acquisitions on market entry, or venture capital financing. Below, while reporting the estimation results, we replace the interaction variable $Treated_i \times post_{it} \times Acq_{it-1}$, by the term “POST x Cumul acquisitions (t-1)”.

- TABLE 2a-b HERE –

[9] This implies an assumption that neither firms planning market entry nor venture capital investors may not react immediately to new acquisitions but rather scan past acquisitions while making decisions. We estimate the models using the data giants' current cumulative acquisitions, Acq_{it}, instead of the lagged ones. This modification did not substantially change the estimation results or our qualitative conclusions.

We estimated the above model for the product markets in i) United States and ii) the EU area. Table 2a-b present the estimation results for the basic model. The estimation results of Table 2a-b indicate that the number of firm acquisitions of technology giants has decreased the entry rates of new technology companies both in the product markets of the United States and the EU countries. The estimated coefficient of the variable "POST x Cumul acquisitions (t-1)" gets value -0.36 in EU countries' products markets and -0.16 in the US product markets for the market entry equation. The estimated coefficient of the variable is only marginally (at p=0.10) statistically significant among the EU countries. Estimation results for the venture capital investment equations indicate that the acquisitions of technology giants have decreased investments to companies both in Europe and in the United States.

- TABLE 3a-b HERE –

Table 3a-b reports the estimation results of the model that identifies the impact of large incumbents' platform company acquisitions in non-platform markets. The estimated coefficient of the interaction term "POST x Cumul platform acquisitions (t-1)" is negative and statistically significant in the entry rate equations both among the EU and US non-platform markets. Interestingly, when we control for the platform acquisitions, the estimated coefficient of the variable "POST x Cumul platform acquisitions (t-1)" gets a statistically insignificant coefficient among the EU countries. It seems that the kill zone effect in the EU markets arises rather from the technology giants' platform company acquisitions than the acquisitions of the non-platform product market in question. In the United States, the variable's coefficient is negative and statistically significant and six times smaller than that of the variable "POST x Cumul platform acquisitions (t-1)". This suggests that the technology giants' acquisitions in a product market in question dominate the magnitude of kill zone effect in non-platform product markets, but the technology giants' platform company acquisitions increase the kill zone impact in non-platform markets. These empirical findings support hypothesis 3, proposing that technology giants' acquisitions of platform companies that accumulate their consumer databases decrease future entry of new firms in non-platform markets.

In the United States, we further find that the impact of technology giants' platform company acquisitions tend to decrease venture capital investments providing further support for hypothesis 3.

- TABLE 4a-b HERE –

We further extended our analysis to explore how the large technology companies' acquisitions affected the market entry and venture capital finance during the years of a relatively slow accumulation of consumer data from (particularly social media) platforms (i.e., the years 2002-2010) as opposed to the fast increase in the number of platform users from 2011 to 2018. The user bases of the global technology giants' platforms, whether acquired or developed initially by the company, have generally not experienced rapid growth until the 2010s. When Google acquired Youtube in 2006, it had about 20 million users, while it now has over 2 billion user base. Similar growth trends are characterized by various other social media platforms generating user data for the global technology giants such as Facebook and Whatsapp (acquired by Facebook in 2014).[10] While we do not have direct measures for data giants' accumulation of consumer data over the years, we assume that due to increased userbases of social media other platforms, the chilling effects would be more significant in the latter years of our data (from 2011 onwards) compared to the earlier part (2002-2010).

In the United States, the estimated coefficient of the variable "POST x Cumul acquisitions (t-1)" is negative and statistically significant both in the entry rate and venture capital investment equations for the years 2011-2018, but not for the years 2003-2010 supporting hypothesis 4. We find similar results among the EU sample for the entry rate equation. The order of magnitude of the estimated coefficient of the variable "POST x Cumul acquisitions (t-1)" is smaller among the EU product markets (i.e., -0.61) compared to the US product markets (i.e., -0.31). This finding is consistent with the estimation results presented in Tables 2a-b. When we split the sample into two time periods, we do not detect the statistically significant impact of technology giants' acquisitions on venture capital finance in the EU area.

5. Conclusions

We studied the effects of acquisitions made by the large US-based technology companies on the entry dynamics and venture capital financing in different product markets. We used data from 742 product markets globally, distinguishing the US and European markets for the years 2003-2018. Our estimation results suggest that the technology giants' buyouts subsequently reduced market entry rates and decreased available venture capital funding in the target product markets of tech giants' acquisitions. In other words, the acquisitions of data giants seem to generate the so-called kill zone effect.

Our empirical analysis further suggests that the kill zone effect was strengthened during the 2010s when large technology companies gained increasing access to user data. Furthermore, we find that technology giants' acquisitions of platform companies have decreased market entry in non-platform markets. In the US,

[10] See, e.g., https://ourworldindata.org/rise-of-social-media (accessed February 3, 2020)

unlike in the EU area, also available venture capital financing has declined in such non-platform markets from which technology giants have acquired companies. These empirical findings suggest that the kill zone effect may arise particularly from such acquisitions that accumulate large technology companies' consumer data, and it may also expand to the traditional markets. These findings confirm with the view that a dominant company in one market can exploit consumer data from that market to become dominant in other markets. They are also consistent with the notion that network effects operate non-linearly: as the data giants have spread to more product markets, their effect on competition has increased.

Interestingly, our data suggest that in Europe, the kill zone effect in non-platform markets has primarily arisen from the data giants' platform company acquisitions. Instead, in the US, the technology giants' acquisitions within a specific product market had a more substantial chilling effect on market entry and venture capital investments in that product market than the large technology companies' platform acquisitions. One possible explanation for this finding may relate to the fact that most data giants' acquisitions have taken place in the US. The magnitude of technology giants' non-platform acquisitions in Europe may not (yet) be sufficient to generate the kill zone effect in non-platform product markets. An intriguing question is whether the constraints set by the GDPR (i.e., General Data Protection Regulation) to personal data exploitation in the EU have subsequently affected the size or significance of the kill zone effect arising from the data giants' acquisitions of platform companies. The question of the impact of privacy regulation on the kill zone effect would be one intriguing future avenue for research.

Our empirical findings suggest that the effects of acquisitions in digital markets go far beyond enriching the acquired companies' founders. On the contrary, it seems that venture capitalists are generally less interested in funding start-ups in markets that have already been proliferated by data giants. Furthermore, previous studies suggest that decreased market entry may adversely affect the incumbent companies' incentives to innovate. A bulk of empirical research supports this view (e.g., Aghion et al. 2004), highlighting that in the previous period of the history of capitalism, entry of new firms has been a significant driver of both aggregate growth in productivity and consumer welfare.

Though our results do not necessarily imply that consumers are worse off due to data giants' acquisitions, not at least in the short run, the generation of kill zone in various markets is likely to have detrimental effects on competition and consumer welfare in the long-run. Our data suggest that an increased concentration of platform ownership to data giants via their acquisitions poses a threat not only to the competition in platform markets but also in those markets offering complementary, traditional products.

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Figure 1: Funding and number of companies according to Crunchbase

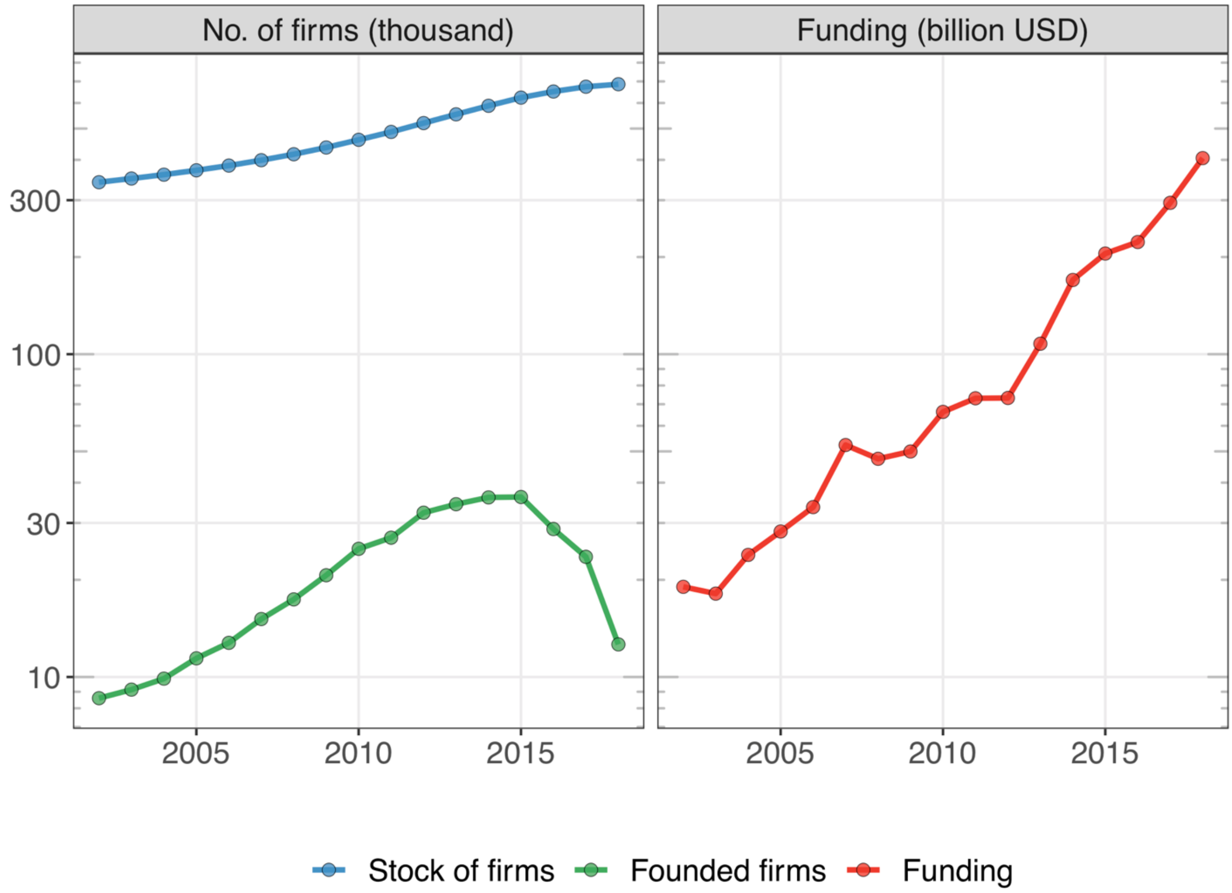


Figure 2: geographical acquisition patterns of the digital giants

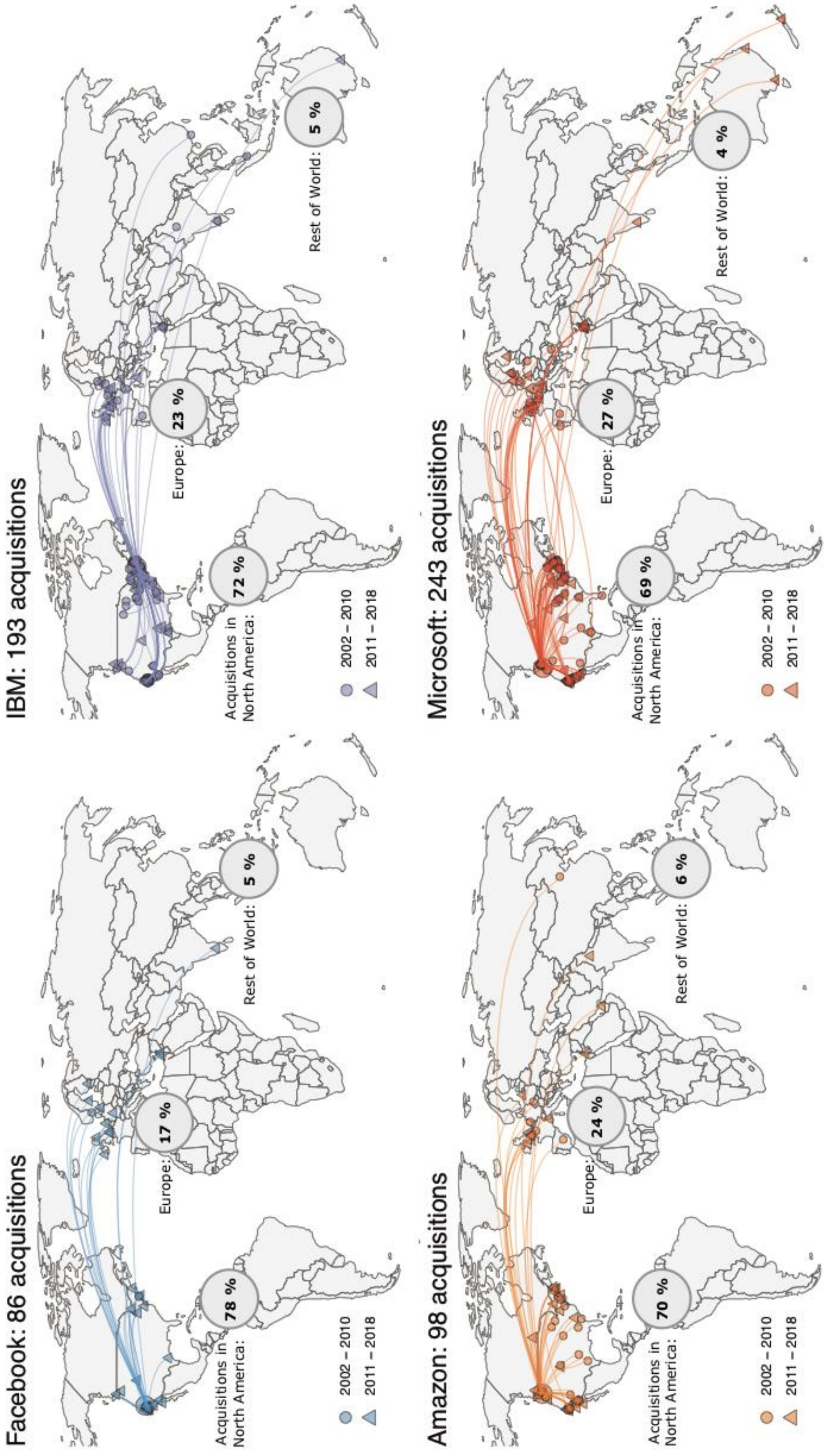


Figure 3: acquisition patterns across category groups for data giants

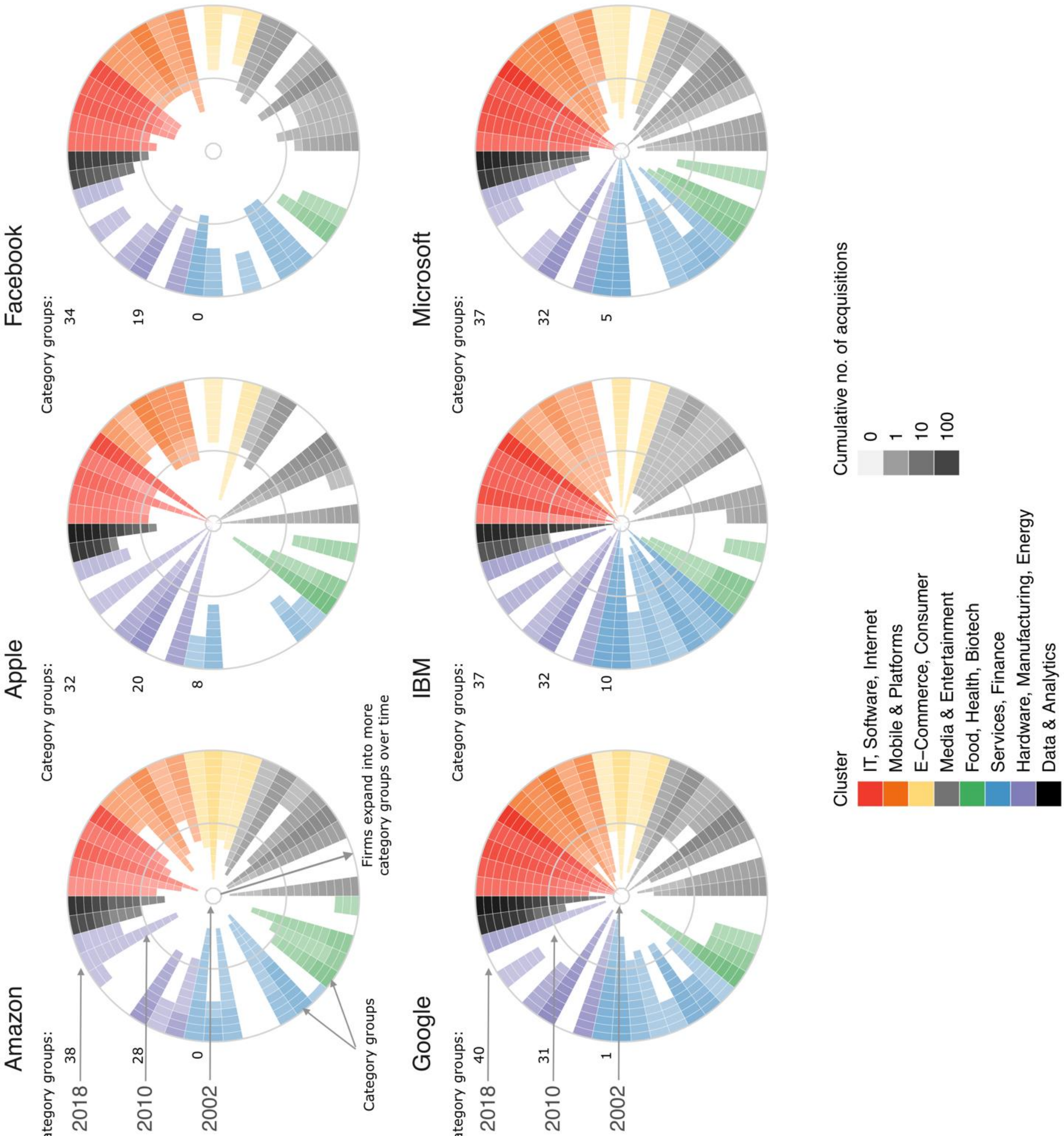


Table 1. Descriptive statistics

Statistic	Mean	St. Dev.	Min	Max
Entry rate	0.066	0.062	0	1
Venture capital funding (million USD)	702.127	2,986.77	0	84,928
Treated	0.264	0.441	0	1
Data giant acquisitions	0.197	0.992	0	29
Cumulative acquisitions by data giants	1.544	8.185	0	265
N	13,356			

Table 2a. Estimation results of fixed effects model for entry rates and venture capital investments: US

	(1) Entry rate	(2) Investment
POST x Cumul. acquisitions (t-1)	-0.165***	-0.043***
	(-4.93)	(-6.45)
Observations	11705	9121
LHS mean	7.113	3.953
R-square (within)	0.109	0.347
Product market FE	Yes	Yes
Calendar year FE	Yes	Yes

z statistics in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 2b. Estimation results of the fixed effects model for entry rates and venture capital investments: EU

	(1) Entry rate	(2) Investment
POST x Cumul. acquisitions (t-1)	-0.363*	-0.147***
	(-1.81)	(-3.94)
Observations	11608	7086
LHS mean	7.393	2.570
R-square (within)	0.090	0.339
Product market FE	Yes	Yes
Calendar year FE	Yes	Yes

z statistics in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 3a. Estimation results of the fixed effects model for entry rates and investments in non-platform product markets: the effect of platform acquisitions in the US

	(1) Entry rate	(2) Investment
POST x Cumul platform acquisitions (t-1)	-0.020***	-0.003***
	(-3.49)	(-2.90)
POST x Cumul. acquisitions (t-1)	-0.120***	-0.013*
	(-3.16)	(-1.74)
Observations	11358	8829
LHS mean	7.002	3.942
R-square (within)	0.109	0.335
Product market FE	Yes	Yes
Calendar year FE	Yes	Yes

z statistics in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 3b. Estimation results of the fixed effects model for entry rates and investments in non-platform product markets: the effect of platform acquisitions among EU countries

	(1) Entry rate	(2) Investment
POST x Cumul platform acquisitions (t-1)	-0.370**	-0.025
	(-2.44)	(-0.84)
POST x Cumul. acquisitions (t-1)	-0.225	0.032
	(-1.01)	(0.77)
Observations	11262	6841
LHS mean	7.272	2.556
R-square (within)	0.089	0.297
Product market FE	Yes	Yes
Calendar year FE	Yes	Yes

z statistics in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 4a. Estimation results of the fixed effects model for entry rates and venture capital investments over time: US 2003-2010 vs. 2011-2018

	(1) Entry rate: 2003-2010	(2) Entry rate: 2011-2018	(3) Investment: 2003-2010	(4) Investment: 2011-2018
POST x Cumul. acquisitions (t-1)	-0.081	-0.313***	-0.031	-0.045***
	(-0.44)	(-5.15)	(-0.86)	(-4.14)
Observations	5817	5888	3808	5313
LHS mean	6.888	7.336	3.526	4.259
R-square (within)	0.062	0.168	0.117	0.213
Product market FE	Yes	Yes	Yes	Yes
Calendar year FE	Yes	Yes	Yes	Yes

z statistics in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

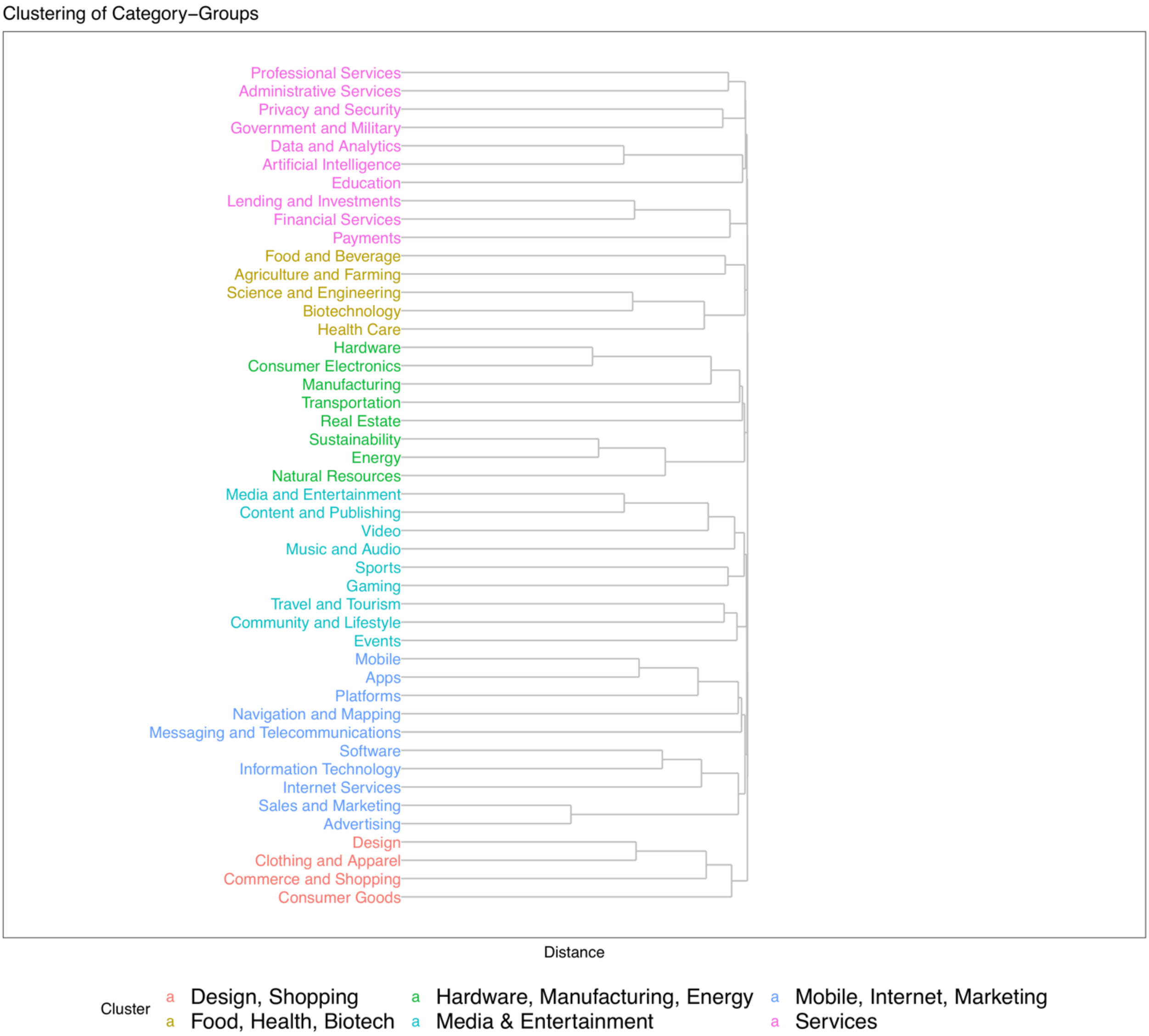
Table 4b. Estimation results of the fixed effects model for entry rates and venture capital investments over time: EU countries 2003-2010 vs. 2011-2018

	(1) Entry rate: 2003-2010	(2) Entry rate: 2011-2018	(3) Investment: 2003-2010	(4) Investment: 2011-2018
POST x Cumul. acquisitions (t-1)	-0.734	-0.609**	0.196	-0.013
	(-0.60)	(-2.18)	(0.87)	(-0.26)
Observations	5753	5855	2291	4795
LHS mean	6.488	8.281	2.220	2.737
R-square (within)	0.031	0.145	0.104	0.257
Product market FE	Yes	Yes	Yes	Yes
Calendar year FE	Yes	Yes	Yes	Yes

z statistics in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Appendix

This figure presents a dendogram of clusters of category groups used for coloring Figure 2.



Elinkeinoelämän tutkimuslaitos

ETLA Economic Research

ISSN-L 2323-2420
ISSN 2323-2420 (print)
ISSN 2323-2439 (pdf)

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