BEYOND 4.0

VALUE CREATION AND EXTRACTION IN THE PLATFORM ECONOMY: A COMPARATIVE APPROACH

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Josh Ryan-Collins, Steven Dhondt,
Pietro Ghirlanda, Vassil Kirov,
Mariana Mazzucato and Ilan Strauss

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Author/s:	Josh Ryan-Collins, Steven Dhondt, Pietro Ghirlanda, Vassil Kirov, Mariana Mazzucato and Ilan Strauss
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Major digital platforms play an increasingly important role in determining the trajectory of modern economies, innovation and employment dynamics. We examine how leading digital platforms based in the U.S. and Europe create and extract value in entrepreneurial ecosystems in the European Union. Whilst there are important differences between the major platform companies' business strategies, we find convergence towards a model of 'digital rentiership'. This involves a strategy of aggressive Mergers and Acquisitions to reduce competition, large R&D expenditures to support the development of algorithms that enable more rapid user growth and monetization of user data and attention and a 'financialised' corporate governance model focused on maximising short-term returns to shareholders. Using SCOPUS data, we then analyse large digital platforms' co-publications with European universities, research institutes and non-financial firms. Again, we find evidence that the US Big Tech firms may be extracting more value than they are creating. Finally, we consider cooperative platforms as an alternative business model and consider the advantages and challenges these models face. The final section considers potential policy interventions to address the challenge of digital rentiership and support alternative models of corporate governance for digital platforms.

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Contents

Introduction 4

1. The Big Tech business model: digital rentiership? 6

1.1. Network effects and the multi-sided market place 6

1.2. Mixed motives 8

1.3. Intangible assets and Mergers and Acquisitions 9

2. Big Tech: a financialised business model? 11

2.1. Financialization 11

2.2. Methodology 12

2.3. Findings 12

2.4. Summary 20

3. Big Tech And Knowledge Creation And Extraction In The European Union 20

3.1. Methodology 21

3.2. Who leads in knowledge development? 23

3.3. Who funds this research? 29

3.4. The entrepreneurial ecosystem 31

3.5. Summary 33

4. Alternatives: the cooperative digital platform 34

4.1. The cooperative platform model 34

4.2. Different actors and their roles in the cooperative platform ecosystem 41

Case study: Fairbnb.coop – towards a vacation rental market benefiting local communities 43

4.3. Competitive advantages and challenges of platform cooperatives 43

5. Policy implications 44

5.1. Levelling the playing field: a Big Tech disclosures framework 44

5.2. New M&As and corporate governance regulations 45

5.3. Creating a thriving research and entrepreneurial ecosystem in Europe 46

5.4. Policy interventions to support cooperative platforms 47

Case study: Barcelona – a city 'data commons' model 47

5.5. Conclusion 48
Appendix: Big Tech and knowledge creation and extraction in the EU – additional information 49
A1. Digital platforms research: Topics 52
Facebook 52
Amazon 54
Google/Alphabet 57
EU-platforms 58
References 60

Introduction

The Beyond4.0 project examines two specific digital transformation developments: the application of Industry 4.0 technologies in manufacturing industries and the rise of digital platform companies. Both developments have different impacts on economic value creation and distribution, on the quality of work and employment and are shaped by and themselves influence public policy and regulations (Warhurst et al., 2020). In WP4 and WP8, we examined several entrepreneurial ecosystems, thirty companies and how they manage knowledge spill-overs (Dhondt et al 2022). The focus there was on start-ups and the major companies, suppliers, and different knowledge providers and how they generate new enterprises. In this paper, we focus specifically on the dynamics of established platform companies, often referred to as 'Big Tech', in terms of value creation and extraction, again in an ecosystem setting.

Recent years have seen enormous growth in the market power of digital or online platform-based firms.[1] At the time of writing, Apple ($2.2trn), Microsoft ($1.9trn), Alphabet ($1.4trn) and Amazon ($1.1trn) were the four biggest private firms in the world by market capitalisation, with Facebook ($549bn) in 8th position.[2] These firms are the size of large European economies in GDP terms and have been described as the 'infrastructural core' of the Information and Communication Technology (ICT) sector (Van Dijck et al., 2018). The same firms are responsible for almost a quarter of all R&D spending by non-financial U.S. public companies, meaning they are central to modern dynamics of innovation.[3] The covid-19 pandemic has significantly accelerated their growth due to the massive increases in digital communication, e-commerce and streaming services resulting from global lockdowns and a shift towards working from home, a shift that may well become more permanent (Eliasson, 2022).

Big Tech's algorithms decide what search information and products the world's population have access to; their marketplaces decide the cost of doing business for millions of firms and app developers; their privacy rules play a key role in governing what happens to users' data (Zuboff, 2019); and their business models are revolutionising vast swathes of service work with significant implications for workers' rights, job quality and job security (Kenney and Zysman, 2016; Mathieu and Warhurst, 2020).

In response to fears over their growing dominance, U.S., Chinese and, in particular, European regulators have launched major new regulatory initiatives. In the EU, this includes the European Commission's Digital Services and Digital Markets Acts (DSA and DMA) aimed at producer harm and consumer protection, respectively (European Commission, 2022a; 2022b). But many questions remain as to how effective new regulatory frameworks will be

[1] The term 'online platform' is used to describe a range of services available on the Internet, including marketplaces, search engines, social media, creative content stores, app stores, communication services, payment systems, services involving the so-called 'collaborative' or 'gig' economy, and many others (OECD 2022).
[2] Data from https://companiesmarketcap.com (accessed 20th May 2022). Saudi Amco occupies first place but is a state-owned company.
[3] S&P Compustat North American database

given significant information asymmetries between regulators and digital platforms. A lack of publicly available information on Big Tech's products and integrated platform ecosystems has left regulators largely reliant on whistle-blowers and lengthy litigation procedures to extract the necessary information from such firms and understand their business models (Strauss et al., 2021; Haugen, 2022). More generally, the understanding of Big Tech's multi-sided marketplace business model, generating income directly from fees from sellers and customers that use their platforms but also from advertising and more indirectly via the monetization of users' freely given data, is poorly understood.

In this paper, we take up this challenge, examining how digital platforms both create and extract value (Mazzucato, 2018; Mazzucatoet al., 2020) and contribute, negatively or positively, towards entrepreneurial- or innovation- ecosystems in Europe. By 'ecosystem', we mean the collaborative effort of a diverse set of actors towards innovation, as suppliers deliver key components and technologies, owners provide capital, the state provides infrastructure, education, R&D and regulation, and workers carry out tasks of varying complexity, other organisations provide complementary products and services, and customers build demand and capabilities (Moore, 2016).

To understand the impacts of Big Tech's multi-sided business model, involving a key mediating role between suppliers and consumers, it is necessary to understand how they shape such ecosystems for better or worse, given their monolithic market positions. We follow the neo-Schumpeterian perspective outlined in Work Package 7 (Perez and Murray Leach, 2021), with a focus on how new technologies and innovation strategies are shaped by business models and public policies, and how these translate into rewards and losses to the different ecosystem actors in the digital platform sphere.

This ecosystem lens more generally requires a rethink of traditional concepts of competition and anti-trust. These are focused on neoclassical consumer welfare models and assume that the target of policy should be the creation of competitive pricing dynamics. This is inappropriate for digital platforms where profits, innovation and market power are generated from, in many cases, ostensibly free products (Khan, 2018). These provide unique access to user data, behavioural information and user attention that enables the creation of algorithms and related product and service innovations that allow further market expansion and consolidation without necessarily leading to any related price effects (Rikap and Lundvall, 2020; Birch et al., 2021).

The paper is structured as follows. In section 2, we examine the Big Tech business model in-depth, reviewing how the scientific literature has shifted perspective from a generally positive view on Big Tech's innovation potential in the earlier years of growth to a form of 'digital rentiership' today, with aggressive Mergers and Acquisitions playing a key role in establishing monopoly power.

In section 3, we look at the extent to which the Big Tech business model(s) and their business practises might be described as 'financialised' or focused on prioritizing rentier-type returns and shareholder value maximisation over and above investment in capital and labour and the

supporting of healthy entrepreneurial ecosystems. We compare US Big Tech firms with a selection of major European digital firms.

In Section 4, we examine the interaction between digital platforms and the European research community. We use a SCOPUS analysis of published academic papers as a proxy measure for establishing the extent to which major digital platforms from both the U.S. and EU contribute to knowledge creation and spill-overs in the European Union.

In section 5, we consider alternative platform business models and, in particular, the model of cooperative digital platforms that gives workers and other stakeholders more control over the direction of major platforms. We examine the history of and some examples of platform cooperatives and consider the challenges such alternative models face in scaling up.

Section 6 considers policy recommendations to meet some of the challenges raised in the preceding sections and concludes.

1. The Big Tech business model: digital rentiership?

1.1. Network effects and the multi-sided market place

A consensus is now forming in both policy and academia that the Big Tech business model is problematic, with strong tendencies towards monopolistic business strategies and value extraction (Zuboff, 2019; Coyle, 2019; Mazzucatoet al., 2020; Sadowski, 2020; Rikap, 2021; Birch and Cochrane, 2022). The defining features of the Big Tech business model are, firstly, control over a multi-sided marketplace or platform where powerful network effects are created via the rapid achievement of extremely large user bases; and, second, profits being generated from the extraction, assetization and monetization of data and attention from this userbase. This model involves the extraction of value from monopolistic control over an asset (the platform) that is becoming central to economic activity and social re-production. In other words, it is a rentier business model.[4]

A simple two-sided platform consists of a paying supplier side and a subsidized consumer-facing side (Eisenmann et al., 2006). The paying side could be advertisers, app developers, product and service retailers, content producers or, in the case of transportation and delivery marketplaces (like Uber or Lyft), individuals offering services for hire. Network effects occur when increased numbers of participants improve the value of the good or service being used (Katz and Shapiro, 1994; O'Reilly 2017). The more consumers use a platform, the more desirable, even utility-like, it becomes, and the more the paying side will be attracted to it

[4] Economic rent can be defined as "income extracted from the ownership of a scarce asset or control over an activity required for economic production in excess of the costs required to maintain the asset or activity." (Mazzucato, Ryan-Collins, et al., 2020, p.2)

and the higher the fees the platform will be able to charge them. A key aspect of the rapid scaling of user bases is the provision of free or subsidised products on the consumer side.

These network effects shift the emphasis from using standard financial measures to evaluate firm progress to operating metrics, including monthly active users and measures of user engagement. For example, customer acquisition cost (CAC) and the lifetime value (LTV) of that user to the company have become key metrics that most platform-based technology companies are primarily concerned with (Birch et al., 2021). User growth in a product's adoption drives the platform's utility and, in turn, the company's revenue growth.

User data and user attention are then monetized in a variety of ways. Monetization can be achieved through selling adverting space to potential suppliers or other parties wishing to target the user base using the platform; via subscriptions or platform fees that give users additional benefits to the core platform provision (for example, Amazon 'Prime' provides users with next day delivery and free access to its streaming television service in return for a small monthly fee); or via selling to other parties' – including public sector agencies - access to user data. These could all be described as forms of direct monetization.

However, user data and attention, and the ability to monetise it into a useful asset, can also improve the platform's service dramatically, making it a key source of competitive advantage and business growth (Birch 2020; Hwang 2020; Birch et al2021). This includes better search results and product rankings, more accurate user reviews, better ad targeting and an enhanced user experience. This can be seen as a form of indirect monetization (Strauss et al., 2021).

User data and attention thus need to be understood as essentially free *inputs* to the production process of digital platforms, in contrast to standard understandings of production involving paid inputs of land, labour and capital (Zuboff, 2019). This has led some scholars to claim that we are witnessing a paradigm change in the nature of the economy. Terms include "Platform capitalism" (Srnicek, 2017), "Surveillance capitalism" (Zuboff, 2019), intellectual monopoly capitalism (Pagano, 2014; Rikap, 2021)and "digital rentiership" (Mazzucato, et al., 2020; Birch and Cochrane, 2022) have been used to describe this transformation.

These network dynamics make scale a key condition for Big Tech firms' growth and long-term profitability. Big tech firms have raised huge amounts of venture capital to capture large users bases as quickly as possible well before becoming profitable, a strategy described as 'Blitzscaling' (Hoffman and Yeh 2018; O'Reilly 2019). The need for scale also helps explain why these firms engage in very high levels of R&D spending (discussed further in section 3.3) aimed at expanding and retaining their user bases. Similarly itdrives rapid product diversification to widen the scope of their product ecosystems and to envelop competitors' users (Eisenmann, Parker and Van Alstyne 2011; Coyle 2019). A noticeable feature of Big Tech's development has been convergence over time on particular products including social networks, email and chat; digital payment; cloud software services; virtual assistants; fitness, entertainment, gaming and retail. Platforms often bundle together free or subsidized products to envelop users in their ecosystems. For example, Google and Microsoft typically

offer users email, calendar applications and cloud storage in one package. Overall, the evidence suggests that the more dominant the platform becomes in these fields, the more it can consistently monetize user attention and data as fewer competitors exist and consumer lock-in is greater.

1.2. Mixed motives

The logic of a two-sided platform or marketplace is a need to satisfy both the paying (supply-) side and consumer side at the same time. This can lead to what Google founders Larry Page and Sergey Brin referred to as the problem of 'mixed motives' (Brin and Page 1998). In the early stages of development, a for-profit platform is likely to be incentivised to focus on enhancing the quality of product and service provision to help grow the user base as fast as possible to maximise network externalities, as discussed above. This can be seen as a form of value creation. And indeed, the Big Tech platforms have provided significant positive innovations, in particular to consumers, massively enhancing the efficiency and scope of products and services such as search, mapping, travel and communications.

On the supply-side, platforms such as Facebook, Google Play and the Apple App Store have created opportunities for independent entrepreneurs to offer their self-developed software applications ("apps") to large, increasingly global groups of platform users, creating new "dynamic entrepreneurial ecosystems "(Fan et al., 2021). Few studies have examined regional impacts, but one exception found that digital platforms change "regional development from focused areas to multiple areas, from a hierarchical structure of firms to a network of diverse firms, and from scope and scale economy-based firms leading regional development to creative economy-based firms leading regional development" (Yun et al., 2017). At the European level, there has been a lot of insistence on helping build the new European Facebook (Teffer, 2015). Policy action is directed at forcing the digital giants to keep European data in Europe, and much attention has been focused on regulating privacy issues in the interest of the European consumer (Tarkowski and Keller, 2021). Less is known about how these major digital companies support entrepreneurship in a region or in Europe in general.

This is the positive narrative on Big Tech, yet it seems to apply more to their early years of development. Once a certain scale and dominant market position have been reached, the incentives change as the platform seeks to maximise its returns. It may then begin to compete with the pre-existing supply side of its marketplace by substituting the existing products with its own – so-called 'self-preferencing' activity that has become a major focus for competition and anti-trust authorities in recent times (Ferrari, 2021).

For example, more than half of all Google searches are now satisfied by Google's own content rather than by referrals to external websites (Fishkin 2018; O'Reilly 2019). Apple has been found to consistently favour its apps by displaying them more prominently than similar apps in App Store search results and on the App Store homepage (Kotapati et al., 2020). And there is evidence that Amazon has entered growing markets established by third parties with

its own products and adjusted its search algorithms to favour the latter (Zhu and Liu, 2018; Etumnu, 2022). Amazon has also begun asking suppliers to pay for increased visibility of their products to consumers via advertising fees, meaning consumers' search rankings are no longer purely determined by quality or relevance (so-called 'organic' search algorithms) (Dash et al., 2021). These activities can be viewed as forms of value- or rent extraction, as well as being anti-competitive.

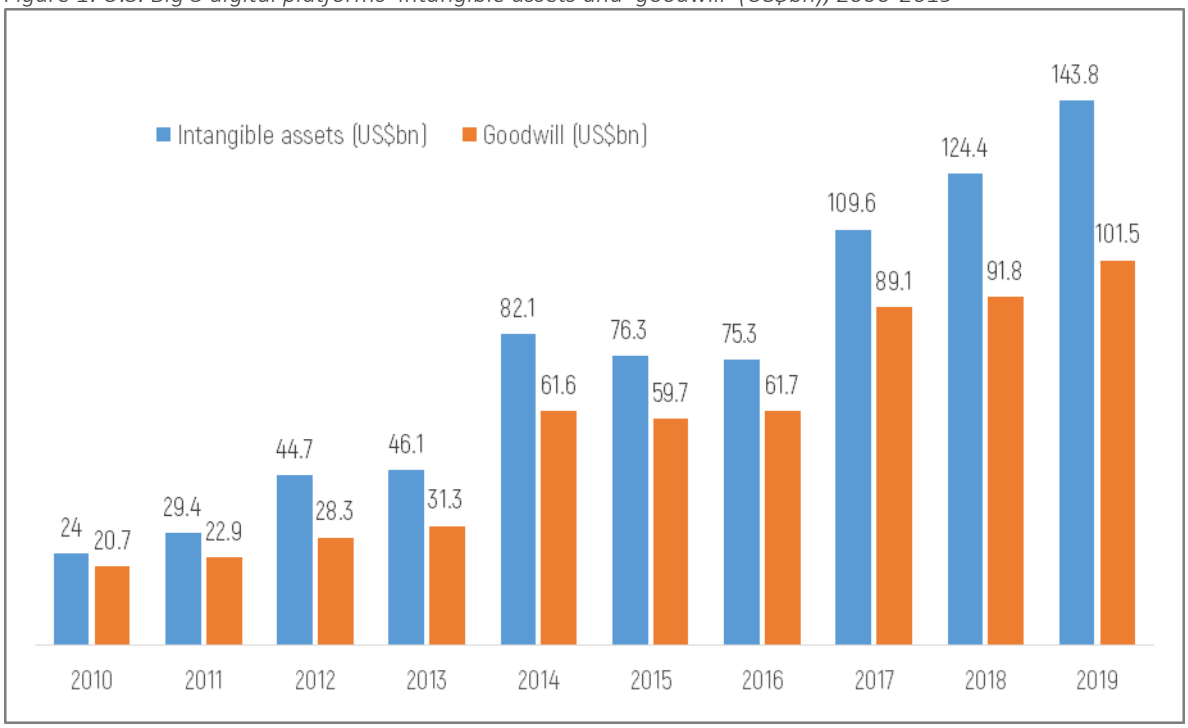
1.3. Intangible assets and Mergers and Acquisitions

Furthermore, Big Tech's business model relies more strongly on intangible assets such as patents, data and related analytics and 'goodwill' (Fernandez, 2020, p.10) that can be considered as forms of rent extraction, whereby the firm's value is determined by control over artificially created scarce assets. 'Goodwill' is an accounting term that is used in Mergers and & Acquisitions (M&As) to describe the positive difference between the purchase price of the firm and the book- or fair-market value of the latter's total assets. This premium reflects the acquiring corporations' willingness to bet on the future operational advantage of combining their brand, customers and data with their own. Higher levels of goodwill can thus be seen as an indicator of increasing monopoly power, rising barriers to entry and reducing competition.

As can be seen in Figure 1, US Big Tech firms have seen rapid growth in their intangible assets since 2010, and a large and rising proportion of this (from 70% in 2010 to 80% in 2019) has been made up of goodwill from aggressive Merger and Acquisition activity. Another independent recent analysis found a similar result, reporting that approximately 78 per cent of the total economic goodwill present in the big 5 U.S. firms' major transactions from 2004 to 2019 can be understood as profit-related, while 22 per cent can be attributed to targets' intangible assets (Mclean 2020). This means the value of the average start-up acquisition was based largely on the expected increased future income.

Big Tech firms have collectively engaged in 813 acquisitions of competitor firms and product offerings between 2000 and the present, and 573 since 2010 (Strauss et al., 2021, p.20). This is in addition to hundreds of smaller acquisitions which are below the reportable minimum purchase amount (Heller 2021). Most such transactions were not scrutinized by competition authorities as they did not reach the traditional turnover thresholds, and those reviewed were not blocked. Notable examples include Google/YouTube, Facebook/Instagram, Facebook/WhatsApp, and Microsoft/GitHub mergers. Many such acquisitions are viewed to have been key to Big Tech platforms expanding their market dominance and preventing emerging competitors from scaling – so-called "killer acquisitions" (Katz, 2021). Cabral (2021) notes that digital industries are characterised by high uncertainty about where the next competitive threat comes from, which lowers the pre-emption motive for acquisitions.

Figure 1: U.S. Big 5 digital platforms' intangible assets and 'goodwill' (US$bn), 2000-2019



Source: Adapted from Fernandez et al. (2020: 43).

The first major study of Google Play apps found that of those acquired by Big Tech firms, around half were discontinued, and these were smaller, less frequently updated, and less privacy-intrusive than acquired apps that are continued and typically offered for free to users but requesting more privacy-sensitive permissions (Affeldt and Kesler, 2021). This suggests such acquisitions may have a deleterious impact on competition and innovation as well as enhancing Big Tech's user base and ability to monetize customer data and attention.

In regard to work and employment, the perspective on digital platforms has changed over time. In the first part of the last decade, the digital platforms were seen as important tools for 'mass capitalism', providing instruments to scale-up social innovations (Dhondt et al., 2013; Garrigos-Simon and Narangajavana, 2015) and supporting a new, more efficient and more sustainable 'sharing economy' via 'collaborative consumption' (Schor, 2016; Cheng, 2016; PricewaterhouseCoopers, 2016).

The rise of the food delivery platforms and the self-riding apps (Uber) has changed the mood significantly. The platform economy is now recognised as driving new insecure employment relationships and changes in tasks (Huws, 2014). Workers are forced into self-employment, and tasks are reduced to "clickwork". The recent survey by ETUI provides a detailed view of the poor quality of work and pay for 47.5 million internet workers in the EU (17% of the working-age population). These internet workers provided digitally mediated services through online platforms, apps or websites on a freelance basis, sold products online (apart from second-hand belongings) or rented accommodation online. The study also shows that 'delivery work' is a rather limited part of the total platform-driven work, even if the media does focus its attention on this (Piasna et al., 2022).

In summary, whilst in their early years, there was a generally favourable view on the rapid growth of the major digital platforms and their business model, over the past seven years, a much less positive consensus has emerged. The Big Tech business model is now seen as increasingly an extractive one, with growth being achieved through monopolistic control and value extraction rather than innovation and the creation of public value and decent work. But there is surprisingly little empirical work to substantiate this perspective. In the next two sections, we undertake such analysis, examining in more depth the Big Tech business model.

2. Big Tech: a financialised business model?

2.1. Financialization

Financialization refers to the "increasing importance of financial markets, financial motives, financial institutions, and financial elites in the operation of the economy and its governing institutions, both at the national and international levels." (Epstein, 2001). Corporate financialization is used to describe non-financial corporations' shifting their business models away from a long-term orientation focused on reinvestment of profits (based on profit-maximization), and towards boosting their share price to satisfy the short-term needs of shareholders – 'shareholder value maximisation' (Froud et al., 2000; Lazonick, 2011).

Shareholder value maximisation strategies will typically include aggressive Mergers and Acquisitions, paying out dividends to shareholders and engaging in share buybacks, all of which ramp up share prices. This type of financialization has been linked to increasing returns to capital over labour (Stockhammer, 2013) which leads to stagnating wage growth and a decline in capital investment relative to profits and retained earnings (Davis, 2017), a driver of stagnating productivity (Lazonick, 2011; Davis, 2018). For example, over the decade 2006-2017, net equity issuance[5] of nonfinancial corporations averaged -$412 billion per year (Lazonick, 2017), meaning firms have taken out more money from the stock market than they have raised from it.

To what extent are modern platform companies firms engaging in such financialised behaviour? This is a surprisingly under-researched field, given Big Tech's size and market power.[6] The initial evidence – explored below – suggests that Big Tech increasingly engages in notable financialized behaviour (particularly as growth has slowed relative to profits) – though this is highly uneven over time and by firm age. Moreover, high returns to shareholders have not prevented high levels of capital expenditure and R&D expenditure from occurring.

[5] Defined as new share issues less shares taken off the market through buybacks and merger and acquisition deals.
[6] Two exceptions are Fernandez et al (2020) and Lianos and Mclean (2021).

2.2. Methodology

In the section that follows, we examine firm-level data from S&P Compustat North America[7] and Fernandez (2020) on the five U.S. 'Big Tech' firms (Amazon, Apple, Alphabet, Meta Platforms, and Microsoft) and, where data permits, compare them with developments in five major European platform companies. These European firms are:

- Spotify, the Swedish-based music platform, is currently the largest of its type in the world,
- Trivago, the leading German accommodation platform,
- Yandex, a Russian-owned, Dutch-based, multi-service platform that has the largest market share of any search engine in Europe and also provides transportation, e-commerce, navigation, mobile applications, and online advertising,
- SAP SE, German-owned, is the largest non-American software company by revenue and the world's third-largest publicly traded software company by revenue, specialising in Enterprise software to manage business operations and customer relations,
- Booking Holdings (owner of Booking.com), a Dutch online travel agency for accommodation and travel products, currently with over 28 million listings, and is available in 43 languages.

These European firms were chosen because of their size but also because they are all listed on U.S. stock exchanges (New York Stock Exchange, NASDAQ), which enables easy data comparison with Big Tech firms. It should be noted that data is not available for the same periods for all firms, with data on the younger European firms (Spotify, Yandex and Trivago) and Facebook only available for the last decade or thereabouts, whereas for the other firms data is availableback to the mid-2000s.

2.3. Findings

Firstly, we see in Figure 2 below that Big Tech companies' business model is one which prioritizes growth and requires exceptionally high levels of R&D expenditure in order to achieve the scale to attain the aforementioned 'network' effects. R&D spending scales strongly with sales in Figure 2. This emphasis on growth (especially for younger companies) means that high levels of cash are needed, and a high 'burn rate' of cash ensues – Figure 3. This is particularly true for earlier-stage platform companies. (For a company like Amazon, cash and inventory management is different due to its retail business.)

[7] See https://www.spglobal.com/marketintelligence/en/?product=compustat-research-insight

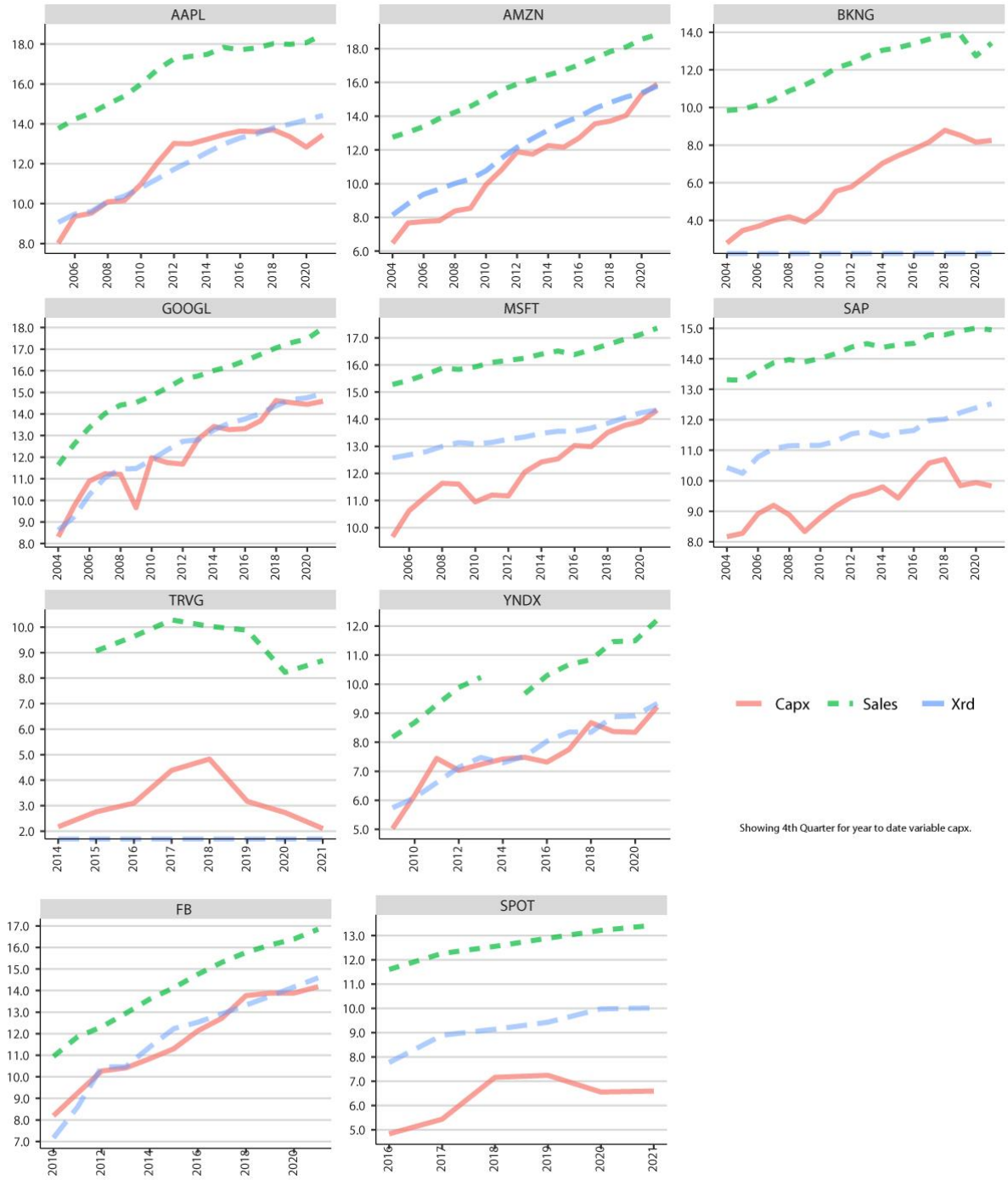
On the face of it, the R&D-intensive nature of Big Tech might be seen as a positive in particular, given historic declines in R&D investment in advanced economies. Again, however, this depends on the activities the spending is funding and their outcomes in terms of the impact on the ecosystems they operate within. Some initial studies suggest Big Tech's business model in relation to R&D may be extractive rather than value-creating.

For example, a recent study of Amazon, Google and Microsoft's innovation activities argues that they establish scientific collaborations with universities and other research institutions but seldom share intellectual property, profit from open-source communities and acquire technology by acquiring promising start-ups (Rikap and Lundvall, 2020). They should be thus be conceptualised as a paradigmatic form of "intellectual monopoly capitalist"(Pagano, 2014), which systemically creates scarce intangible assets to generate economic rent, rather than a driver of innovation and entrepreneurial wealth (Foley, 2013; Mazzucato, Entsminger, et al., 2020; Birch, 2020). In this view, digital platforms collect and transform public knowledge and data into private knowledge assets, a new form of 'enclosure' that deprives labour of knowledge as a means of production (Harvey, 2007; Teixeira and Rotta, 2012). We explore Big Tech's interaction with the EU research community in more depth in section 4.

Figure 2 (log scale) shows a remarkably consistent business model across firms, highlighting a strong complementarity between R&D and 'capx' (gross fixed capital expenditure)[8]. In general, these firms are engaging in substantial levels of capital investment and have in recent times also increased their purchase of PPEGT (property, plant, and equipment) – most notably Amazon and Alphabet. Amazon, for example, spent US$98 billion in 2019, mainly on warehouses and related machinery as well as data centres, whilst Alphabet spent a similar amount primarily on data centres (Fernandez, 2020, p.32). Apple's fixed capital has not grown as fast, in part reflecting its outsourced and offshored material production business model (Froud et al., 2014). Apple, however, has now brought chip design and production more in-house – at substantial expense.

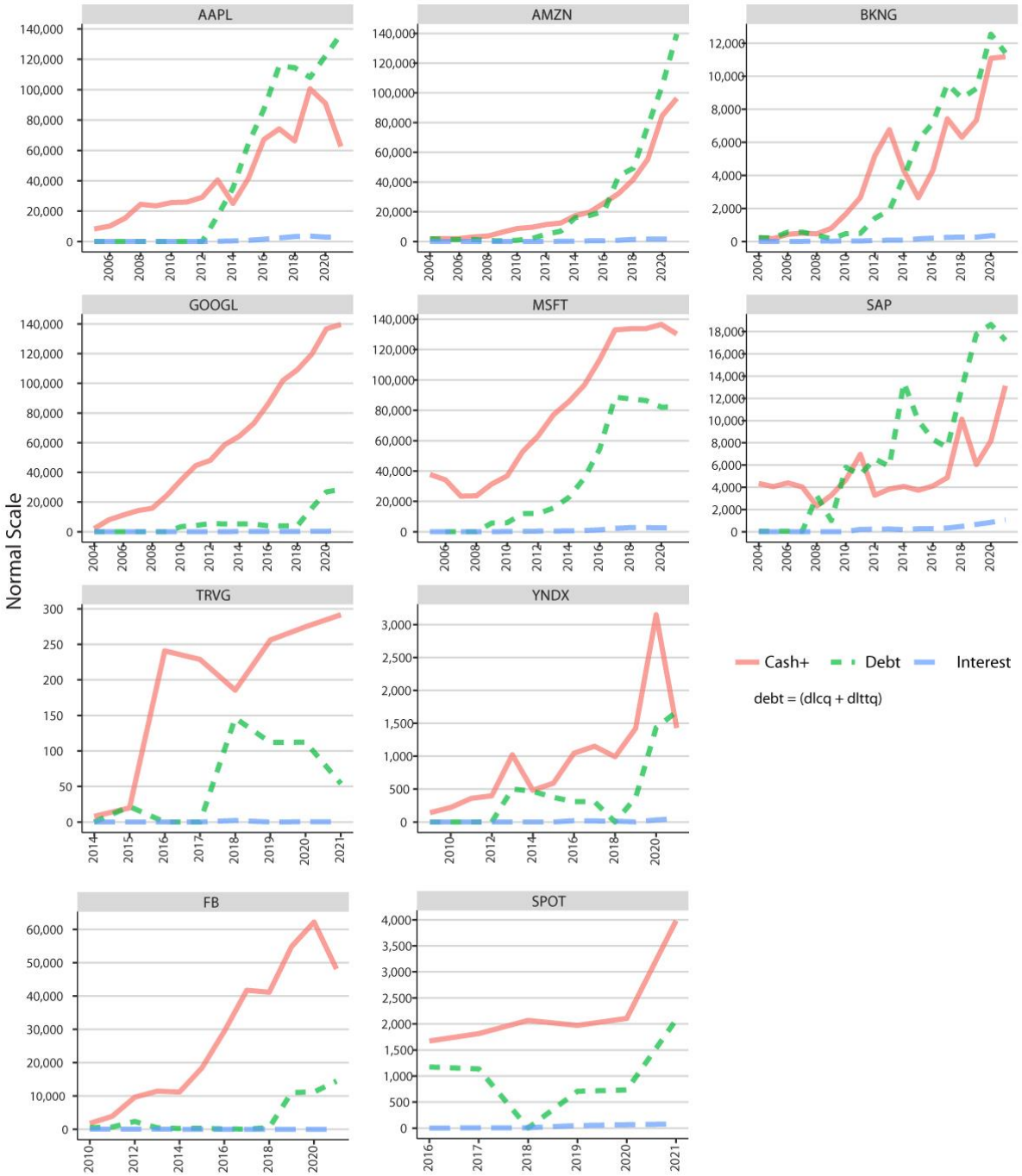
[8] Trivago and Booking Holdings don't report R&D data in Compustat

Figure 2: Platform business model is R&D intensive (capital expenditure, sales, R&D), log scale (US$ millions; time period varies by firm)



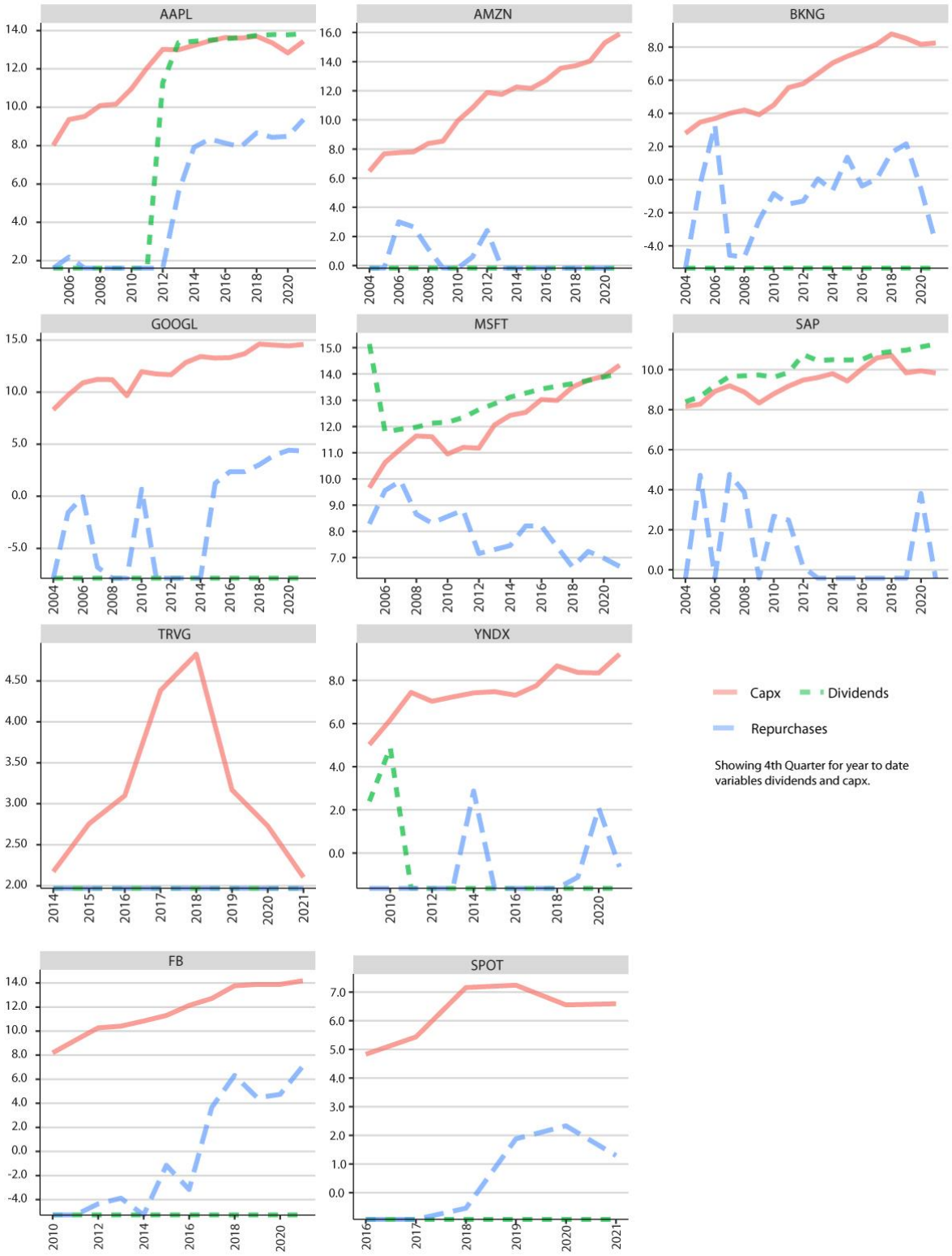
Note: AAPL = Apple, AMZN = Amazon, BKNG= Booking holdings, FB = Facebook, Goolg = Alphabet, MSFT = Microsoft, SPOT = Soptify, TRVG = Trivago, YNDX = Yandex; Capx = Capital expenditure, Xrd = R&D expenditure. NA values replaced with zero for Xrd.. Source: Compustat North America.

Figure 3: Cash, debt stock, and interest payments by company (US$ millions), time period varies by firm.



Note: 'Cash+' includes near-cash substitutes, including government debt and money-market mutual funds.Source: Compustat North America.

Figure 4: Dividend payments and share repurchases by company vs. capx (normal scale), starting period varies by company.



Source: Compustat North America. Note: NA values replaced with zero.

As a result, a company like Apple can end-off 2021 with almost $25 billion in cash[9] despite returning almost $100 billion to shareholders in 2021.[10] This makes Apple (and Microsoft) global investors in their own right, even amidst accelerated capital return programs to shareholders, raising further questions about their ability to influence government and corporate policy at a global level. The *European* platforms, starting from a much lower base, have not experienced such consistent growth in cash holdings.

It is despite increasing returns to shareholders – primarily through share repurchases (Figure 4 above), that cash and liquid asset holdings have been growing rapidly over the past decade among the US Big Tech firms, with Microsoft and Google holding around US$140bn in this form at the end of 2021 with Facebook and Apple closer to US$60bn. Of this, at the end of 2019, the Big five held US$263 billion in municipal and federal government bonds from both the US and other countries; this was followed by corporate bonds at US$163bn, with around US$50bn held in money mark funds and mortgage-backed securities (Fernandez, 2020, p.29).

Thirdly, Big Tech companies are somewhat unique in their historical aversion to releasing cash to shareholders (Figure 4). Figure 4 shows that this changes from around 2014 (or earlier) when Apple, Google, and Facebook initiate a regular capital release program through share repurchases. Such activity helped Apple to boost its share price and EPS (Aramonte, 2020) whilst still maintaining substantial cash and liquid asset holdings due to high profit margins and strong sales growth. Facebook similarly engaged in major buybacks from 2012 onwards but has so far refrained from dividend payments. In contrast, Microsoft and SAP have a longer history of rewarding shareholders and pumping up share prices.

This aversion to releasing surplus funds is less true of the older Tech companies, who have stable and high profit margins and more settled patterns of capital expenditure (Apple, Microsoft and SAP – who all pay regular dividends). Amazon, Google and Facebook do not pay a dividend – despite incredibly large cash piles – see also Table 1 below, reflecting a strong preference to be able to engage nimbly in regular mergers and acquisitions or to fund large capital costs (Ghosh 2021). It also reflects a historical aversion to short-term shareholder needs – which appears to have finally softened. The firms of European origin do not show as clear a time-change from 2012: Booking increased repurchases strongly from 2008, while SAP and Yandex engage in repurchases to release surplus funds on an irregular basis – as is common for S&P 500 companies. Data for Spotify is more recent, but they show a strong recent tendency to engage in share repurchases, despite being a young company.

Table 1 highlights the contrasting attitude to shareholder returns by firm age, with younger firms – regardless of the geographical origin of the firm – generally not releasing surplus funds to shareholders. Figure 4 shows the changing dynamics over time, as discussed above. Amazon in 2022 also initiated a share repurchase and stock-split program, partly in response to its ailing share price (Dhawan, 2022).

[9] See: https://www.apple.com/newsroom/pdfs/FY22_Q1_Consolidated%20Financial_Statements.pdf
[10] See: https://www.cnbc.com/2022/01/03/apples-3-trillion-market-cap-shows-value-of-share-buybacks-dividend.html

Table 1: Cumulative share repurchases and dividend payments up till fiscal year 2021 (US$ millions)

	Total Repurchases	Total Dividends
Microsoft	5,295	175,323
Apple	2,909	117,037
Facebook	277	-
SAP	95	23,437
Alphabet	81	-
Booking	26	-
Amazon	23	-
Yandex	13	35
Spotify	12	-
Trivago	-	-

Note: starting years vary: Alphabet, Amazon, Booking and SAP is 2004; Amazon, Apple, Microsoft is 2005; Yandex is 2009, Meta is 2010, Trivago is 2014, Spotify is 2016. NA values replaced with zero. Source: Compustat North America.

European policymakers may be concerned to see leading young platform firms like Spotify and Booking engaging in buybacks; indeed, in August 2021, Spotify's board of directors approved a $1 billion share repurchase program that would last until April 2026, leading to a jump in its share price but leaving many investors citing concerns about the company's investment priorities (Henderson, 2021). Spotify remains barely profitable and is stuck in a low-margin business from which it is trying to diversify out of. Spotify's buybacks reflect it was acquiescing to shareholders' impatience with economies of scale and not changing Spotify's underlying financials.

The U.S. Big Tech firms, in particular, provide the majority of their high-skilled staff compensation through stocks rather than wages – Table 2. Paying compensation in stock provides strong motivation to pursue corporate operations that would most likely be reflected in increasing share prices, reinforcing the above-mentioned dynamics. Historically, this approach proved to be less of an issue to employees or to maintain a strong reinvestment dynamic when share prices and companies were in their growth phase. In 2022, with falling share prices, base wages for software engineers and managers at most Big Tech companies are now doubling to compensate for falling share prices.

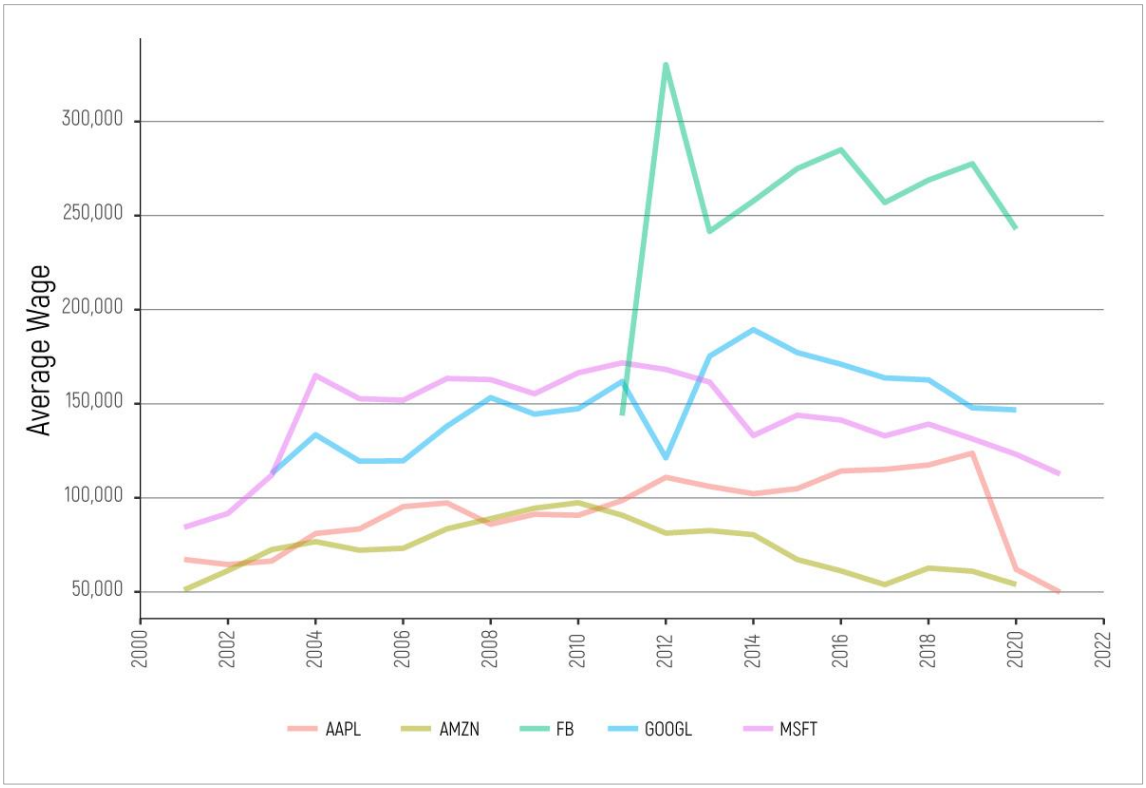
Table 2: Total share-based compensation in U.S. Big Tech firms, 2015-2019

	US$m	As % of total net sales
Alphabet	39,732	6.9
Amazon	21,591	2.3
Apple	24,044	2
Facebook	18,893	8.9
Microsoft	17,100	3.4

Source: Fernandez et al (2020: 38)

Lastly, in contrast to the rising holdings of financial assets, corporate debt, capital and R&D expenditure that has characterised the major digital platforms, the *average* wages they have paid employees have been relatively stagnant – though at much higher levels compared to most sectors (Figure 5).[11] High average pay masks vast inequality of pay within Big Tech companies (though exact figures are not known). The average wage shown closely tracks median wages, which is publicly available (SEC, 2022). Big Tech has among the highest median wages in the S&P 500, with Google the highest at almost $300,000 at the median (Pacheco, 2022). The majority of remuneration for high-skilled tech workers comes from shares, however, making them among the highest paid workers in the U.S. This stands in contrast to low-skilled workers in Big Tech's call centres, fulfilment centres, and externally contracted 'mechanical turk' style workforces (Perrigo, 2022), who suffer from low-pay, precarious work contracts, and anti-unionization stances (Streitfeld, 2021).

Figure 5: Average wages paid by U.S. Big 5 digital platform companies, 2000-2021, (US$)



Source: Compustat North America.
Note: Average wage is (XLR*1,000,000/EMP*1,000). XLR is imputed from the income statement identity where, xlr = xsga - xrd - xpr - xrent – xad. All NA values for xpr and xad are replaced with zero. Removing 2010 from Facebook where data is volatile in the build-up to 2012 listing.

[11] Facebook's sudden rise in average renumeration in 2012 is strongly related to its public listing in the same year.

2.4. Summary

In summary, this section demonstrates that Big Tech's business model can be broadly described as following a logic of financialization and shareholder value maximisation, although there is considerable heterogeneity across time and across different firms. Apple, Microsoft and SAP, as older firms, have larger profits and release more profits to their shareholders than younger firms in our sample, as expected by the lifecycle theory of the firm (Brealey et al., 2018). Amazon, notably, has, up to very recently, resisted pressure to reward shareholders and instead ploughed its profits into growth (Lazonick, 2018). Yet, with falling share prices due to the uncertain geopolitical situation, rising inflation and energy prices, it has also succumbed to its first major stock buy-backs of $2.1bn in 2022 and raised the ceiling on its total share buy-back options to $10bn (Unglesbee, 2022). Nevertheless, major digital platform firms still do invest a massive amount in R&D and perhaps a higher rate of capital investment than might be expected for firms that are mainly focused on the creation of intangible assets. In the next section, we examine in more depth how they interact with the European research and development community to explore the extent to which these types of investments create or extract value.

3. Big Tech And Knowledge Creation And Extraction In The European Union

In this section, we examine how major digital platforms interact with the European research and development ecosystem. Entrepreneurial ecosystems are attractive for policymakers and other stakeholders mainly because they generate knowledge spill-overs that generate new business (Bendickson et al., 2021). However, even with a decennia long research into what drives entrepreneurial ecosystems, there is limited understanding of how these knowledge spill-overs work and what they bring for new business.[12]

Despite this significant literature, there has been limited interest in looking at the large American platform companies and their role in knowledge spill-overs. Yet over the past decade, most of the U.S. platforms have invested in European headquarters, research centres and data centres. For example, Facebook has been allowed to build a data centre in The Netherlands (Kraan, 2021). The question is if these investments are beneficial for the European digital sectors and knowledge production? Can we see these investments leading to new European businesses and entrepreneurial ecosystems?

In this section, we examine how they are developing their core research centres in Europe, their strategies for acquiring European knowledge and how they engage with European

[12] See, for example, Leendertse et al. who focus on Crunchbase data, mainly looking for unicorn companies (Leendertse et al., 2021). Cuvero et al. (Cuvero et al., 2019) are mainly interested in how start-ups can learn from other companies and knowledge providers along with the different steps of their growth.

knowledge producers to share their 'knowledge capital', including the number of start-ups and scale-ups linked to platform companies' activities.

As in the previous section, we compare the US Big Tech platforms with European firms. In this case, we examine Amazon, Google/Alphabet and Facebook/Meta (AAF) and the following European platform companies: Spotify, Trivago, Booking.com (already introduced in section 3) as well as Zalando (a clothing and fashion platform) and Bol.com (a retail company which is the largest platform in the Netherlands and Belgium, owned by Albert Heijn (HN)). Spotify, Zalando, and Booking.com have already developed themselves to global leaders in their domains, whilst Trivago and Bol.com have a more localised sphere of influence.

These EU platforms have started later with their scaling-up, so we do not have sufficient results to consider each of these firms separately. Instead, they are analysed collectively as one category of 'EU platforms'.[13] The main purpose is to compare their overall research behaviour to the US platforms. The EU platforms generally are at a disadvantage in the sense that they have to develop their propositions in fragmented markets and cannot profit from the global scale and enormous product and service diversification of the US platforms, as described in section 2. This is due to language challenges and the diversity of rules and regulations across different EU countries. For example, Bol.com is based in Netherlands and Belgium where there are very different rules around the use of self-employment and personnel policies compared to other EU countries, creating significant costs if it wished to expand in to other EU markets.

The analysis focuses on the extent to which the relationship with knowledge providers (universities, research institutes and non-financial companies), leads to investments by these platforms in regional or local knowledge provision and in creating new local entrepreneurial activity and enhances the quality of innovation ecosystems. The advantage of using this specific set of stakeholders is that we can develop a perspective on the last part of task 9.1: how does the behaviour of the platform companies affect the quality of jobs? Research posts are generally recognised as high-value, high-quality jobs. What is the perspective on how these jobs develop and are maintained? What is the cost/benefit balance of funding these high-quality jobs? Do they offer opportunities for European knowledge providers?

We also analyse the extent to which US and EU digital platforms exploit public funding or reinvest in local research communities. Can we say they are creating new public value (Mazzucato, Entsminger, et al., 2020), or are they only extracting knowledge and transferring it to their US-based headquarters?

3.1. Methodology

To map the practices of platform companies in scientific research, we use the Elsevier SCOPUS database (www.scopus.com) to analyse co-publications involving these firms. Such

[13] We also checked if any of the food delivery platforms (Just Eat Takeaway, Foodpanda, Glovo, Deliveroo) could be interesting cases to research, but the number of scientific papers on SCOPUS is negligible.

co-publications are seen as an important source of innovation (Hollanders and Es-Sadki, 2017) and a means for assessing knowledge spill-overs. SCOPUS provides an overview of citations, abstracts and other material to support researchers and teachers. If any of our chosen platform companies have participated in any (authoritative) EU research or included European researchers in their work, the SCOPUS database will contain a reference to these publications. The database contains the title and the abstract, and information about the funding.

Research with the SCOPUS database is currently quite limited. Using SCOPUS, Lee & Haupt (2020) show that US researchers lean more on Chinese innovations to keep up in the international science race rather than vice versa (Lee and Haupt, 2020). Pohl (2021) analyses the share of international co-publications for understanding the importance of academic corporate co-publications. These academic-corporate co-publications "are shown to be useful as one of the many potential tools to assess collaborations (p.1329)". He also shows a correlation between the country's innovation standing in the European Innovation Scoreboard and the share of academic-corporate co-publications in a country (Pohl, 2021).

More research has been conducted on patents and the SCOPUS database. Bae et al. (Bae et al., 2020) use patent information and publications from SCOPUS to estimate knowledge spillover efficiency, i.e. the level of academic and practical influence of research and development outputs. Both inputs, patents and publications, are separate building blocks in the model. Barra et al. produced studies more aligned to our purpose: impacts of university academic research on innovation by companies at the local level, using SCOPUS (Barra et al., 2019; Barra et al., 2021; Dhondt, 2022).

Using the SCOPUS database, we examine: 1) the number of scientific publications AAF are involved in with EU firms; 2) whether they lead the research which would indicate positive spill-overs towards the EU firms participating, or not (measured by examining author order); and 3) Funding arrangements. The following variables were downloaded from SCOPUS in February 2022: affiliation, authors, scopus-link, date, index keywords, funding and funding text. For each of the platform companies (and their derivatives), we have downloaded all publications that can be identified in the SCOPUS database on 20/1/2022.[14] In total, there are 5332 co-publications. For example, for Google, we have references going back to 1995. The search was limited to authors coming from any part of Europe, where the lead author's affiliation could be identified. For some variables, additional coding was needed, including: 1) coding the authors as company, research institute, university, public authority, health institution; 2) coding the funders as EU, national, or company-based funding; 3) a specific separate analysis has been done to identify the companies as a start-up, scale-up or otherwise.[15]

[14] The data for 2021 may be incomplete in the study: more 2021-publications may not have been integrated into SCOPUS. Another limitation is that we only looked at the background of the first six authors. In ten per cent of all records, there are more authors listed. We do not expect this exclusion to change the results in any way.
[15] We used the Dun and Bradstreet database to check if firms self-identified as a start-up. Firms with other 20 staff were classified as scale ups.

Finally, we make a distinction between the European locations of Facebook, Amazon and Google and their other locations. We have limited the research to any publication in which a European partner was participating. SCOPUS allows for the selection of the country of the authors. The Appendix provides a table (A1) with a full summary of our results, further information on the geographical location of the research centres linked to the co-publications and also reports on an analysis of the topics of research that feature most prominently in the co-publications.

3.2. Who leads in knowledge development?

Figure 7 shows that the number of publications involving digital platforms has been rapidly growing, really taking off in the last ten years for the US firms, and the last five years for the EU platforms in our sample. The recent tailing off may well be related to the Covid pandemic. It should be noted that this growth of the US platform publications is happening in a context where there is growing and significant pushback from the European Commission and individual countries against the power of these platforms, which may, of course, affect scientific collaboration.

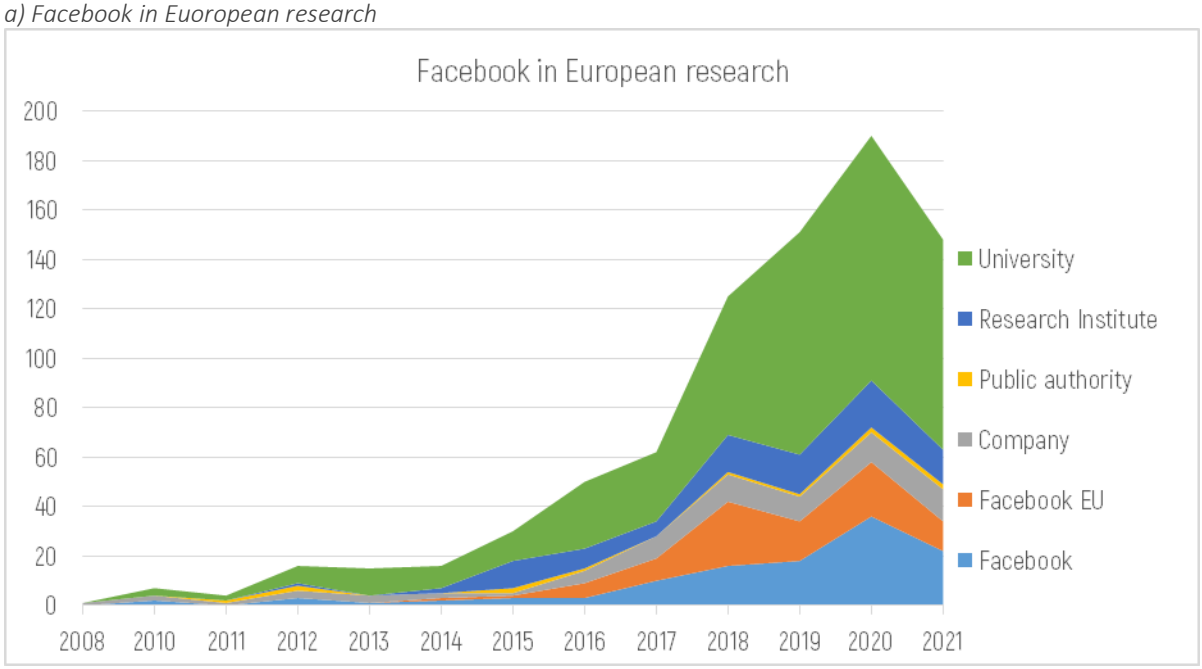
Google stands out as the dominant co-publisher in EU-related co-publications (Table 3). It has at least a five-year lead on Amazon and has an average of 150 co-publications each year, outpacing the other two U.S. platforms and the EU platforms, which have 20 publications on average each year. Amazon also started quite early with publishing but has not seen as rapid growth as the other platforms. Indeed, Facebook, which began co-publishing four years later, has already overtaken them. The EU platforms' apparent peaking around 2019 may pose a concern for EU policymakers, suggesting this lagging position behind the US firms may continue in the coming years, although there is also evidence of a drop in the latter.

Table 3: Contribution to scientific co-publications by digital platform companies (data = Scopus)

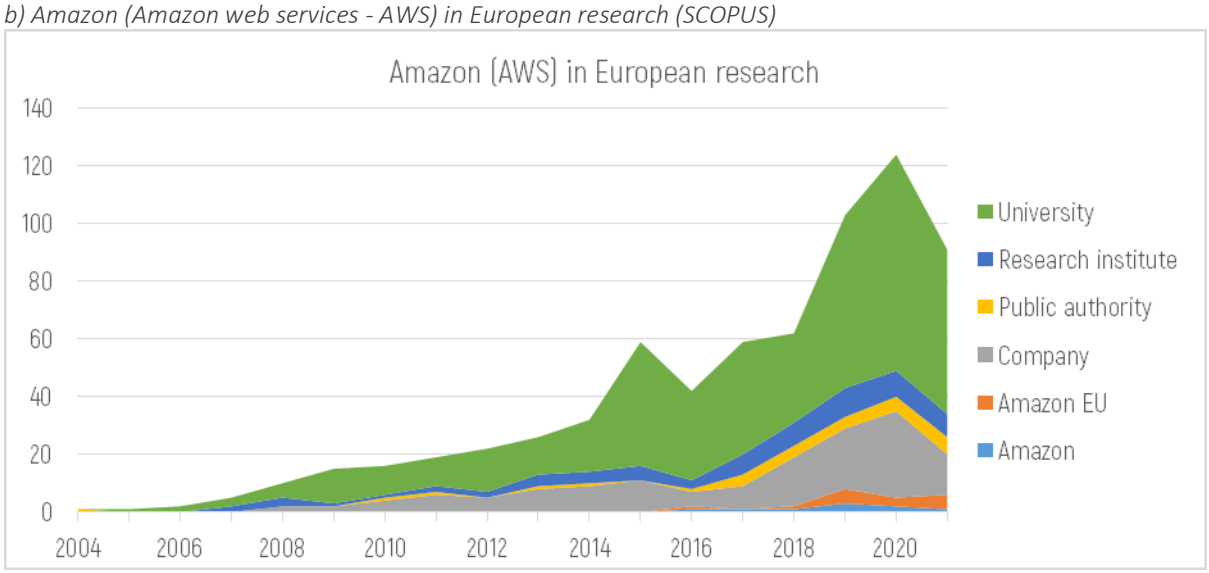
	Facebook	Amazon	Google	EU-platforms
Number of publications with EU partners	817	695	3452	368
Startdate	2008	2004	1999	2010
Number of co-authors	2840	2606	11776	1077
Lead in the research	58	39	150	31
• Percentage of non-EU authors	49%	50%	49%	45,1%
• Percentage of platform authors as 1st author	25%	3%	12%	39%

Figure 6: Number of co-publications in which platform companies have participated, by type of lead author (1997-2021) (SCOPUS)

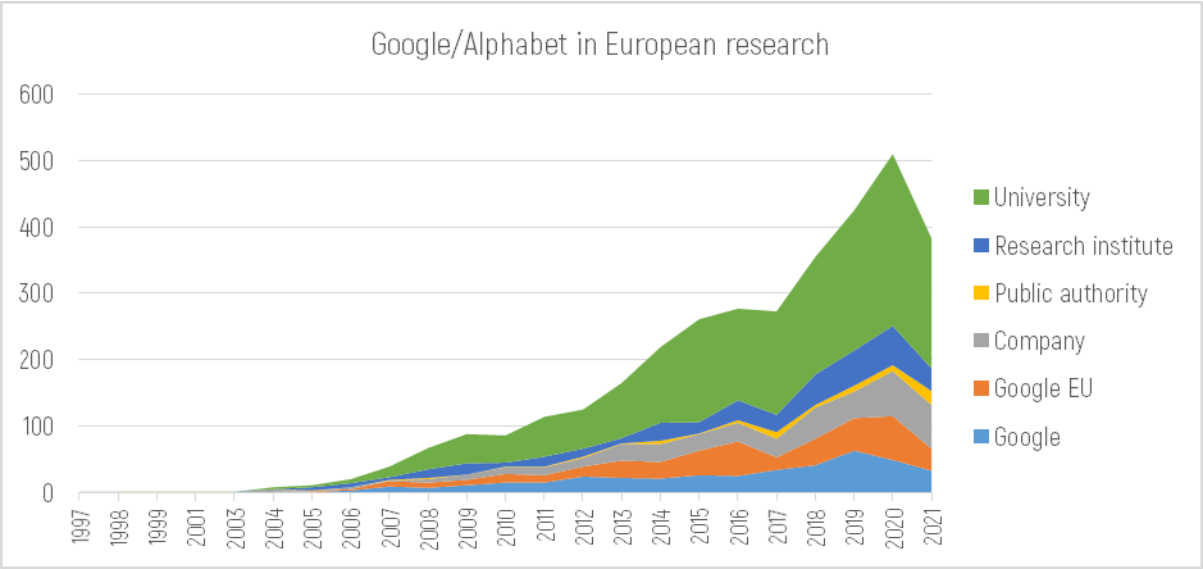
a) Facebook in Euoropean research



b) Amazon (Amazon web services - AWS) in European research (SCOPUS)



c) Google/Alphabet in European research (SCOPUS)



d) EU-platforms in European research (SCOPUS)

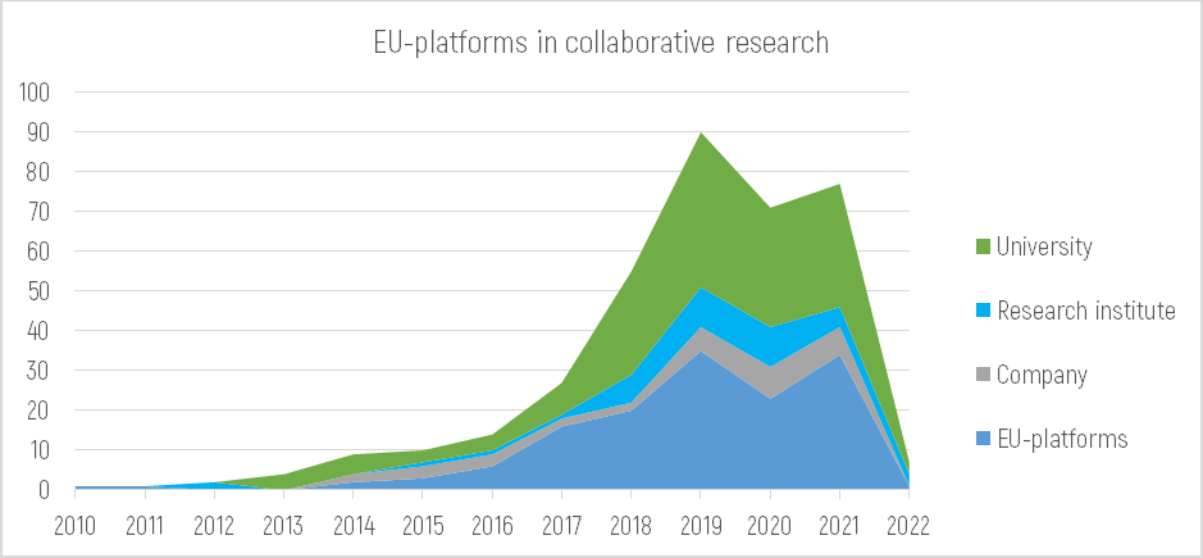


Figure 6 demonstrates that researchers in European universities are the dominant lead author in co-publications involving digital platforms. Amazon has a higher proportion of collaborations where the lead author is from another firm relative to the other platforms and, in general, has very few publications where it is the lead author (either Amazon US or Amazon EU). This supports other research that suggests Amazon may have an extractive R&D business model where it outsources research and innovation activities to other institutions but captures the knowledge produced to help it build its algorithms and improve its business performance (Rikap, 2020). A similar argument might be made for Google. In contrast, the EU platforms are leading in almost two-fifths of their co-publications, much higher than the other platforms. This could be seen as the firms contributing more to the European innovation ecosystem. However, it could equally indicate EU research institutes, and universities give these platforms less importance in their research priorities. Nine per cent of co-publications are driven by other companies for the EU-platform publications. Most of these companies are US-based, with only two EU-based companies with two or more leads in

the publications: Microsoft (4), Netflix (4), IBM Comcast Labs (3), Google (2), Happiness Research Organisation (2), Orange Labs (2).

Over 50% of the EU platform publications come from Spotify, with Zalando and Booking.com as the next best. For all companies, a shift of publications outside of Europe is visible. This means that the benefits are not necessarily staying in Europe. The average number of authors in EU-platform publications is 2-2,2. For other publications, the average number of authors varies between 3,3 and 3,6 authors per publication.

Notably, publications led by the platform company have a lower average number of authors. This suggests that, when initiating the research, the digital platforms are working within the confines of the company networks and potentially keeping more detailed results to themselves. In most of the publications, the platforms piggyback (extract) on the efforts of the other lead authors, learning more from the efforts of the others. This is not an exceptional result because we identified the same practice with advanced manufacturers in Europe (Dhondt et al., 2022). The led-publications are focused on topics relevant to the development of the platform technologies. The follow-publications cover a greater diversity of topics.

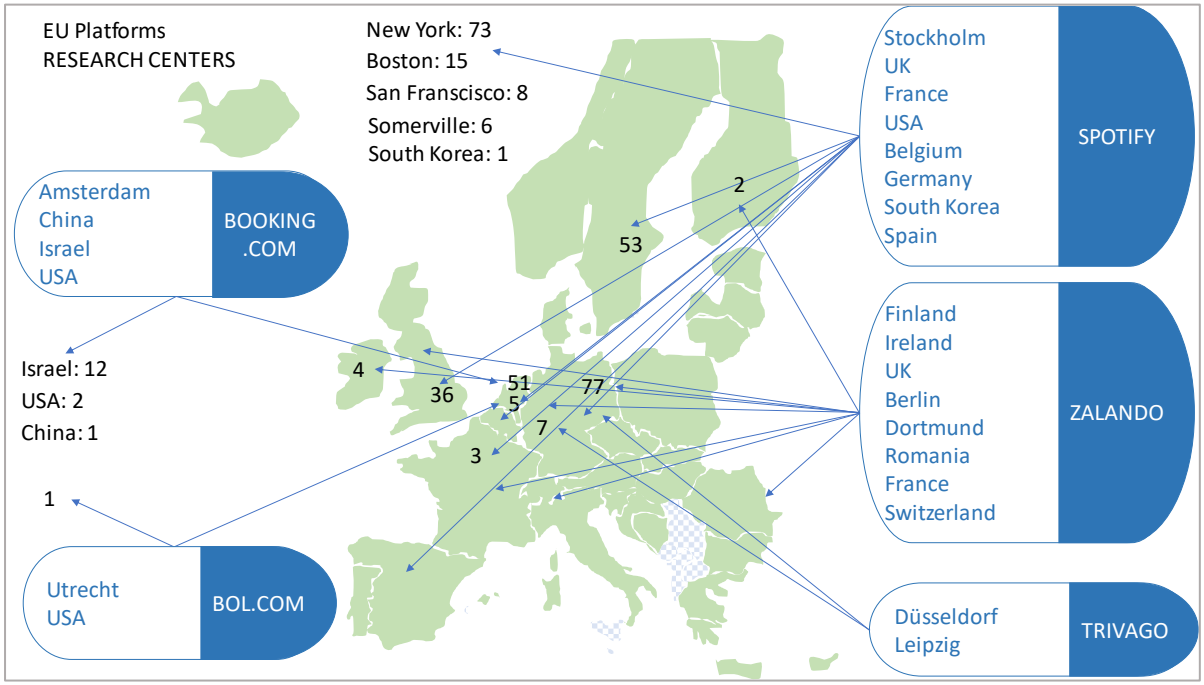
Notably, only half of the authors are from Europe (Table 3. The EU platforms have more EU-lead publications, but even here, 45% of authors are non-EU. On the one hand, this means that most of the results will profit non-EU partners. On the other hand, EU authors will also learn from other parts of the world. It would be worth understanding if there is a division of knowledge tasks between the research centres globally. We cannot identify the actual prominence of EU authors in certain research domains. This could be the focus of future research.

Figures 7a and b and 8a and b show the geographical spread of research centres involved in EU platform company-related publications and for Google, respectively (see the Appendix for Amazon and Facebook). We find that EU platforms are more linked to smaller research institutes (e.g. Stockholm, Berlin, Amsterdam), whereas Google, Amazon and Facebook have clear connections to the major research centres and universities in the UK, France and Switzerland. With regard to the EU platforms, Booking.com has the Netherlands (Amsterdam) and Israel as publishing headquarters; Bol.com works from Utrecht (Netherlands). Trivago works from Düsseldorf; Zalando from Berlin (Germany) and Ireland; Spotify from Stockholm (Sweden), New York (US), Boston (US), the UK and many more countries. The greater spread may exist because these platforms have not yet decided on where their 'intellectual centre' will be. It interesting is to see that Spotify has more than half of its co-publications coming from outside of Europe. After 2017, the European locations of Spotify only account for a quarter of publications. The lead is in the US, which may pose concerns for EU policymakers.

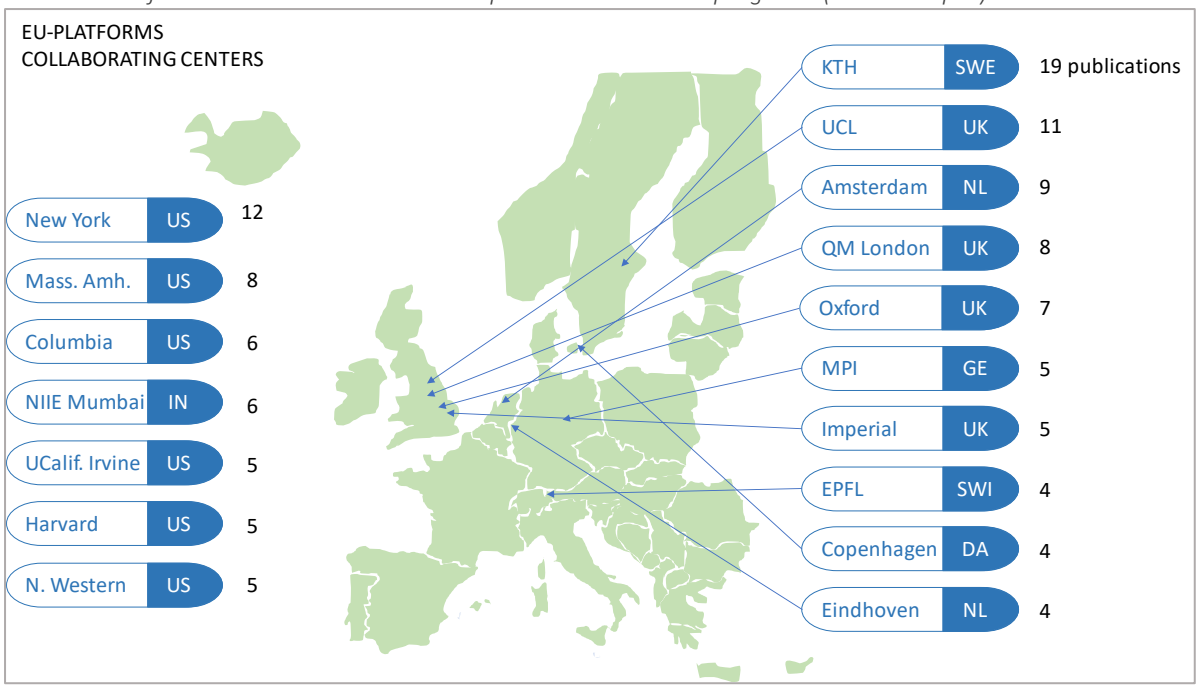
The prominent place of the Swiss research institutes (EPFL, ETH), which dominate as locations for publications for both Google and Amazon, is also surprising. One explanation may be the attractive public funding offered to the Swiss applied research universities

(Lepori, 2008; Lepori et al., 2014) and the attractive environment. Also notable is the dominance of the four UK universities: Oxford, Cambridge, UCL and Edinburgh. Possibly, the language advantage and reputation favour collaboration with these universities. There will also likely be strong path dependency and agglomeration effects.

Figure 7a: Research centres of participating in EU platform publications

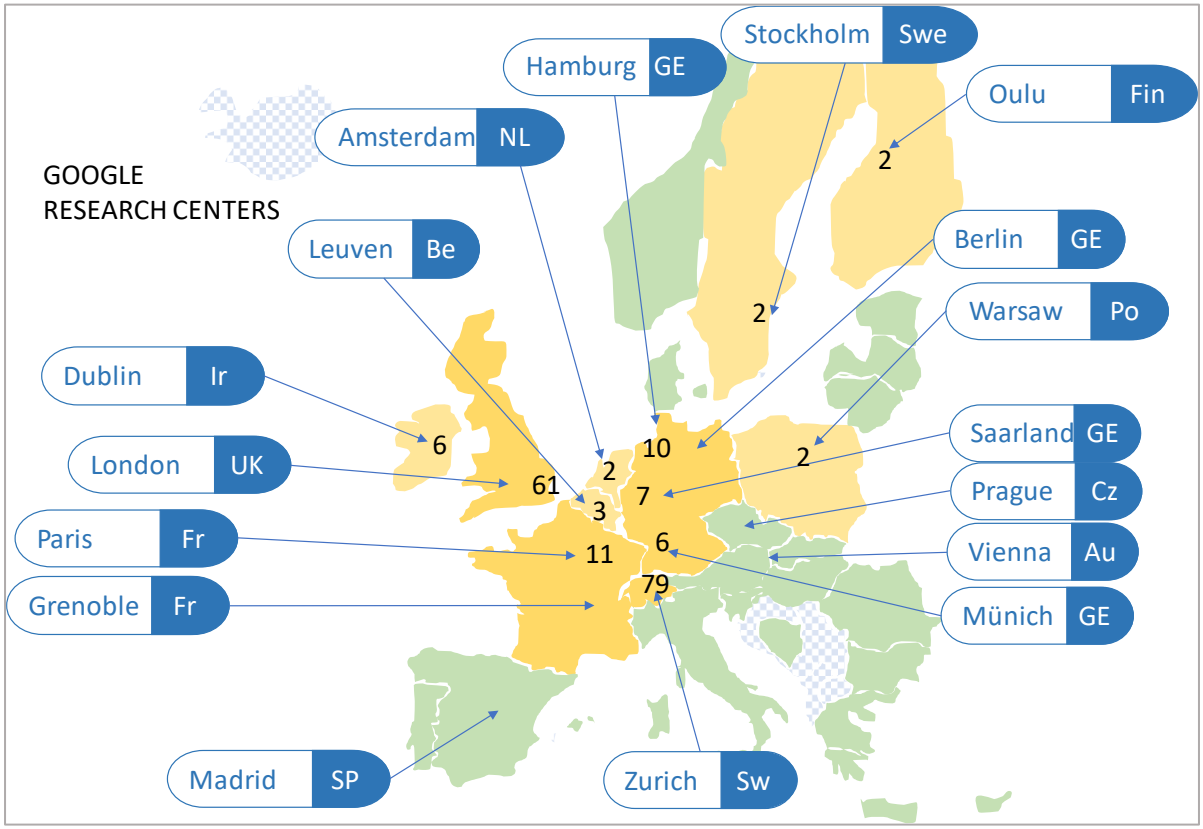


7b overview of research centres with most co-publications with EU programs (data = Scopus)

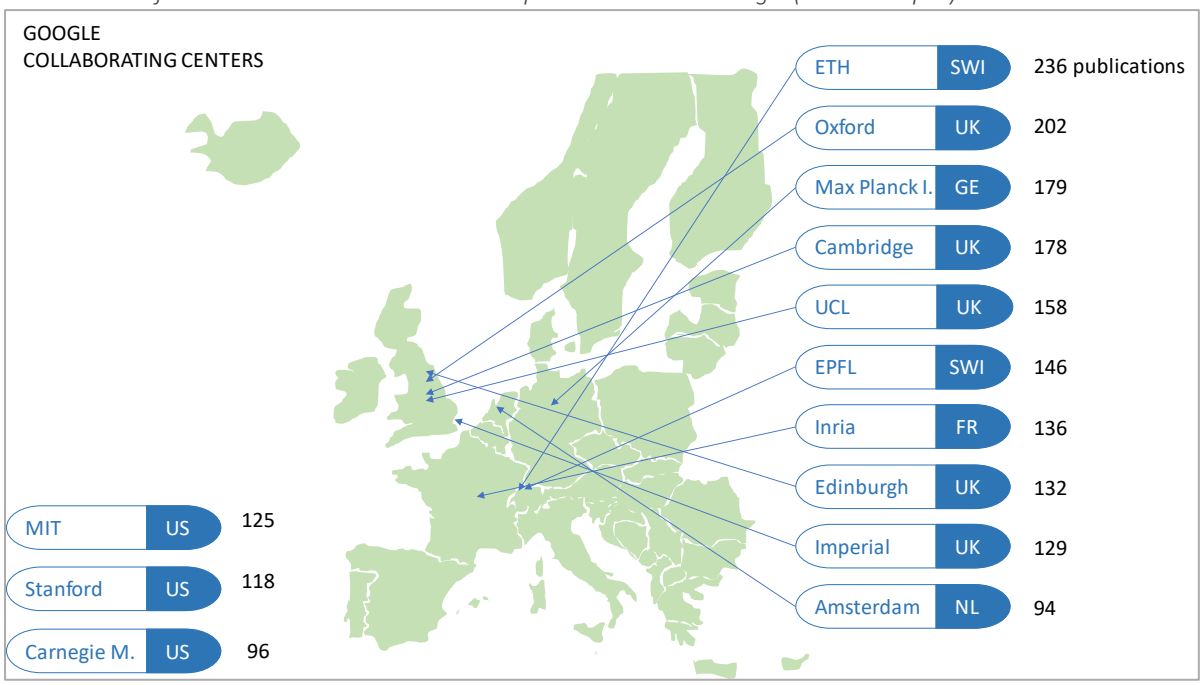


Note: Where no number is shown, just one paper has been published.

Figure 8a: Research centres participating in co-publications of Google (if no number: only one publication)



8b: overview of research centres with the most c-publications with Google (data = Scopus)

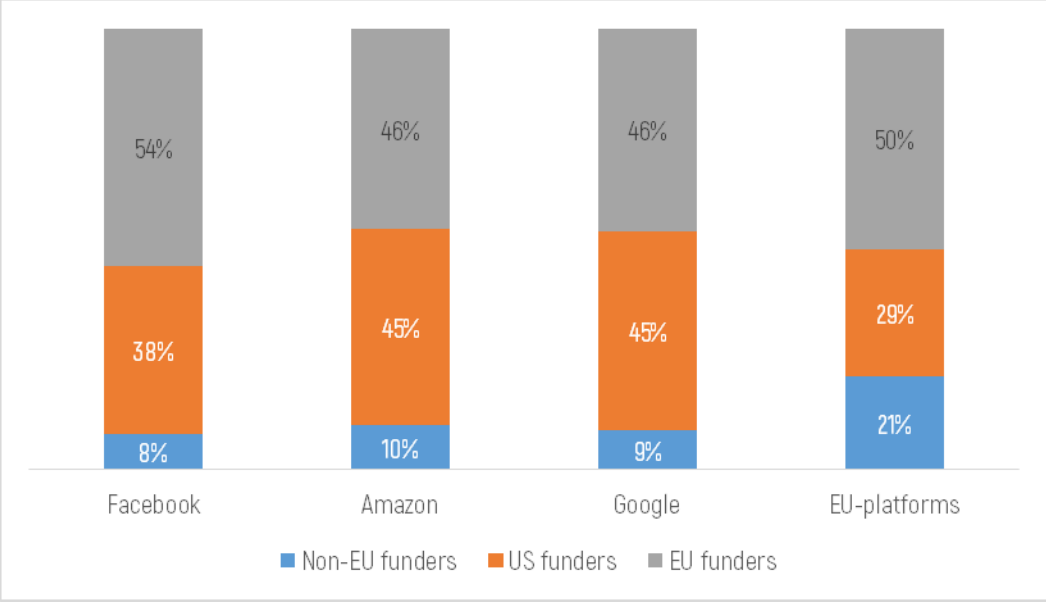


3.3. Who funds this research?

Figure 9 shows the funding patterns related to the platform co-publications. In the past, publications did not always show who the funders were. More and more, journals are requesting to clarify the different conflicting interests and funding. For the different platforms, we only know the funders in 30 to 50% of publications. One hypothesis is that most of these publications are funded by the platforms themselves, and where this is the case, it is often not stated. Figure 10 shows that the percentage of unknown funders is higher with a smaller number of authors. We know that these publications are led by the platforms, which probably also indicates that these publications are self-funded.

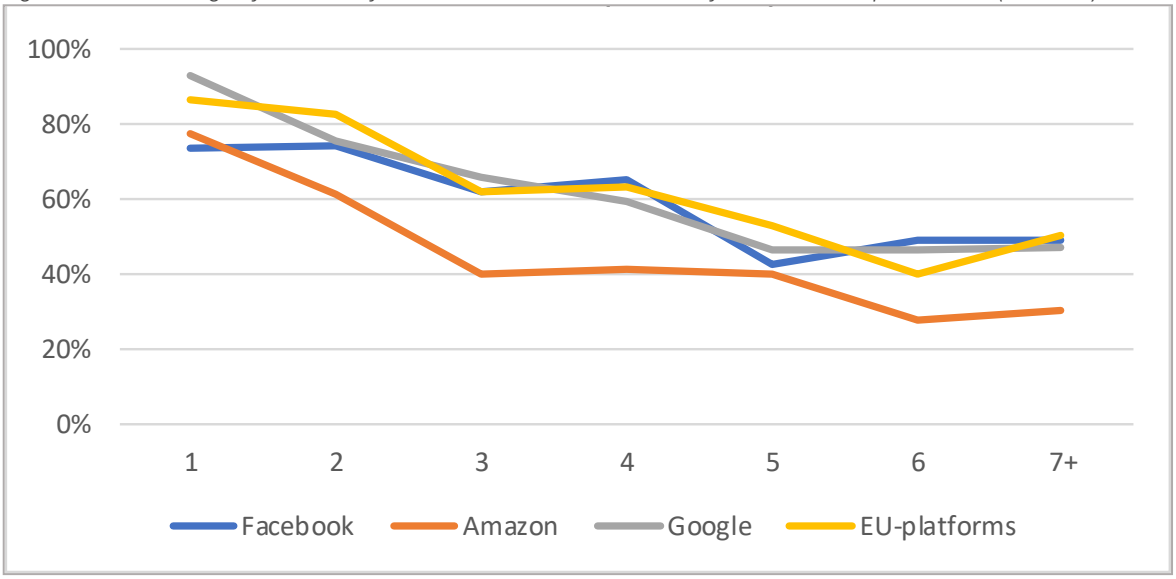
Of the publications where the funder is known, we see a roughly even split of funding between US and EU (the latter including both EU institutional funding and individual EU-country funding) for the three U.S. platforms. EU platforms receive relatively less US funding but more funding from outside the US and EU as a proportion of the total.

Figure 9: Funding patterns of digital platform publications (SCOPUS)



Note: Where no number is shown, this means just one publication has been published.

Figure 10: Percentage of unknown funders related to the number of authors in co-publication (SCOPUS)



To illustrate how the platform companies use funding, we focus on the detailed information on the funders of Facebook's publications (Table 4). The main funder by some distance are the National Science Foundations, and secondly, the European Commission (FP7, Horizon 2020, European Research Council). Companies also participate in about 10% of the funding (4,5% of co-publications), as far as this is a good estimate of all publications. Facebook itself is only listed as a funder in three co-publications, however, next to the funding details, the funding text also provides more insight into possible funding by Facebook. These texts reveal a total of 34 publications in which Facebook provided funding, research awards, support, resources, or grants to conduct the research. This is still only 10% of the first funders of the research.

Table 4: Breakdown of Facebook's co-publication funders (data = Scopus)

	1st funder	2nd funder	3rd funder
National Science Foundations	152	40	28
European	74	45	25
Company	29	17	17
University	16	11	9
Health	10	10	5
Defence	9	12	5
Ministry	8	7	8
Facebook	3		
Research institute	3	7	4
Public authority	2	3	1
Total	306	152	102

Interestingly, for the publications in which (EU-)Facebook is the only author, six of them are funded by the EU. Some five per cent of publications have been funded by defence

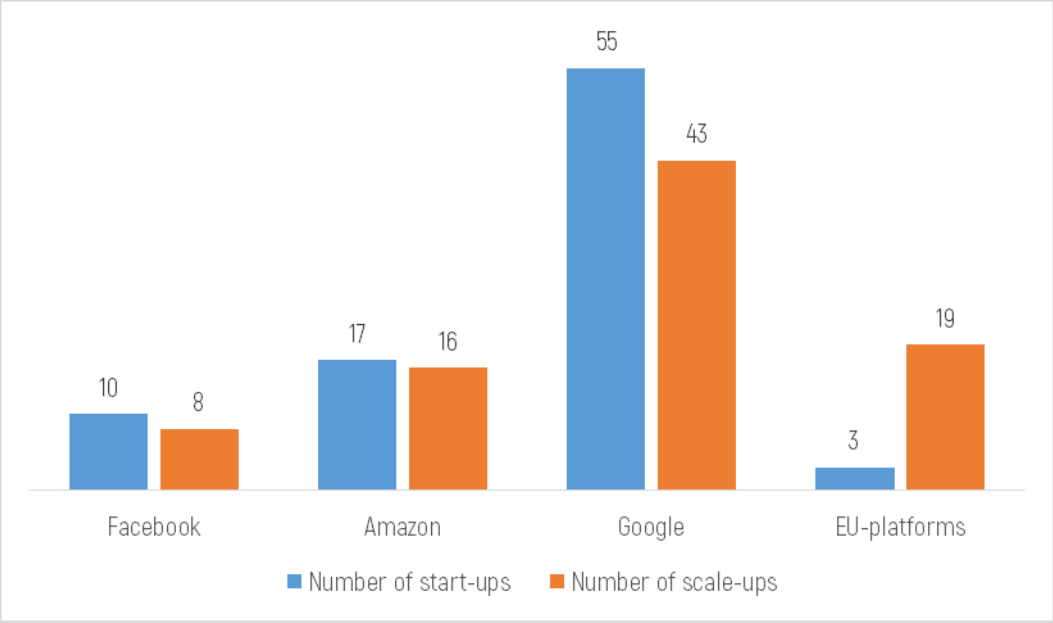
organisations (DARPA-type of funders). This suggests that role of the defence funders seems to be limited for these platform organisations, in contrast, for example, to key innovations such as smartphones and GPS (Mazzucato, 2015).

In summary, it seems as if in most of the publications is it involved in, Facebook does not fund at all and that Facebook itself is profiting from national and European funding. Even if it is the case that Facebook is the main funder in the unknown funding, this table shows that Facebook does not really take a role in funding publications in the European research area.

3.4. The entrepreneurial ecosystem

Many of the publications of the platform companies are focused on developing platform technologies, either by developing technologies, statistics, AI-knowledge and other topics (see Appendix for more detail on word associations related to the publications). Since the publications allow us to identify the linked companies, it is also possible to see if these companies are 'start-ups' or 'scale-ups'. Figure 11 shows the actual number of start-ups and scale-ups connecting to the total number of co-publications. We can see that Google is someway in the lead here, but in terms of start-up/scale-up connections as a % of total publications, we find Amazon has the highest rate per publication at 5%, followed by Google at 3% and Facebook and the EU platforms at 2%. Policymakers might be concerned to note the low number of start-ups linked to EU publications relative to the US firms, although this may just be a result of the relatively young age of the EU platforms. Nearly half of the publications from EU platforms are connected to non-EU start-ups, which doubles the percentage of co-publications. It seems that the EU platforms generate more entrepreneurial activity than their US colleagues, but half of these companies are outside of Europe. The benefits are not only for Europe.

Figure 11: Total start-ups and scale-ups associated with collaborative scientific publications (SCOPUS)



A couple of qualifications are worth noting. Firstly, these figures are likely an underestimation of the number of start-ups or scale-ups created or developed connected to the publications. A number of university or research institute-based authors may have gone on to create companies after publication, but this was beyond the scope of the research. Secondly, our data is necessarily biased here towards bigger companies: to participate in a co-publication, you probably need funding or support from a bigger company. Many start-up specialists may not be focused on (co-)publishing. Third, we may be overestimating the actual number of entrepreneurial activities linked to the co-publications. We have selected companies as being a start-up or scale-up on their actual starting date, as reported on the website. The classification into either type is based on the actual number of people currently working in the company. If this remains below twenty, we see the company as a start-up. However, the co-publication may have nothing to do with the entrepreneurial activity itself. These are topics for further research.

If we examine core- centres participating in the co-publications, the US-platform companies operate out of 2 -to-4 main hubs for (publishing) research. The network development can be different from what the research centres (and mother companies) are trying to achieve. When looking at the market share of top-10 companies in term of number of publications in (Table 5), we see that this share for Amazon is more than three times higher than the other platform companies. The companies that benefit are mainly US-based, with Microsoft, IBM, Amazon, Yahoo Labs as main examples. Amazon appears to have an interest in limiting its connection to a limited set of companies rather than having a broad collaboration with companies, universities or research institutes. Overall, the platforms do support the rise of start-ups and scale-ups. Although the number of such companies seems low (2-6% of authors), this figure is what we also found in advanced manufacturing (Dhondt et al., 2022).

Table 5: Network development relating to digital platform co-publications

	Facebook	Amazon	Google	EU-platforms
European research centres (> 10 publications)	2	3	4	4
Market share top-10 companies in co-publications	10%	35%	7%	9%
Market share top-10 EU-institutes in co-publications	19%	15%	10%	11%
Market share top-10 non EU-institutes in co-publications	11%	10%	5%	9%
Market share EU-companies in co-publications	12%	7%	5%	41%

When looking at the share of top-ten non-EU institutes, we see that Google is the most focused on EU-research institutes of the four platforms, considerably more so than the EU platforms. The last figure concerns the percentage that EU companies represented in the

total share of authors. Here the EU platforms cooperate much more with EU companies than the US platforms do, as might be expected. Google has the least connection to EU companies.

3.5. Summary

Overall, the benefits for Europe from the platform companies seem to be mixed. There is a benefit in that the US platform collaborates with European researchers and the development of start-ups and scale-ups. On the other hand, the actions of the platform companies have a downside for Europe. Firstly, the European platforms are still in an early phase. They are contributing to the rise of new research centres, but their impact on research topics is only a fraction of the big-three US platforms. In addition, there is evidence of substantial EU-funding disappearing to the US. US platforms do gain from European funding to develop their knowledge capital, either from individual countries or Europe itself.

Can we say that the different platform companies contribute to the development of a vibrant entrepreneurial ecosystem? The answer is not straightforward. In recent years, the US platform companies have built up a reasonable technological competence in Europe. The development of various company-based research centres is testimony to this. The establishment of networks with universities and research institutes is also evidence of this.

However, various practices are less encouraging. Firstly, the core publications from the platforms are mainly 'internally' focused. That is, the knowledge is not primarily shared with European partners. It seems that the growing relationship with European institutions is partly aimed at extracting knowledge and value from Europe. This type of publication seems to be financed 'internally' in the first instance, but this observation requires further exploration. The current SCOPUS data does not allow us to conclude this with certainty.

As with the financialization story described in section 3, we notice considerable heterogeneity in terms of the behaviour of the four platforms in relation to scientific participation. Google has embedded itself strongly in the European knowledge infrastructure. Its knowledge development is broadly based and has been developed for over twenty years. Facebook centralises knowledge development in two locations, reinforcing the perception that these are linkage points to US research and marketing departments. Amazon has a very different network structure, focused on companies and more embedded in the German context. Here too, the orientation seems to be more towards serving the US offices rather than building advantages locally.

The European platform companies lag behind what the US platforms have achieved here in terms of contribution to European research. A worrying sign is that a platform like Spotify is clearly shifting the core of its knowledge development to the US east coast. The other platform companies are still building their knowledge networks, and these seem to be using global inputs at the outset.

Finally, the willingness of universities and research institutions to cooperate with the various platforms shows great openness. The question is whether this openness is of benefit to Europe or whether there is some naivety in mainly supporting knowledge development for the benefit of foreign platforms. This should be looked at more closely.

4. Alternatives: the cooperative digital platform

The previous three sections have focused on the largest and most successful digital platforms, their business models and behaviour in regard to research in the EU. Although we have noted significant heterogeneity in these platforms in terms of their business models and research and development strategies, there is strong evidence of convergence in terms of corporate behaviour towards a form of 'digital rentiership'. This model involves aggressive efforts to assert control over an exponentially increasing quantity of users, their attention and data to maximise network effects and provide a constant source of raw material to refine and improve the algorithms that help these firms develop assetizeable products and generate profits and conquer new markets.

But what are the alternatives? Perhaps the most interesting alternative model is related to new ownership and governance structures. As a matter of fact, digital platforms are increasingly acting as infrastructures, providing public utility-type services (Frischmann, 2012; Muldoon, 2022; Schneider, 2018a). This is at all scales, ranging from enabling instant communication between people at a global level (messaging, email), to exercising direct control over municipal transportation networks when they operate at the local one. Consequently, they can be seen to manage both the digital and urban 'commons', impacting on a larger community than one of their direct users and reshaping our virtual and physical environments. This inevitably raises the question of whether a wider range of stakeholders from the communities that platform companies operate within should be given property and control rights.

4.1. The cooperative platform model

Europe has a long and strong tradition of cooperative business models, in particular in sectors such as agriculture (Gonzalez, 2018) and banking (Ayadi et al., 2010). We focus our attention here on the concept of the cooperative platform, where, rather than being owned privately or publicly listed, platforms are owned directly by their ecosystem stakeholders. The platform coop movement is growing fast and there are different models emerging, with still limited literature analysing their organisational structures and societal impacts. Nathan Schneider provides a broad definition, proposing that, "under the banner of 'platform cooperativism,' an emerging network of cooperative developers, entrepreneurs, labour organizers and scholars is developing an economic ecosystem that seeks to align the ownership and governance of enterprises with the people whose lives are most affected by them" (2018a:320). Under more democratic ownership regimes, less focused on short-term

profits for a limited number of private owners, the hope would be that platforms would develop more inclusive, value-creating business models (Morell & Espelt, 2018).

Trebor Scholz, the founding father of the cooperative platform movement, theorises the ten central principles that should guide all platform cooperatives to reach these outcomes (2017:180-184): a) collective ownership of the Net, b) decent pay and income security for workers, c) transparency and data portability, d) appreciation and acknowledgement for all value creators, e) co-determined work, f) protective legal framework guaranteed by public institutions, g) portable workers' protection and benefits, h) protection against arbitrary behaviour, i) rejection of excessive workplace surveillance, j) the right to 'log off' from platforms.

Accordingly, Simon Borkin (2019) recognises four membership types that platform co-ops can adopt for implementing these principles: 1) multi-stakeholder/community platforms; 2) producer-led platforms, 3) consortia/worker platforms, 4) data consortia platforms. To this taxonomy, we can then add the case of city-owned platforms (the case study of Barcelona is analysed in the next section).

An alternative taxonomy is proposed by Schneider (2018a), focusing instead on the different possible design patterns that platform co-ops can adopt, i.e., the non-mutually excludable dimensions on which they can decide to build their alternative ownership structures. More specifically, he claims that platform cooperatives can respectively:

a) put work at the centre, shifting from looking at workers merely as value creators to considering them as value owners[16];

b) elaborate innovative solutions for fostering the democratic management and collective ownership of data;

c) promote the open source principle, looking at the digital code as a common good;

d) module their organisational structure through distributed protocols;

e) search alternative financing strategies to scale up and compete with the incumbents without relying on venture capital;

f) experiment with different ways to educate their members on cooperative values;

g) combine alternative ownership structures with coherent governance models;

h) ask and push for the active involvement of national and local governments. Indeed, those are both essential stakeholders of the platform economy and

[16] For a broader discussion about how platform cooperatives reframe the concept of value, see Morell et al. (2016).

stewards of the digital and urban commons that platforms are supposed to manage;

i) involve academics and activists to co-design strategies for the future of the digital economy.

The last category clearly overlaps with the discussion in section 4 around the role of research institutions in collaborating with digital platforms. Here, it is worth mentioning again Scholz's dual contributions to the growth of the cooperative platform movement as its principal theorist and advocate. In fact, he first established the research field as director of the Institute for the Cooperative Digital Economy at the New School, and he now organises and finances annual itinerant conferences for bringing together academics and practitioners from all over the world and disseminating original research and case studies. Furthermore, he also created the Platform Cooperative Consortium (PCC – https://platform.coop), an international hub that provides support to platform cooperatives around the world by sharing best practices, alternative design approaches, and educating cooperators on platform cooperative principles through online courses and tools.

Table 6 provides an overview of a selection of some paradigmatic cooperative platforms, including their scope, membership type and design pattern.

Table 6: Selection of some paradigmatic platform cooperatives

Name	Scope	Membership	Actors	Design pattern	Origin	URL
Fairmondo	Online marketplace aiming to spread internationally to create a network of autonomous but interrelated local co-ops	Multi-stakeholder co-op with open membership	Users, platform staff	Alignment of appropriate ownership and governance structures, digital code as a common good	Germany	www.fairmondo.de/global
Resonate	Cooperative alternative to Spotify with a "stream to own" listening model	Multi-stakeholder co-op	Artists, listeners, music labels, platform staff	Workers as value owners, alternative financing strategies, alignment of ownership and governance	Germany	https://resonate.is/
Stocksy United	Stock photo agency providing royalty-free and high-quality photos	Producer-led platform	Founders, staff and photographers	Workers as value owners, alignment of ownership and governance	Canada	www.stocksy.com/
Fairbnb.coop	Fairer alternative to Airbnb and Booking.com offering short-term socially sustainable vacation rentals	Worker co-op transitioning to a multi-stakeholder structure (Vidal, 2022)	Staff, members of local communities, local governments	Alignment of ownership and governance, education of members on cooperative values, involvement of scholars, involvement of governments	Italy	https://fairbnb.coop/

Name	Scope	Membership	Actors	Design model	Origin	URL
Consegne Etiche	Alternative organisational model to commercial food-delivery platforms aimed to tackle the negative societal impacts of the Covid-19 pandemic (d'Alena, 2021)	Multi-stakeholder co-op	Workers, Riders Union Bologna, local shopkeepers, Municipality of Bologna, University research centres, users and civil society, pre-existing cooperatives	Workers as value owners, alignment of ownership and governance, involvement of scholars, involvement of governments	Italy	https://consegnetiche.it/
Coopcycle	Bike-logistics digital infrastructure and federation of local bike delivery co-ops (Kasparian, 2022)	Multi-stakeholder co-op	Algorithmic developers, local cooperatives	Alignment of ownership and governance, alternative financing strategies, education of members on cooperative values, digital code as a common good	France	https://coopcycle.org/en/

Name	Scope	Membership	Actors	Design model	Origin	URL
Eva	Redefining the gig economy with a new social contract for the ride-hailing and delivery sectors	Multi-stakeholder co-op	Passengers, drivers, worker members, individual supporter members, corporate supporter members (Mannan, 2020)	Alignment of ownership and governance, distributed protocol	Canada	https://eva.coop/#/
The Drivers Cooperative	Driver-owned ride-hailing platform from New York City that guarantees its drivers higher salaries than Uber and Lyft (Forman, 2022)	Worker co-op	Drivers	Workers as value owners, alignment of ownership and governance	USA	https://drivers.coop/
Polypoly.com	Creating a data economy fairer, more transparent and greener (Scholz & Calzada, 2021)	Data co-op	Users, computer scientists	Alignment of ownership and governance, collective ownership of data	Germany	https://polypoly.com/en-gb
Up&Go	95% of the profits to workers who manage the platform directly	Worker co-op	Cleaners	Workers as value owners, alignment of ownership and governance	USA	www.upandgo.coop/

Source: Authors' elaboration of Scholz & Schneider (2016), Borkin (2019), SWIRL (2021), Bunders (2021) and Bunders et al. (2022)

4.2. Different actors and their roles in the cooperative platform ecosystem

As we can see from the examples, different actors play key and complementary roles in a synergistic platform ecosystem. First and obviously, a fundamental role is played by cooperative developers. Bunders (2021), analysing the case in which gig workers directly play the role of developers (Kirsanova et al., 2021), recognises at least three different strategies they can adopt for coordinating themselves and launching a platform co-op: 'creation,' i.e., a new cooperative is built and organised from scratch; 'conversion,' i.e., an existing platform is mutualised by its workers[17]; 'coding,' i.e., an existing worker cooperative adopts a platform[18]. Another development strategy is the federative one, as in the case of CoopCycle (Table 6), which aims to solve the network effect issue and deal with the huge initial cost of building the technological infrastructure by promoting the sharing of the same code provided by an umbrella co-op of algorithmic developers within a network of independent but affiliated local cooperatives.

As well as developing new platforms, cooperative developers together with innovative unions of gig workers can also play an important role in elaborating alternative forms of collective action for resisting the digital rentier business model (Woodcock & Graham, 2020). Someone indeed often forgets that the cooperative and union movements started their lives together in twentieth-century England before separating; now may be a favourable time to bring them back together thanks to the opportunities and necessities that digital tools offer and pose (Peck, 2016). In its initial aspiration, the case study of *Consegne Etiche* (Table 6) was an excellent example of the positive collaboration that can originate between self-organised unions of gig workers and platform cooperatives.

Alongside cooperative developers and worker unions, in a multi-stakeholder perspective, a prominent role can also be played by customers and, more in general, by the broader community of citizens affected by the extractive operations that traditional commercial platforms make (Muldoon, 2022). Given the key role they play in providing the raw material that digital platforms need to extract and assetize for their production process, platform consumers can be reimagined as 'prosumers' (Ritzer, 2015) with some of the additional rights and responsibilities that come with being producers.

Furthermore, the involvement of users in their ownership and governance structures could also offer a solution to one of the main challenges that platform cooperatives face, i.e., the financing issue. Borkin (2019) has defined this issue as the 'capital conundrum,' i.e., the main obstacle for the scaling up of platform cooperatives that cannot rely on the venture-backed

[17] Tej Gonza and David Ellerman (2022) have expanded on this topic, analysing how ESOPs (employee stock ownership plans) can be used to democratise labour-based platforms.

[18] This strategy and the related challenges have been instead extensively analysed by Elena Como et al. (2016). Two examples are SMart, a Belgian-born cooperative of freelance workers for risk mutualisation (Charles et al., 2020), and Doc Servizi, an Italian cooperative of professionals born in the music industry for the mutual protection of its members (Martinelli & Chiappa, 2019).

capital that sustains the 'growth-before-profits' business model of the incumbents. More specifically, his proposal to solve the conundrum is a well-elaborated investment model based on community shares.

In table 7 below, we summarise the main actors that can be found in a synergistic and flourishing cooperative platform ecosystem, the specific role they can mutually play and the relevant literature that has examined them. While the role of academics and activists has been analysed in the previous sub-section, public institutions will be considered in the next section.

Table 7: Overview of role of cooperative platform ecosystem stakeholders and related literature

Actors	Role	Literature
Cooperative developers	Coordinating for collective action and launching platform cooperatives	Bunders (2021), Kasparian (2022), Kirsanova et al. (2021), Scholz & Schneider (2016)
Gig workers' unions	Pushing for worker-friendly legislation and playing a complementary role with platform co-ops	d'Alena (2021), Peck (2016), Scholz & Schneider (2016), Woodcock & Graham (2020)
Customers and civil society actors	Participating in the management of platform co-ops and helping to solve the capital conundrum	Borkin (2019), Muldoon (2022), Scholz & Schneider (2016)
Public institutions at the local, national and supranational level	Promoting competitive legal strategies, creating a level playing field, reclaiming data sovereignty, partnering and/or incubating platforms directly	Monge et al. (2022), Muldoon (2022), Schneider (2018a), Scholz & Schneider (2016), Scholz et al. (2021), Smorto (2017)
Academics and activists	Co-designing innovative solutions and disseminating cases and good practices	Schneider (2018a), Scholz (2017)

Source: Authors' elaboration

Case study: Fairbnb.coop – towards a vacation rental market benefiting local communities

Fair Bnb Network società cooperativa is formally an Emilian worker-owned cooperative founded in 2018, even if the project already started in 2016 as a collaboration between groups from Amsterdam, Barcelona, Bologna, and Venice. Its mission is offering short-term, socially responsible vacation rentals in order to address the problem of gentrification posed by the incumbents of the sector (Foramitti et al., 2020). Additionally, it is also in the process of becoming a multi-stakeholder cooperative as it grows throughout Europe (Vidal, 2022). Due to this, the platform's developers plan to include local ambassadors in its governance structure. These individuals will be in charge of interacting with public institutions in the areas where Fairbnb operates and identifying the local social projects to connect to the listings. At the same time, local authorities may be tasked with certifying the platform's sustainability and establishing favourable regulations so that Fairbnb may more effectively compete with its current opponents (Ghirlanda, 2022). Three policies distinguish Fairbnb.coop from competitors:

1. The "one-host-one-home" rule, which seeks to avoid the extractive multi-hosting phenomenon typical of Airbnb and Booking.com;

2. The transparent sharing of data with local administrations and compliance with local regulations;

3. Half of the 15% commission on bookings going to fund social projects defined by local communities and directly selected by customers

4.3. Competitive advantages and challenges of platform cooperatives

Cooperatives are viewed as having many advantages as an ownership and governance model that may be carried through to digital platforms. This includes their ability to establish missing markets and meet unmet needs; their capacity to offer protection from exploitation for members; their greater efficacy in sharing information among stakeholders and balancing asymmetries; their lower chance of failure; and their ability to save on transaction costs (Schneider, 2018b). Borkin (2019) also notes their potential greater efficiency as compared to their commercial alternatives because of the non-monetary incentives they can create for engaging workers, their capacity of placing creators in control, their stronger resilience to external shocks, and their lower levels of staff turnover, pay inequality and absenteeism rates.

Yet, cooperative platform solutions have also weaknesses to face, besides the previously mentioned financing issue, i.e., raising the money necessary to compete with the incumbents without relying on venture capital. Borkin himself (2019) notes for example three other challenges: first, a governance challenge, since platform co-ops usually lack a geographically

rooted community due to their characteristic digital orientation, and this is a huge problem in a market that strongly relies on network effects. Second is the 'technological challenge,' since the technological infrastructures of their commercial competitors are often very costly. The third is a 'growth challenge,' since platform co-ops must find out alternative and unexplored paths to scale up beyond the classical 'growth-before-profit' business model. Furthermore, platform co-ops experience challenges even in balancing competing interests, such as the heterogeneous preferences of their workers for wages and working conditions, the different positions of public institutions in relation to the external socio-political environment and the non-identical consumers' willingness to be involved in their governance structure. A related challenge is the difficulty of taking collective decisions and gaining the institutional support they need to compete (Bunders et al., 2022).

In the following section, we consider the ways in which public policy could support the development of cooperative platforms to face some of these challenges.

5. Policy implications

5.1. Levelling the playing field: a Big Tech disclosures framework

How have U.S. Big Tech digital platforms come to attain such a dominant position in their markets in such a short space of time? Is the 'digital rentier' business model they operate inherently superior in terms of growth? Or is it a model that simply reflects weaknesses in the current policy framework for dealing with this newly emerging sector?

Currently, considerable activity is being focused on problems around competition, anti-trust and privacy in both the US and EU, as mentioned in the introduction. Yet authorities have struggled in this endeavour. Notably, anti-trust investigations have been hobbled by a lack of understanding of how Big Tech actually operates and creates and extracts value from the ecosystems that it has come to dominate. An important reason for this is that the regulatory disclosure framework Big Tech faces is not well designed for the multi-sided platform business model described in Section 2 (Strauss et al., 2021).

Mandatory public disclosures on Big Tech's business activities from the annual public 10-K reports, which they file with the US Securities and Exchange Commission (SEC), the primary U.S. financial markets regulator, tend only to cover the *paying-side* of the platform, ignoring the subsidised consumer-facing side. But, as we have shown, value is co-created through both sides contributing to the platform. In its simplest form, this means no obligations to report user numbers, a key performance metric that is used as the standard for internal reporting. In the more complex case, this means not disclosing the indirect role that free products, or 'free' user data, play in increasing the monetary value of other products within the ecosystem as a whole.

Furthermore, 10K segment reporting practices allow Big Tech firms to disguise what they are doing in terms of product diversification. Although the current segment reporting rules were

designed to ensure that large, diversified conglomerates release disaggregated financial information, in practice, the rules give companies wide discretion to define what counts as an "operating segment." Big Tech companies still portray themselves as 'single segment' or 'two segment' product companies in their 10-K reports. Apple, for example, defines its segments not by product but by geography, so it is not required to disclose App Store profits..

Antitrust regulations can no longer rely solely on price-based measures of consumer and producer surplus, and monopoly power. A re-vamped disclosure regime, which includes non-price disclosures, would thus be a key first step in getting to grips with Big Tech's market power, allowing regulators but also investors to 'look under the hood' and better comprehend the digital rents that Big Tech creates as a matter of routine. Regulators must go beyond "profit and loss" reporting to require specific non-financial operating disclosures on all products that meet a certain threshold of monthly active users. This rule would require disaggregated operating disclosures on products like Alphabet's Google Search, YouTube, Chrome, and Android, or Meta's Facebook, Instagram, WhatsApp, and Messenger (Strauss et al., 2021).

These rules need to scale with firm size to ensure the release of hidden data from consolidated financial statements. To tackle both issues, companies could be required to disclose detailed financials on any product with at least $5 billion in annual revenues. To put that amount into context, it would trigger the disclosure of financial information on Apple's AirPods and Microsoft's Azure. Just as environmental, social, and governance reporting is becoming essential to help navigate climate change, enhanced 10-K reporting is necessary to reveal the nature and extent of Big Tech's market dominance. This will help understand whether Big Tech firms owe their continued growth to value creation or to value extraction, and enable much more forensic and strategic regulatory interventions.

Lastly, Big Tech derive and leverage considerable market power through creating eco-systems of inter-related products. This means that products can be monetized increasingly 'indirectly'. Facebook, for example, only disclosed in 2021 how it makes money from Whatsapp, by using it to drive ad sales on its other products.[19] Requiring a detailed narrative in the 10-K on how companies make money off their products, including a 'monetization narrative', is important to understand this growing dynamic.

5.2. New M&As and corporate governance regulations

Section 2 and 3 demonstrated how Big Tech has turned towards an increasingly predatory and financialised business model, focused on preventing competition by buying up start-ups before they threaten them, dominating markets and maintaining a high share price. We've also seen increasing convergence of Big firms towards the same key markets to enable user capture. It is clear that new regulations are needed to prevent these activities from leading to ever greater market dominance of a small number of firms.

[19] https://edition.cnn.com/2021/04/28/tech/facebook-whatsapp-earnings/index.html

As with the aforementioned disclosure regime, the current merger regulations are in need of an update to deal with the fact that most of Big Tech's acquisitions do not trigger merger notification threshold tests due to the small financial stature and tangible assets of many start-ups. Mclean (2020) has proposed an alternative threshold test relating to the economic goodwill incorporated in mergers. This would be a proportion-based test, concerned with a target's net tangible assets as a proportion of transaction value which can be seen to represent the gains the acquirer expects to realise from its strengthened competitive position. Authorities could choose a ratio they felt would best preserve competition – the higher the ratio, the stricter the threshold. Big Tech M&As in recent years have involved a goodwill ratio of between 70-80% so this would seem an appropriate starting point for ant-trust and competition regulators to investigate. Assuming regulators regularly acted to block such takeovers, such a threshold test could not only increase competition but also have the advantage of taking some of the speculative froth out of digital platform marketplace, potentially helping to de-financialise the sector.

A range of further steps could be taken to reform corporate governance of Big Tech firms and lean against their financialization strategies. Higher tax rates on retained earnings and dividend payments and limiting firms' ability to tye executive pay to share prices, alongside tax credits for fixed capital expenditures, might help shift firms away from a shorft-term shareholder value maximization approach (Lazonick, 2014, p.10). Incentive compensation should be subject to performance criteria that reflect investment in innovative capabilities, including investment in employees at all levels of the firm, and long-term growth, not share-price.

5.3. Creating a thriving research and entrepreneurial ecosystem in Europe

Section 4 demonstrated that digital platforms in the EU were potentially extracting more knowledge than they were creating. Digital platforms do not appear support entrepreneurial development like the Industry 4.0-driven entrepreneurial ecosystems examined in WP4 (Dhondt et al., 2022). A number of risks were identified. Firstly, that EU-public funding may being channelled to US. Secondly, there is evidence that some EU-companies, such as Spotify & Booking.com, are becoming invreasingly U.S. focused in terms of their research activity. There needs to be a better understanding of how the research centres and EU-research funding is used for corporations that have sufficient own-funds to finance research. More research needed on these developments.

What steps could EU policymakers take to reverse such a process? An obvious one might be to ramp up the level of public R&D spending and research funding for universities in areas like Artificial Intelligence and Machine Learning, which has been stagnating over the past few decades (Soskice, 2022, p.233), so universities do not become dependent on funding from Big Tech firms and intertwined in their business models.

5.4. Policy interventions to support cooperative platforms

Such is the sheer scale and entrenchment of the dominant digital rentier business model, it seems likely that for alternative models, such as cooperative platforms, to be successful, supranational, national and local governments, both as stewards of the infrastructures that platforms control and as relevant stakeholders themselves, will need to play a key role (Schneider, 2018a; Smorto, 2017). As Mazzucato (2018) has noted, given Big Tech firms have been able to dominate markets in part because of innovations funded by the public sector (such as GPS and smart phones), they have an obligation to create more public value.

As well as the national regulatory reforms mentioned above to aid competition, local and regional governments could be doing more to support coops and similar models. This could include: a) mandating platform co-op-friendly procurement policies, b) implementing solidarity-oriented loan programs, c) carrying out public participation in multi-stakeholder cooperatives, d) investing in research to identify and overcome legal barriers, e) providing social benefits to members of platform co-ops specifically, f) creating a list of spaces that platform co-ops could use for free or at a reduced rate, g) providing public regulation by certifying their organisational status as cooperatives, h) facilitating the activities of platform cooperatives by levelling the playing field within their territorial boundaries, i) giving fiscal benefits to platform co-ops, j) investing in platform co-op incubators, k) funding a municipal or national advisory committee, l) including platform co-ops into their political agenda (Scholz et al., 2021). Furthermore, an inclusive business model should involve strong interoperability, data sharing and portability, and limiting of bundling and tying of products.

Cities can be even involved more directly in the digital economy by integrating technology in their civic infrastructure and managing it on their own (Muldoon, 2022). This is indeed the case of Barcelona (see box) under Ada Colau's administration which, under the leadership of the former Chief Technology and Digital Innovation Officer Francesca Bria (Lewin, 2018), developed several projects for ensuring citizenship's sovereignty over data and promoting their direct participation in governing the city (Almirall et al., 2016; Monge et al., 2022).

Case study: Barcelona – a city 'data commons' model

Barcelona's smart city digital transformation agenda conceptualises 'data as a commons' and attempts to enforce appropriate data privacy protections for citizens. Trials include the iDigital/BCNow platform pilot, a partnership with Barcelona City Council and the city's digital democracy platform *Decidim Barcelona*. The pilot aims to allow citizen-generated data to be aggregated and blended from a range of different sources, including noise levels from individual sensors, healthcare data, and administrative open data. This will be displayed in a BCNow dashboard, giving citizens the option to control the use of that information for specific purposes, including to inform policy proposals. It will also provide anonymous verification capabilities (such as when creating and signing local petitions) to minimise the sharing of sensitive or personally identifiable data with the city council. The city has also launched a new

procurement process designed to incentivise responsible innovation with data and respect for privacy and has adopted a focus on open source technologies.

5.5. Conclusion

To effectively govern digital platforms to deliver public value, policymakers need more understanding of the mechanisms and incentives shaping how value is allocated among the key stakeholders in its increasingly large ecosystems. At the present time, value is being allocated primarily towards a small number of extraordinarily well-remunerated executives, owners and, in most cases, shareholders at the expense of the wider ecosystem, including the firms that supply the platform, its users and its employees.

Greater transparency will be an important first step. Reforms to disclosure regimes in the U.S. is vital given the dominance of the U.S. Big Tech firms globally. But the EU can set a precedent by taking steps to force the larger EU digital platform firms also to disclose more information about their operating metrics. Much more restrictive rules on corporate mergers and acquisitions are also required to create more genuine competition between major platforms and prevent them from colonising multiple different key sectors. Shifts in corporate governance to encourage greater long-term and productive investment, including in workers, should also be considered to move digital platforms away from short-term shareholder value maximisation.

But alongside these important regulatory shifts, more needs to be done to support the nascent alternatives to Big Tech business model. City and local and regional governments could play a key role here in supporting mutual and cooperative-owned platform models, particular in areas like transport, food production and delivery and the wider ‘smart cities’ agenda.

Creating an environment that rewards genuine value creation and restrict value extraction is the fundamental economic challenge of our time. Algorithms, Artificial Intelligence and Big data could be used to improve public services, working conditions, and the well-being of all people. But these technologies are currently being used to undermine public services, promote insecure employment, violate individual privacy, and even destabilize the world’s democracies – all in the interest of personal gain. Innovation does not just have a rate of progression; it also has a direction (Mazzucato, 2016). The threat posed by technologies lies not in the pace of their development but in how they are being designed and deployed. A new course is needed.

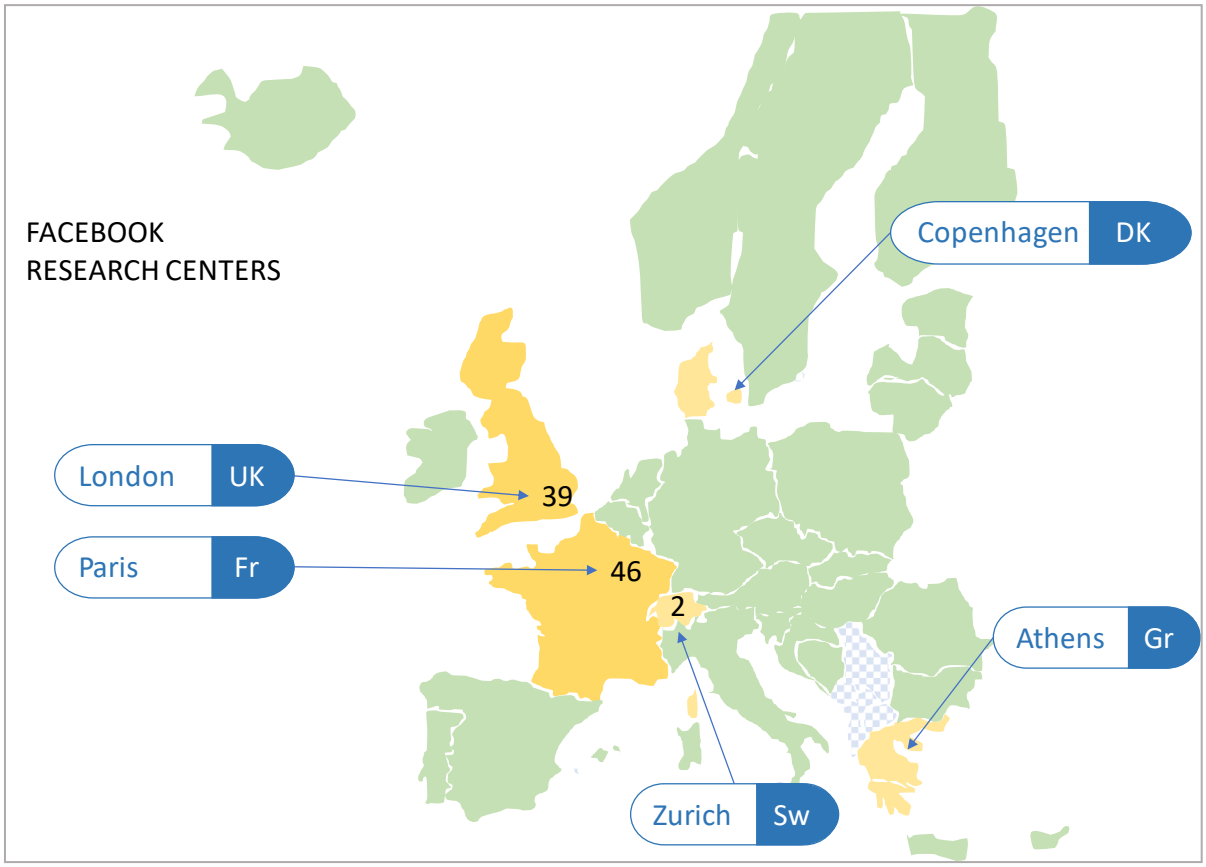
Appendix: Big Tech and knowledge creation and extraction in the EU – additional information

This appendix provides additional detail on the research undertaken to examine the role of digital platforms in the EU research community, described in Section 4. This includes a summary table of the core-indicators (table A1 below), graphics showing the Facebook and Amazon research centres in geographic context and a topic analysis of the co-publications.

Table A1: Core-indicators for comparing US Big Tech and EU platform companies (SCOPUS data)

	Facebook	Amazon	Google	EU-platforms
Number of publications with EU partners	817	695	3452	368
Startdate	2008	2004	1999	2010
Number of co-authors	2840	2606	11776	1077
Lead in the research	58	39	150	31
• Percentage of non-EU authors	49%	50%	49%	45,1%
• Percentage of FAGE authors as 1st author	25%	3%	12%	39%
Funding				
• Percentage of funders known	37%	53%	35%	30%
• Percentage of non-EU funders	8%	10%	9%	21%
• Percentage of US funders	38%	45%	45%	29%
• Percentage of funding from EU	25%	16%	17%	9%
• Percentage of funding from EU-countries	29%	30%	28%	40%
Entrepreneurial spin-off				
• Number of start-ups	10	17	55	3
• Number of scale-ups	8	16	43	19
• EU-Entrepreneurial benefit - 1	All EU	All EU	All EU	55%
• EU-Entrepreneurial benefit - 2	2%	5%	3%	3% (6%)
Network build-up				
• European research centres (> 10 publications)	2	3	4	4
• Market share top-10 companies in co-publications	10%	35%	7%	9%
• Market share top-10 EU-institutes in co-publications	19%	15%	10%	11%
• Market share top-10 non EU-institutes in co-publications	11%	10%	5%	9%
• Market EU-companies in co-publications	12%	7%	5%	41%

Figure A1a. Research centres of Facebook participating in the co-publications in SCOPUS (if no number: only one publication);



A1b. Overview of research centres with most co-publications with Facebook (SCOPUS)

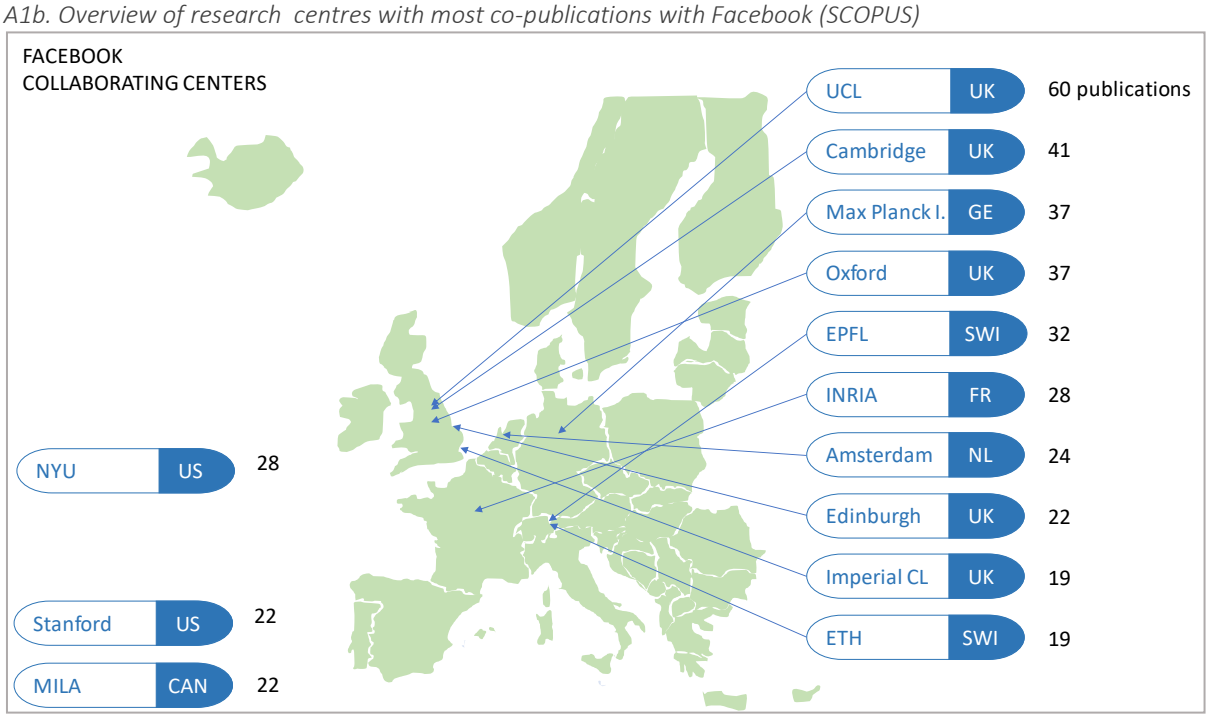


Figure A2a. Research centres of Amazon participating in the co-publications in SCOPUS (if no number: only one publication)

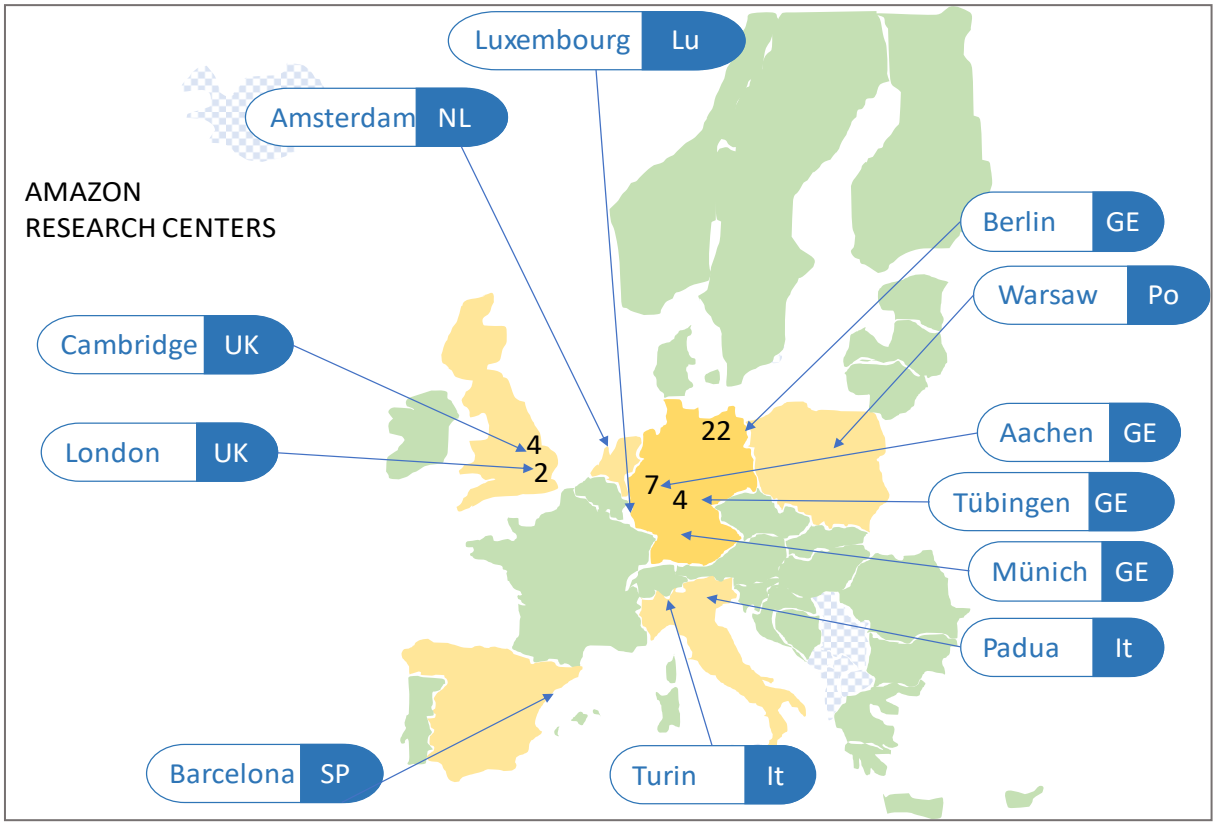
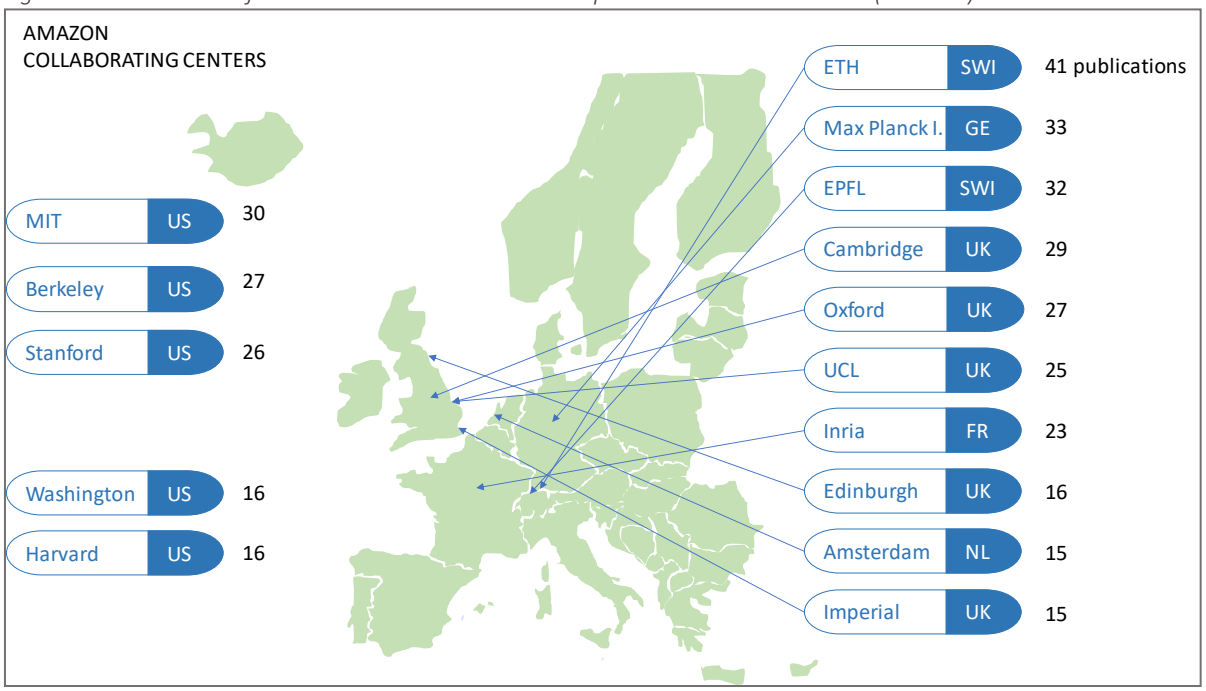


Figure A2b. Overview of research centres with most co-publications with Amazon (SCOPUS)



A1. Digital platforms research behaviour: topic analysis

A content analysis of the research co-publications was undertaken to examine the topics the digital platforms are focused on. For the 817 publications, there are 5083 keywords. The phrasing of these keywords is not always consistent, leading to considerable overlap between keywords. If we reduce this overlap, then we still keep 1998 keywords to investigate.

Facebook

In the figure below, overviews are given of the overlap of the keywords between items that Facebook only lists in their led-publications and the publications led by other (non-Facebook) writers. The number of keywords is counted for each of the publications. On average, both types of publications count 6,9 keywords. This is probably due to the maximum amount of keywords in the publications.

Figure A3: Overlap in keywords in the co-publications (SCOPUS)

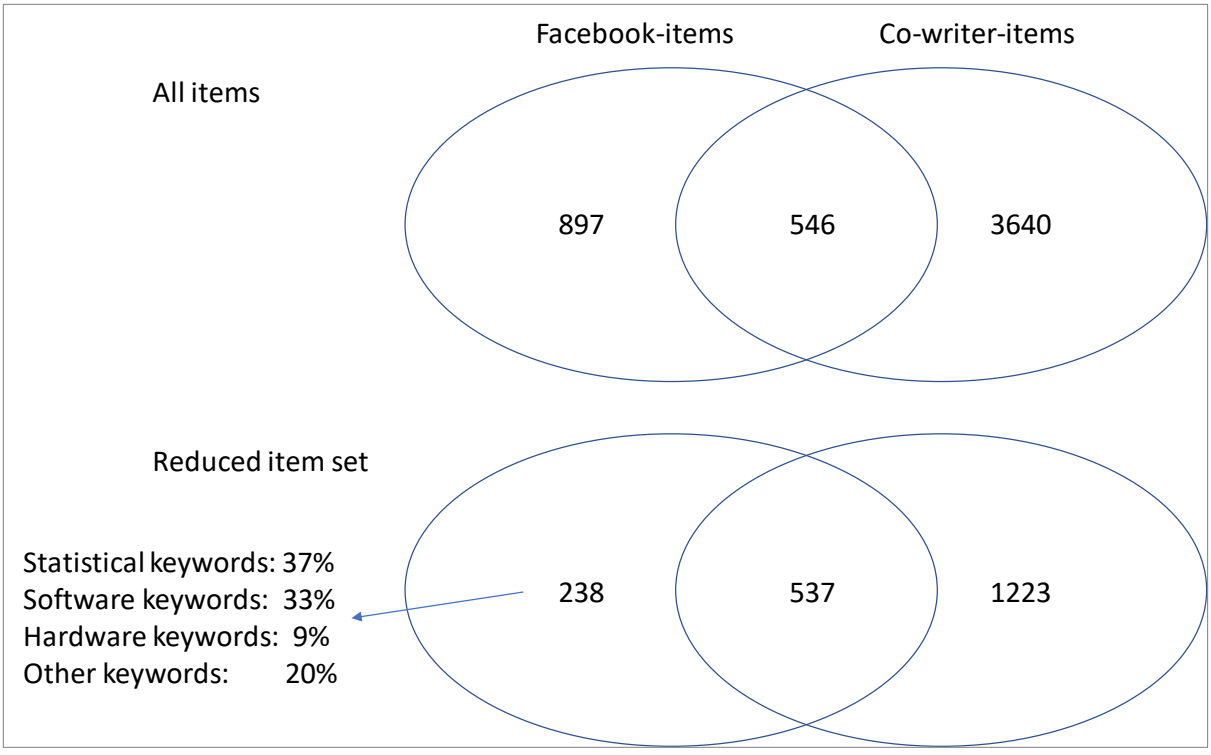


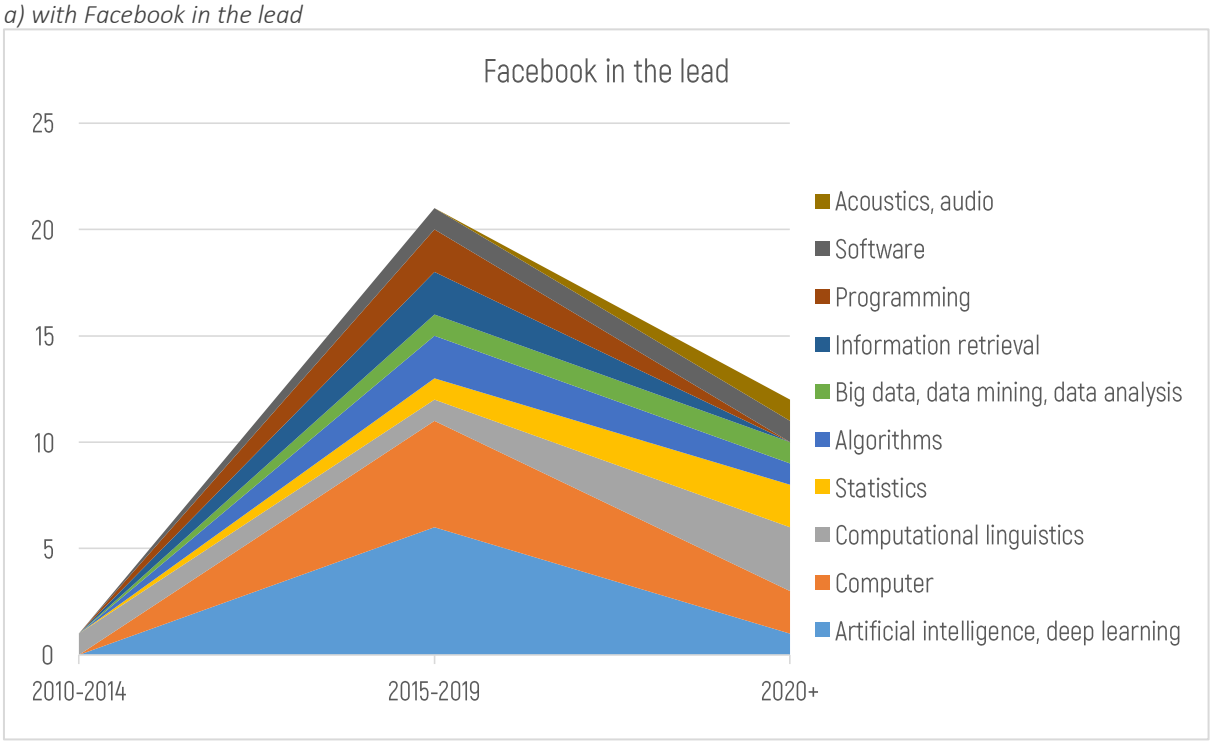
Figure A3 shows that only 11% of the reduced keyword-list (238) are topics that Facebook has introduced. Most of the keywords are on statistical (algorithmic) topics. A third is software and programming keywords, 9% is on hardware related topics, and 20% is very general, not programming related topics. Most of the topics (61%) are offered by non-Facebook researchers. 27% of the keywords are shared between Facebook and the other groups. The figure does not show that Facebook is giving away a lot of knowledge to the European teams. It seems that Facebook is more at the receiving end: a great number of keywords are shared with

the Facebook teams. Facebook is not so much driving the research itself but more following the European research efforts that are central to the publications.

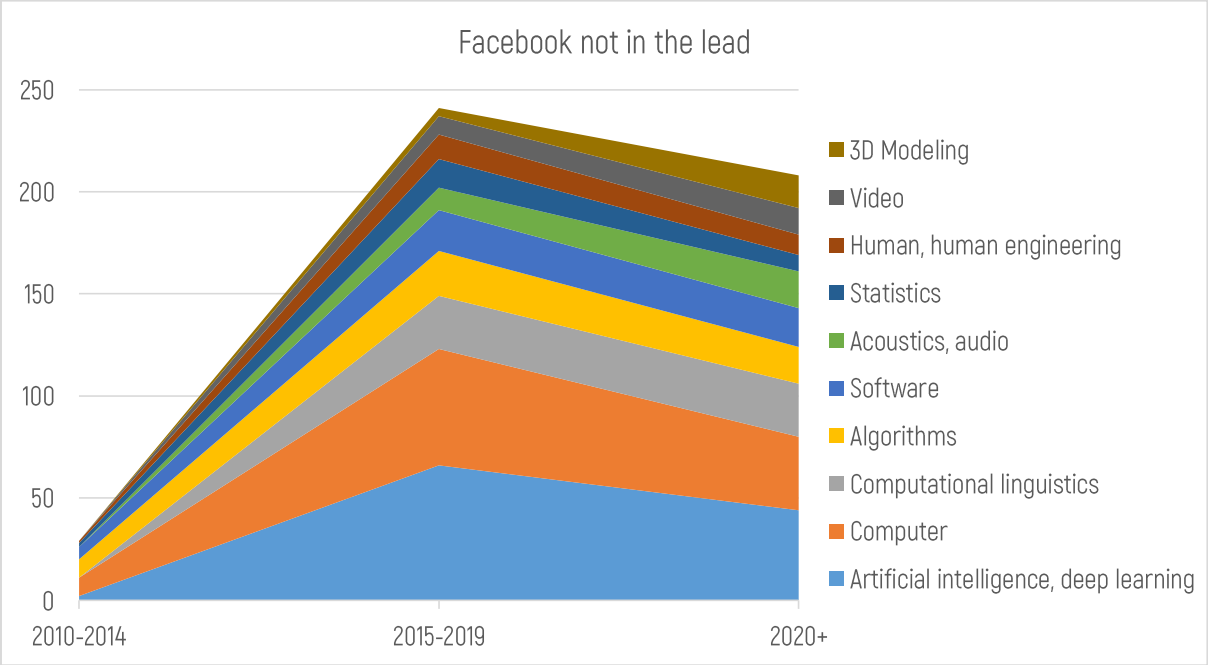
A separate question in this analysis is which topics are taken-up in the co-publications. For each publication, the authors could list a certain number of INDEX KEYWORDS. One publication counted over 93 keywords. The analysis is limited to the first keyword, as this will be the core topic. The 5000+ publications show an enormous number of topics. These topics have been reduced to forty topics. Our main interest is to identify which topics are of interest for the platform companies as lead author and if there is a difference in topics indicated by other lead authors.

The following figures compare the main topics that Facebook has listed in its INDEX KEYWORDS. The left figure shows the (first) keyword for publications where Facebook was lead author, and the second one for the remaining publications.

Figure A4: Main topic in the publications:
a) with Facebook in the lead



b) with Facebook not in the lead (SCOPUS)



The ten topics with Facebook (34 publications) in the lead account for 87% of the topics listed. For the remaining publications (478 publications), the ten topics represent 71% of the topics. The Facebook-publications are focused on AI, computer technology, computational linguistics and statistical/mathematical topics. The differences with the remaining publications are however limited. The only topic that these publications have as different is on human topics (person related issues). Both publications seek to solve (software) technical questions. Algorithms, technical computer issues, and computational linguistics are quite prominent in both lists. The figures shows that Facebook does profit from (software) technical expertise that is developed in the remaining publications.

Amazon

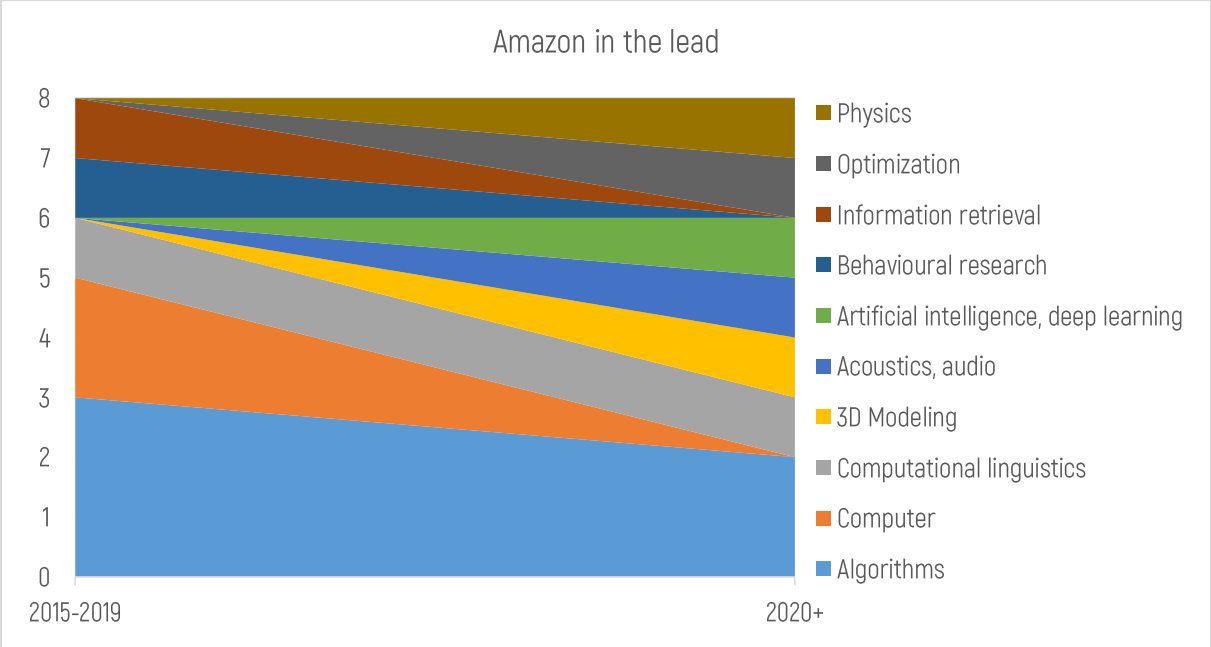
The topics that Amazon is interested in are included in Table A2. Most of the topics are very technical, statistical or dealing with AI-topics. The topics show that the publications are relevant for the knowledge development of Amazon.

Table A2: Count of topics in Amazon-led co-publications (SCOPUS)

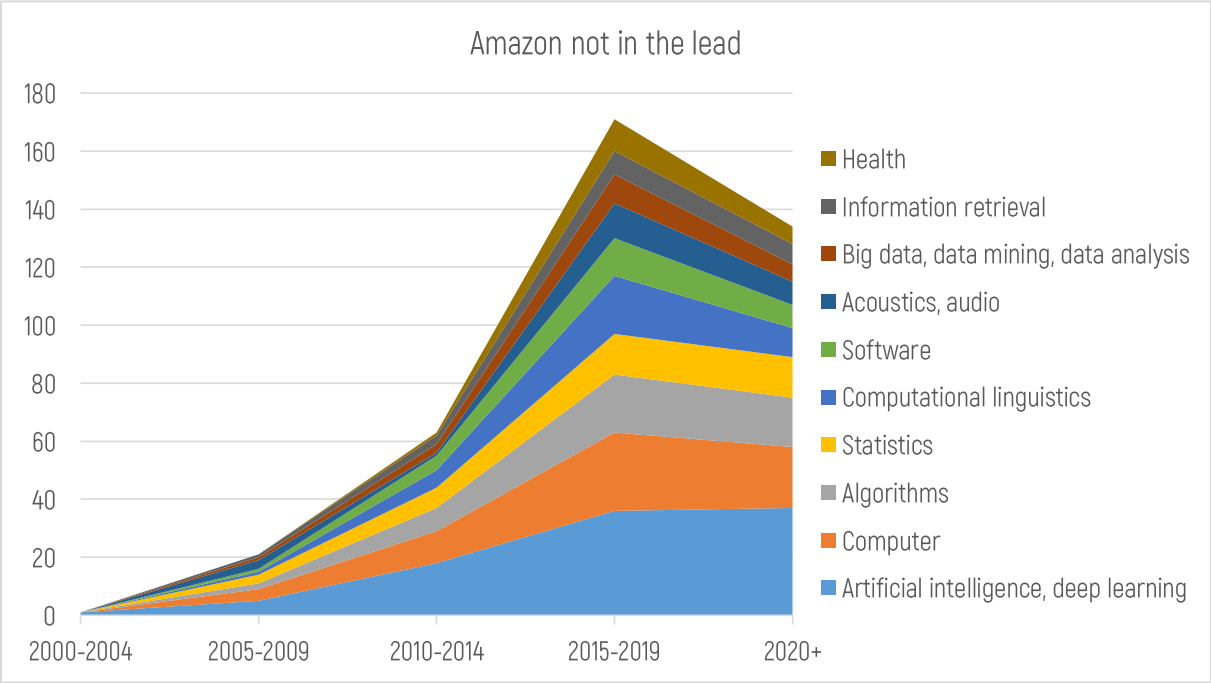
Count	Topic	Examples		
5	Operational	Problem-solving	Benchmarking	Quality assessment
8	Human	Intelligent behaviour	Personality traits	Sex-specific differences
12	Languages	Computer-aided language translation	Computational linguistics	Language pairs
13	Mobility solutions	Roads and streets	Urban change detection	Air navigation, Autonomous vehicle navigation
17	Software	Information management	Large dataset	Open-source software
37	A.I.	Convolutional neural networks	Deep learning	Evolutionary algorithms
57	Statistics	Probability density function	Recurrent models	Tree hub problem, Trees (mathematics)
60	Technical	Loudspeakers	High-quality video	Optical motion capture

The following figures compare the main topics that Amazon has listed in its INDEX KEYWORDS. The left figure shows the (first) keyword for publications where Amazon was lead author, and the second one for the remaining publications.

Figure A5: Main topic in the publications:
a) with Amazon in the lead



b) with Amazon not in the lead (SCOPUS)



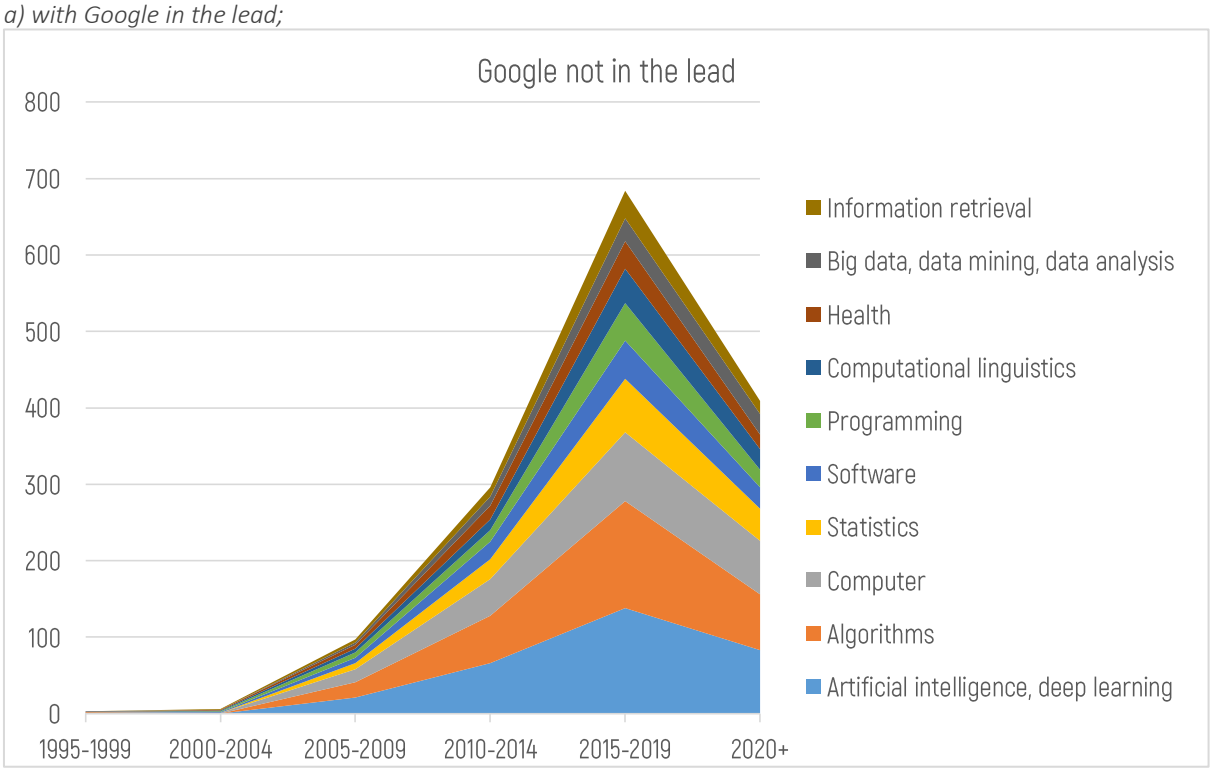
The ten topics with Amazon (16) in the lead account for 89% of the topics listed. For the remaining publications (390), the ten topics represent 70% of the topics. The Amazon-publications are more focused, but the analysis is restricted to a small number of publications. In comparing both list, the main differences are that Amazon is not so much dealing with statistics/mathematical issues, data issues or health issues. Amazon seem to be looking at very technical topics, except for the behavioral research topics. Algorithms, technical computer

issues, and computational linguistics are quite prominent in both lists. The figures shows that Amazon does profit from technical expertise that is developed in the remaining publications.

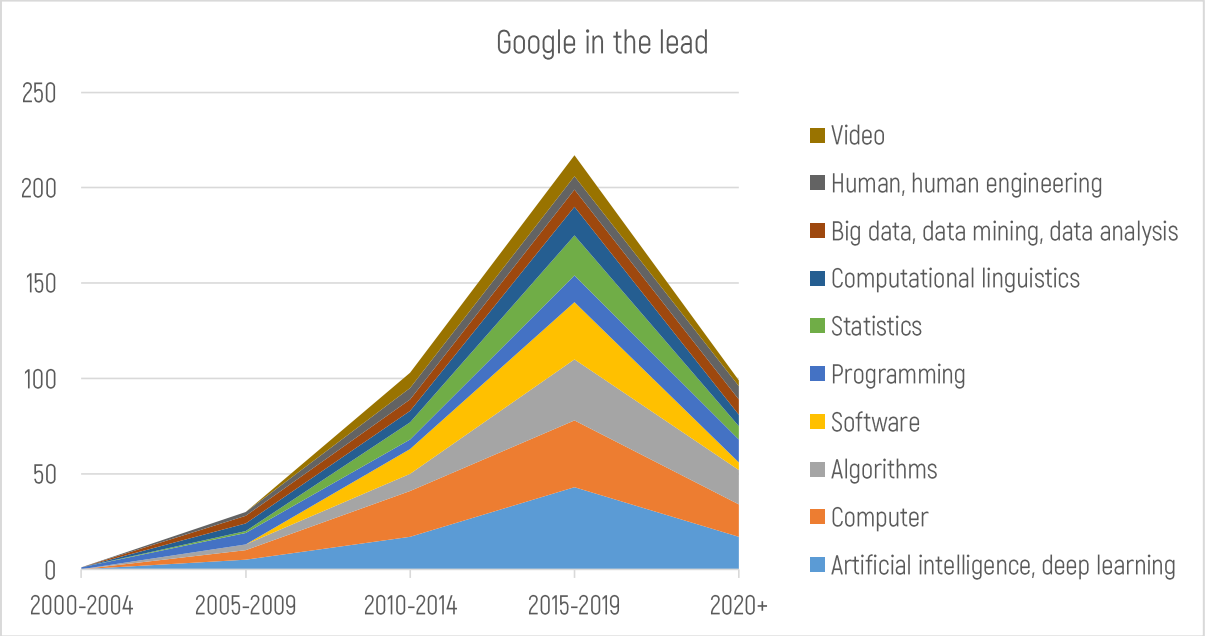
Google/Alphabet

The following figures compare the main topics that Google has listed in its INDEX KEYWORDS. Google has a far greater number of publications that allows us to have some better perspective on the development of topics Google is interested in.

Figure A6: Main topic in the publications:
a) with Google in the lead;



b) with Google not in the lead (SCOPUS)

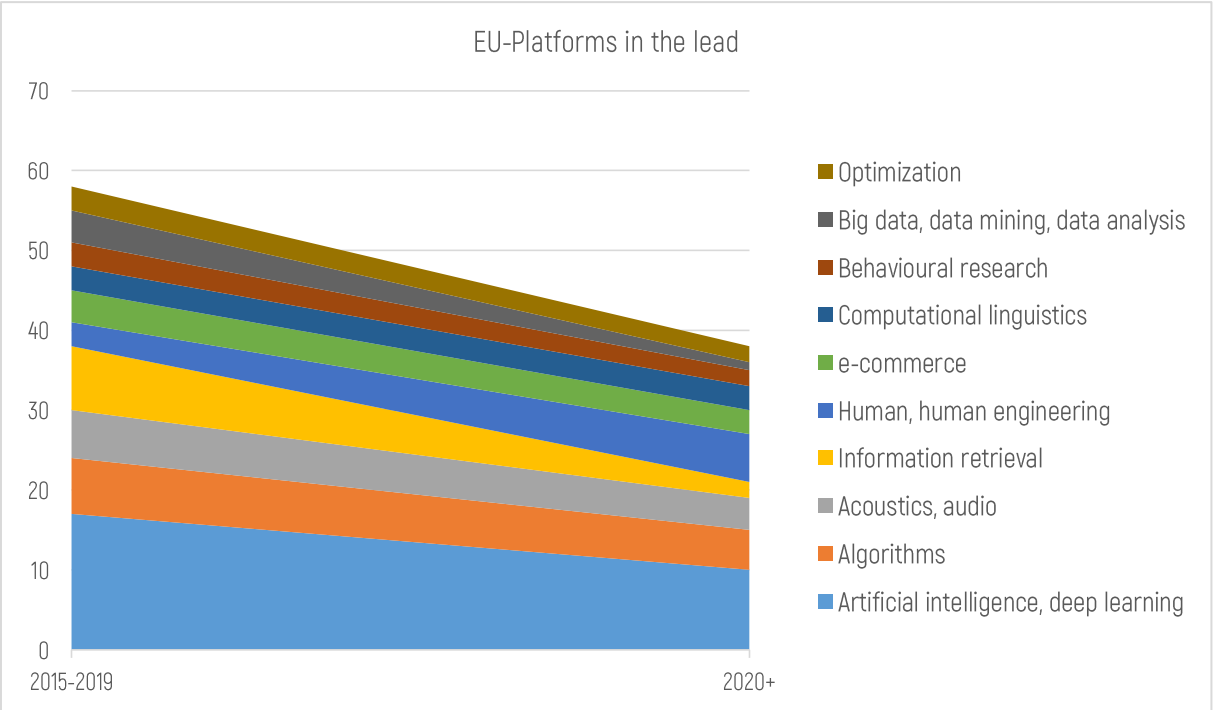


The ten topics with Google (450 publications) in the lead account for 69% of the topics listed. For the remaining publications (1495 publications), the ten topics represent 67% of the topics. Compared to Facebook and Amazon figures, the Google led publications are more diverse in topic. Google is, as with the Facebook and Amazon figures, interested in AI, computer technology and algorithms. The other topics seem to have a declining interest from the direct Google-research. In the non-Google led publications, there is also an interest in health-related topics (mainly how to use AI for health topics). The growing number of publication is in both graphs directed at AI, algorithms and computer technology. Google relies on both sources for this kind of knowledge development.

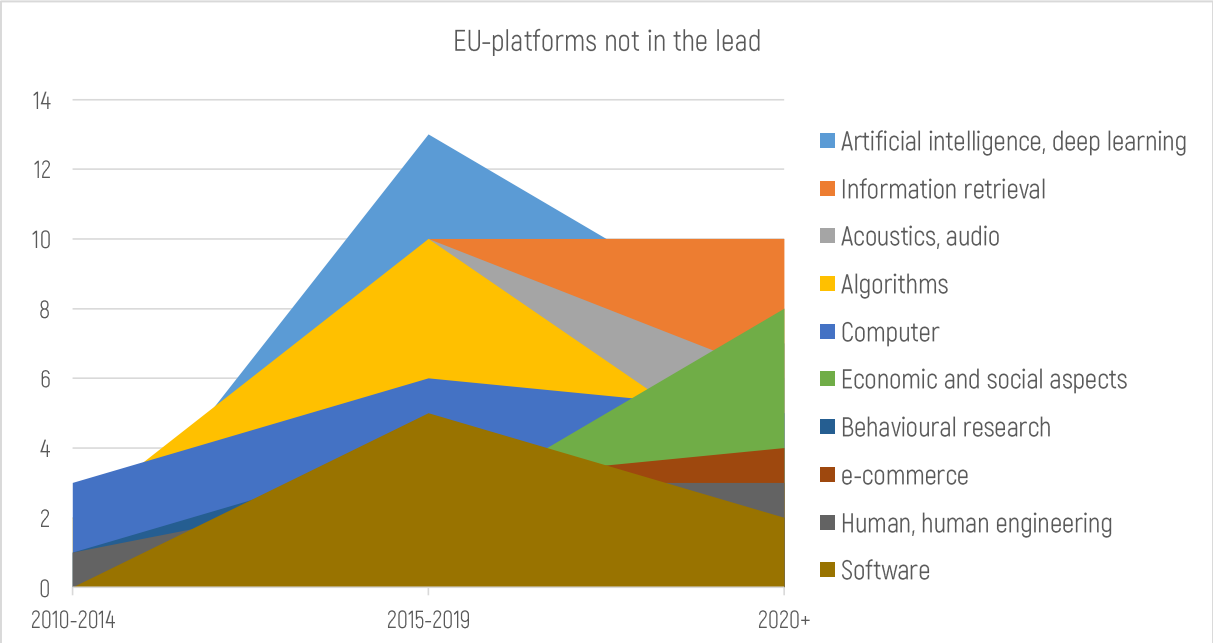
EU-platforms

The following figures compare the main topics that the five EU-platforms have listed in its INDEX KEYWORDS. EU-platform led research only started after 2015. This distorts the figures somewhat.

Figure A7: Main topic in the publications:
a) with EU Platforms in the lead;



b) with EU Platforms not in the lead (SCOPUS)



The ten topics with the EU-platforms (96 publications) in the lead account for 77% of the topics listed. For the remaining publications (123 publications), the ten topics represent 66% of the topics. As with Facebook and Amazon, the number of topics is more limited than when looked at the remaining publications. Compared to US-platforms, the main differences in topics are the interest of these platforms in e-commerce, behavioural research, but also in economic and social aspects. Social issues take an important place in the co-publications after 2020.

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