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CAN **PLATFORM-SUPPORTED DIGITALISATION RAISE THE PRODUCTIVITY** OF EUROPEAN FIRMS

A Non-Technical Presentation of:
"Technology Equalizers: How Digital Platforms Level the Playing Field for Small Firms"

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JULY 2024

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EXECUTIVE SUMMARY

This report provides the context and non-technical explanation and results of the accompanying research paper: "Technology Equalizers: How Digital Platforms Level the Playing Field For Small Firms," by Luis Garicano, Juan Santaló and Christoph Weiss.

The material covered is the same with three differences: here we draw more extensively the policy environment and policy lessons; we only briefly refer to the theory; and we discuss much more extensively the illustrative examples from five business functions.

Systematic description and classification of gains. With the aim to understand better how platforms have affected firm productivity, we analyse five primary functions that small businesses perform: Human Resources ("HR"), Marketing, Customer Relationship Management ("CRM"), Information Technology ("IT") and Procurement. We describe and quantify, using illustrative examples, the potential gains from platform usage in each of these functions. In the different cases we describe how platforms optimise the processes within the business by automating some functions (e.g., market analytics) and integrating artificial intelligence ("AI") tools. We explain how they produce marketplace benefits by increasing the effective market size and allowing for better matching, either between workers and firms or between consumers and producers. Cost savings from digital platform tools used in just a few select business processes amounted to 5% of the revenue for a €2,000,000 revenue company. The cost savings from performing each of these selected tasks varied between 24% and 67%. We consider this illustrative calculation to be conservative, as it does not take into account all processes subject to platform digitalisation and abstracts from the gains due to reductions in informational asymmetries and in enforcing and completing contracts.

Data.
We use data from the European Investment Bank Investment Survey ("EIBIS"), an annual semi-panel survey of around 12,000 European Union ("EU") non-financial corporations conducted since 2016. EIBIS is a unique dataset measuring firm-level adoption of modern digital platforms over time. A new module on technology adoption was introduced in 2019, where firms are asked about the use and use intensity of advanced digital technologies that are specific to their sector.

Digital platforms allow smaller firms to contract the IT investments of larger firms, and enjoy, through the platforms, the benefits of the AI and big data revolution.

Findings.

Consistently with our results from the analysis at the business function level, we document a systematic positive correlation between platform adoption and labour productivity across firms within industry/country categories. This correlation is higher for smaller firms. On average, platform adoption is associated with an increase in labour productivity between 3.6% and 5.3%. For smaller firms, platform adoption is associated with an increase of labour productivity between 6.4% and 10.5%. These results hold after accounting for endogeneity bias, which suggests a causal relationship between platform adoption and productivity. Furthermore, the adoption of new technologies is positively associated with a higher probability of becoming an exporter in the next year with a mitigated effect for larger firms, a result consistent with the (heterogeneous) increases in productivity driven by platform use extending firm's market reach.

We conclude that the gains of digital platforms are particularly valuable for smaller firms. Digital platforms reduce the requirements for successful digitalisation by not only eliminating the large capital investment required to build "in-house" solutions, but also reducing the needs for complementary investments in human capital and managerial skills required to maintain and manage those solutions. Digital platforms allow smaller firms to contract the IT investments of larger firms, and enjoy, through the platforms, the benefits of the AI and big data revolution. The recent report by Enrico Letta points out the importance of achieving a large scale, continental single market in Europe to provide scale and efficiency to European firms.[1] Certainly, in a world where large IT investments matter, scale is essential. However, a complementary path is also possible: ensuring that small firms also have access to markets and technologies (particularly AI technology) that provide new firms the space to grow.

I.
CONTEXT: DIGITISATION AND PRODUCTIVITY

In this report, we present the results of the analysis in our paper **"Technology Equalizers: How Digital Platforms Level the Playing Field for Small Firms"** (with our coauthor Christoph Weiss)[2] and extract policy conclusions from it. The paper develops a simple theory and uses novel data to study the impact of internet platform technologies on the productivity of firms.

The authors are grateful to the Center for the Governance of Change at IE University for organising a meeting on June 25, 2024 to present their findings and discuss them with a group of leaders from the public, private, and academic sectors. This meeting helped the authors contextualise and refine their conclusions. The authors' gratitude is extended to all the participants of the discussion[3] for their valuable insights and thought-provoking contributions.

Some of the largest platform businesses are being scrutinised for their clout and possible anti-competitive conduct—indeed the EU has developed two sets of tools, developed in the Digital Markets Act and the Digital Service Act, to ensure that their conduct is pro-competitive and that online environments are safe for users. But this legitimate discussion does not detract from the question we study here—whether platform tools may have a significant effect on productivity, in particular among small businesses.

The EU has placed its hopes for future productivity growth on increasing the digitalisation of EU firms.[4] Indeed, digitalisation supports productivity growth by improving and systematising business processes, automating certain routine tasks, and reducing the costs of interacting with suppliers and customers. Connectivity and information processing also facilitate new data insights, opening the door for increased process optimisation.[5] Real-time tracking technology allows rapid adjustments to performance indicators. Verification and authentication technologies reduce some of the risks associated with contracting and so promote more efficient contracts.[6] These technologies as well as rating systems decrease the risk of contracting from unknown suppliers or in new markets where the contracting party has less relationships.

However, the opportunities brought about by digital technologies are not translating into the expected improvements in productivity at aggregate level. Since the 1990s, researchers noted the simultaneous occurrence of a fast pace of innovation in digital technologies and a lacklustre productivity performance of many development economies. They have referred to a "productivity paradox".[7] Across developed economies, instead of a general increase in productivity brought about by new technologies, we appear to be experiencing increasing levels of dispersion in firm-level productivity both in the United States ("US") and Europe.[8] Increases in productivity from the adoption of digital technologies have so far been more prevalent in those sectors where the production in more intensely based on routine tasks.[9] [10]

The full benefits of digitalisation appear to require business process redesign and organisation.

Part of the reason for this difficult path from digitalisation to productivity may be that successful digitalisation requires certain organisational capabilities, skills, capital investment, and scale.

First, the full benefits of digitalisation appear to require business process redesign and organisation. For example, an empirical assessment of the digitalisation of policy departments in the US found that computerisation and adoption of data management packages improved law enforcement only where processes were put in place to contribute, incorporate, and act upon the metrics obtained from data processing.[11] Adopting digital technologies seems to be more beneficial for firms that have made complementary investments in intangible assets such as managerial skills or organisational capability.[12] Examples of superior organisational capabilities include the ability to implement decentralised decision-making systems, job training, and effective business process redesign.[13] People management practices including selection, incentives and worker empowerment are particularly relevant to fully leverage the benefits of digital technologies.[14] Empirical studies consistently identify the productive complementarity between digital technologies and other intangible determinants of firm-level productivity, a finding that seems to apply across a variety of digital technologies.[15] Another empirical study found that the adoption of electronic medical records in US hospitals only decreased costs in those hospitals that had previous experience in adopting new processes or were in regions with a high level of business process innovation, proxied by the local intensity of Information and Communication Technology ("ICT") skills.[16] The type of transformation depends on the type of tools being used—survey evidences on US and European firms found that the adoption of data and information processing tools such as enterprise resource planning solutions ("ERP") or Computer-Aided Design/Computer-Aided Manufacturing ("CAD"/"CAM") facilitate decentralised decision making, while improvements in communications networks support centralised coordination.[17] [18] The complementarity between adoption of technology and intangible assets explains the finding that digitalisation generally appears to benefit the most those firms that are already the most productive.[19]

Skill shortages, including both ICT and managerial skills, decrease the productivity gain from adopting digital technologies such as CRM tools or cloud computing.[20] In contrast, access to skills and other intangible assets appear to magnify the impact of investment in digital technologies.[21]

Concerning capital, a growing literature argues that the large scale of the investments required in IT are part of the reason we see increasing firm sizes and concentration. Hsieh and Rossi-Hansberg (2023) found that IT has sparked a service sector revolution by enabling economies of scale and geographic expansion.[22] Aghion et al. (2023) suggested that reduced overhead costs and efficiency gains in large firms drive increased market concentration, leading these firms to diversify into new product lines.[23] De Ridder (2024) also linked the rise in intangible assets to higher market concentration and reduced business dynamism, as intangibles lower marginal costs and increase fixed costs, thereby offering competitive advantages to firms heavily invested in intangibles.[24]

Institutions also matter. Survey data indicates that a substantial percentage of small and medium sized firms perceive labour market regulations, business regulations, taxation, and access to finance as representing obstacles to investment in digital technologies.[25] Labour market flexibility, competitive pressures, and the availability of risk capital have been shown to increase incentives

to invest in digital technologies as well as to increase the benefits of adoption of technologies such cloud computing or integrated processes.[26] Evidence shows that catching up in digitalisation seems to be correlated with pro-competitive market reforms: those sectors that saw the least product market reforms were those where firms found it more difficult to catch up on technology.[27]

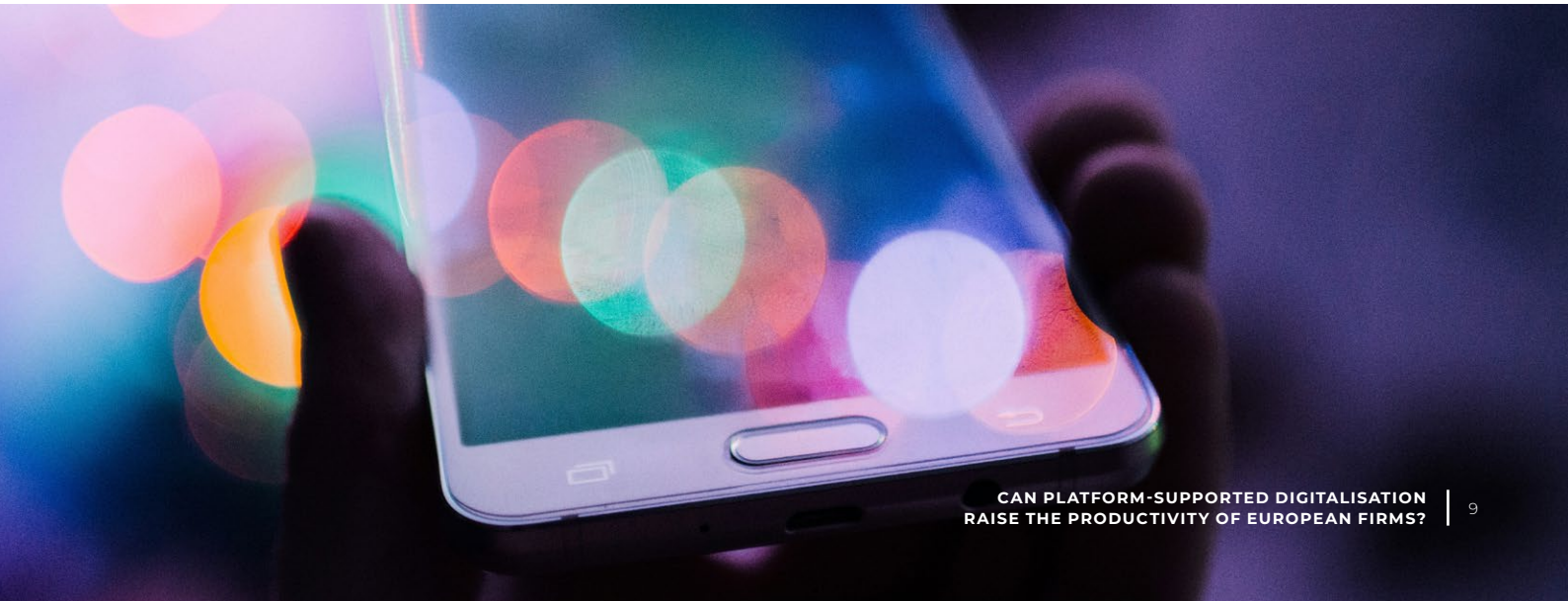
Differences in capabilities and incentives explain the wide disparity in the adoption of digital technologies across firms, industries, and countries. A combination of these factors helps explain why adoption of cloud computing among firms over 10 employees is three times larger in Finland than in Poland in 2016.[28]

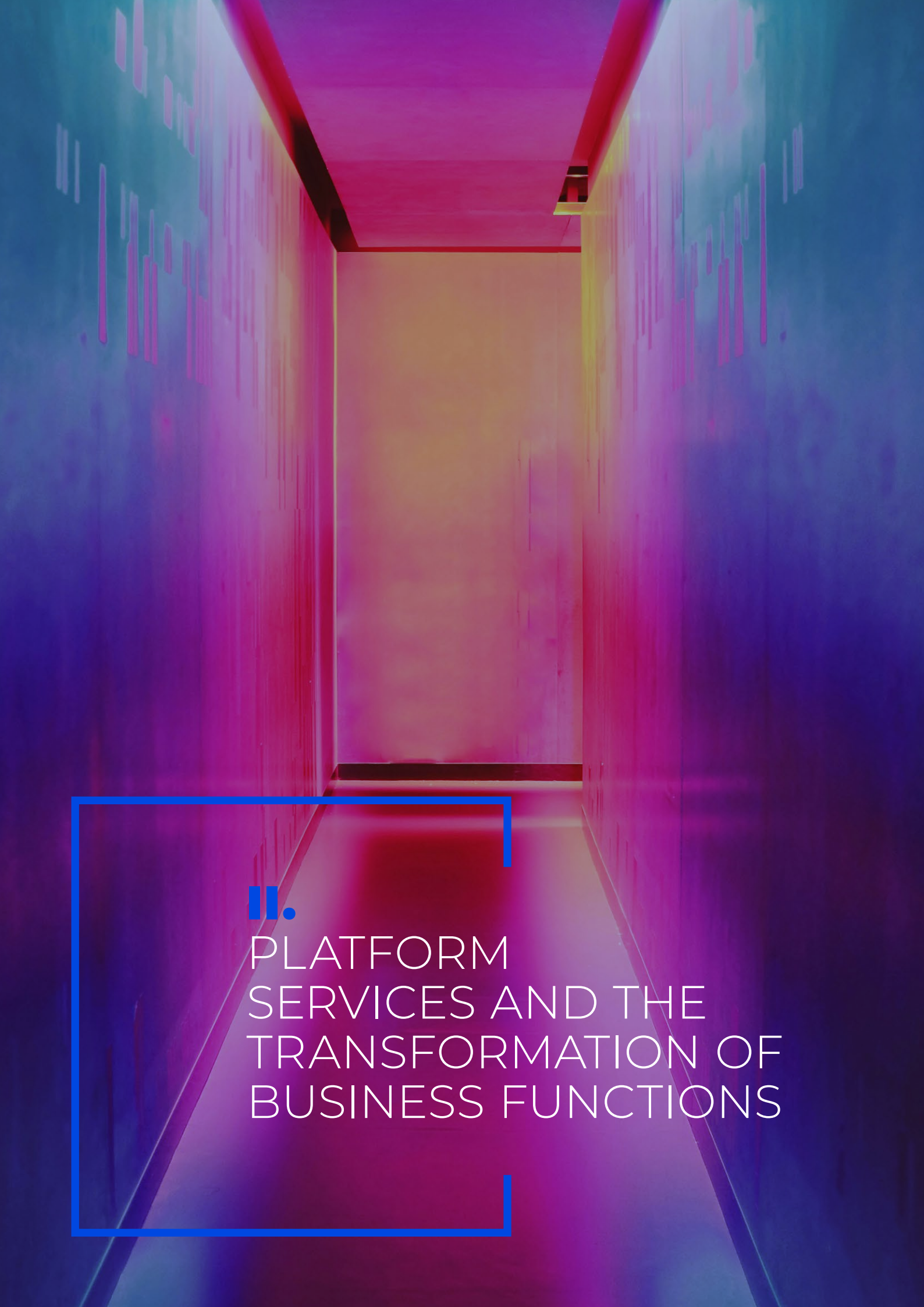
In turn, the disparity in the adoption and benefits from digitalisation creates a widening gap in firm-level productivity dragging down aggregate productivity growth.[29] High performing firms at the edge of the technology frontier are increasingly outperforming a larger group of lower performing laggards in the same industry.[30] The gap between high and low performing firms is larger in highly digitalised industries so that the effect of technology diffusion is not only insufficient to lift the laggards but increases their disadvantage.[31]

This increase in productivity dispersion is economically costly as industries exhibiting a wider dispersion in productivity performance tend to exhibit weaker aggregate productivity growth.[32]

There is one way to digitalise that does not require large capital investment—the usage of platform technologies. Previous literature has hypothesised that platform based digitalisation may facilitate productivity gains by small firms given the possibility of avoiding fixed capital investment.[33] For instance, evidence shows that they particularly benefit from services such as cloud computing as they are able to avoid investing in costly data storage and processing facilities.[34] Some digital technology tools and services allow small firms to acquire "scale without mass".[35] Digital tools or technologies with higher adoptions costs in terms of complementary skills exhibit an overall lower level of adoption. For example, in 2016, 48% of European firms over 10 employees used social media tools while only 12.2% used big data analytics.[36]

In what follows, we discuss how platform technologies may reduce transaction (and production) costs and how the changes they bring about may be particularly beneficial to smaller firms.





II.
PLATFORM SERVICES AND THE TRANSFORMATION OF BUSINESS FUNCTIONS

Platform services are services layered on top of the internet protocol connecting many to many economic agents. Internet allows for almost unlimited interconnections and transmission of data. It has given rise to a variety of businesses that facilitate and structure interactions between different types of users for mutually beneficial communications and exchanges. Platform organisations initially connected users to users for the sharing of personal content or Customer to Customer listings. They then connected businesses to users for the sale of contents, goods, and services. From there, they have evolved into sophisticated operations providing a variety of complex services and using cutting-edge digital technologies to structure information sharing and communications between employees, customers, job applicants, sellers, and even other service providers.

According to the European Commission, there were 10,000 online platforms in 2020 in the EU.[37] They offer a broad range of services.[38]

There is a vast literature documenting the economics of platform-based digital services.[39] Here, we are concerned with one aspect: how platform-based services improve firm's productivity.

We discuss this next.

A. FIXED VERSUS VARIABLE COST TECHNOLOGIES

In Garicano et al. (2024) we propose a simple framework to study the choice and impact of platform technologies on productivity that focuses on firms with varying productivity choosing between outsourcing (lower fixed costs, higher variable costs) and insourcing (higher fixed costs, lower variable costs).[40] We show that firms above a productivity threshold insource, while those below outsource. This is because insourcing reduces variable costs by building capabilities, which is only beneficial for more productive, larger firms. Outsourcing leverages external services, raising variable costs but reducing initial investments. We also show that reduced outsourcing costs via platform technologies increase productivity, lower prices, boost output and profits for smaller firms, and raise the insourcing productivity threshold.

We also extend the analysis to consider stochastic demand. When demand is variable (for instance due to seasonality or to unpredictable factors), fixed costs remain while variable costs are avoided. High fixed investments lead to excess capacity during low demand. In this case, platform technology enables small firms to scale production efficiently, making them more resilient to demand fluctuations. We show theoretically that the value of platform technology rises with the likelihood of demand shocks, increasing the number of firms that choose outsourcing as the probability of negative demand shocks grows.

B. SOURCES OF COST REDUCTIONS

Platforms are not new: physical platforms have been meeting places for centuries. To understand the impact of an internet platform on the cost of making transactions, with a platform owner in charge of designing the marketplace, it is useful to consider by analogy the example of Medieval Fairs, discussed by Fishman and Sullivan (2016) in an HBR article.[41] The count of Champagne designed, starting in 1180 AD, a medieval fair that became "the fulcrum of European trade":

> "The count of Champagne was, in his medieval way, a pioneer in market design. The count intuited the central role he played as a market maker: inviting the right sorts of participants (and more importantly, keeping the wrong sorts away), setting the rules, and punishing transgressors, ensuring a safe and reliable place that was much valued by merchants in a medieval Europe that was fraught with peril."[42]

Modern market designers also decrease the cost of transacting. We classify the reductions in the cost of making transactions obtained through the usage of internet platforms in four categories: improvements in the process (so that the same transaction costs less); improvements in the market reach and functioning (so that new transactions can take place that would not have happened absent the platform); reductions in incentive costs (informational asymmetries) and improvements in contracting.[43]

1. Process Improvements

The benefits from more efficient processes derive from the nature of digital technologies, which have dramatically decreased the cost of interconnecting different actors as well as of collecting, processing, and transmitting information. Processes that required repetitive labour can be automated and simplified.

The largest process improvement is a consequence of the ability of internet platforms to introduce AI tools. The integration of powerful data analytics, machine learning, and generative AI allows digital services that can perform abstract activities such as problem-solving, decision making, and content creation. These activities can vary between AI-based customer management or content proofreading to a simple automated tool for creating logos. The response to many queries can be automated. Workers who are most adept in these tasks typically have high levels of education and analytical capability.[44] Platform services are turning these abstract tasks into routine processes for the firm. Lower levels of skills are needed to operate the user-friendly interfaces found in these services. This may have a significant impact on the level of adoption of digital tools and on productivity increase of small and medium-sized firms.

2. Marketplace Benefits: Increased Marketplace Reach and Efficiency

Internet platforms allow for the same transaction to be undertaken at a lower cost—a process improvement. But they also allow for transactions that would not have taken place otherwise. By expanding marketplace reach and improving matching efficiency, they reduce search costs, enabling parties to find each other who otherwise would not have connected.

Distance matters less for users of digital platforms as they can discover and engage with remote suppliers and purchase from them. A study found that the impact of distance on trade was 35% lower on eBay transactions compared to total international trade flows.[45] More broadly, platforms lower search costs, which results in more efficient matching. In part because of the network effects attracting a large number of users to a single marketplace, successful platforms reduce the cost of gathering information about potential products or counterparts. Platform services usually have a process to organise information and produce matched search results of higher quality for the user. Evidence from the used book[46] and music markets[47] suggest that reducing search costs increases the demand and prices for unusual items as these are more likely to be matched to the consumers who value them. A review of the evidence found that *"digitization reduces the cost of bringing new products to market in music, movies books and television. On balance, digitization has increased the number of new products that are created and made available to consumers."*[48] Also, the expansion of online search services has been associated with lower vacancy rates in rental units markets.[49] Location services on maps or social network services offer new effective ways for consumers to discover businesses and for businesses to attract consumers at the right time.

This is also true for talent. Platforms facilitate access to a global talent pool. A firm in any remote location can access first rate programmers, marketers or engineers at cost that is affordable even for smaller firms. Online job boards help locate specialised skills. An empirical study based on US data found that firms hire outside of their local markets to find specialised skills.[50] The study revealed that US cities with earlier access to online recruitment experienced an increase in migration flows in and out of the city accompanied by an increase in wages.

3. Reduction in Opportunism

The platform owner manages the positive and negative spillovers from interactions on the marketplace. Like the count of Champaign, a platform performs the functions of the regulator of their marketplace,[51] facilitating good behaviour and punishing opportunism, attracting the key sellers and buyers. For instance, platforms adopt pricing strategies and other design solutions to attract the type and quantity of users needed to ensure trade counterparties show up.[52] For example, a marketplace platform offers discounts to the type of users that may be harder to bring on the platform but are attractive to counterparties who value the platform service more. Similarly, traffic and navigation apps have used gamification strategies to attract and retain users and prompt them to provide traffic information that improves the service for everyone.[53] The harnessing and proper management of incentives by the platform services translates into positive network effects that benefit businesses who sell or advertise on them (as well as the platform owner) as it increases the users they can usefully reach.

Platforms reduce the cost of asymmetric infomation deterring users from engaging with unfamiliar businesses. Digital platforms have developed tools to convey information relating to the performance of businesses, in a simple manner, to potential clients. Ratings and user reviews are the most popular of such tools. They have increased the ability of small businesses to attract new customers without having to reach the level of popularity needed for a recognised brand.[54] Online restaurant reviews on Yelp have been shown to increase demand and revenue for independent restaurants while no effect of ratings was found for established chains.[55] Similar results are found for the case of hotels, with online reputation mechanisms being linked to a decrease in the premium obtained by chain-affiliated hotels.[56] Authentication technology adopted by platforms has also increased the amount of trust in digital services.

4. Improvements in Contracting Effectiveness and Completeness

Platforms offer standardised contracts and terms of service and reduce the costs of bargaining and enforcing the contract. Often these include dispute resolution mechanisms that protect both parties against non-performance by the other side—as in the case of AirBnB between hosts and guests.

C. ILLUSTRATIVE EVIDENCE ON PRODUCTIVITY GAINS OF PLATFORM ENABLED DIGITALISATION

This section illustrates the benefits of platform service enabled digitalisation for small firms as described above across several business functions. We consider five primary functions that most, if not all, small businesses perform: Human Resources, Marketing, Customer Relations, Information Technology and Procurement. For each business function, we describe the benefits that small firms can reap from using digital platform services. To better understand how platforms affected business functions, we had some conversations with founders, managers, or head of departments of both large and small businesses. In our discussions, we focused on France as an illustrative European country. Note that the presence of network effects means that some of these services are provided by only a few platform owners. Our approach takes the pricing as given and aims to help us think of the consumer surplus at *current prices*, compared to a world without platforms. A full welfare calculation would require adding the benefit to the platform owner and to those on the other side of the market (e.g. final consumers) as well as the welfare losses potentially associated with the platform owner's market power.[57]

1. Human Resources

Human Resources departments usually take care of functions related to recruiting new employees, performance reviews, promotions, training and administration of payroll and benefits. The importance of good HR practices has been documented in the literature. There is evidence of a relationship between robust HR practices and lower employee turnover,[58] better employer brand,[59] sales growth,[60] customer satisfaction,[61] and labour productivity.[62] The recent digitalisation also brough several improvements in terms of cost efficiency and productivity.[63]

In what follows, we analyse in more detail the impact of HR platform solutions on the recruitment function in small businesses.

a. Process Improvements

With the advent of digital platforms, most, if not all, functions related to HR were transformed. The new platforms have created new ways in which HR activities can be organised. For example, processes like payroll and benefits that once were repetitive and required significant human input have become automated and streamlined with digital document management tools. This is also the case of recruitment, performance monitoring, and management reviews which are now automated with lean standardised processes, efficient information sharing, and easy to use interfaces that reduce the administrative burden and managerial time. In all these cases, employees are put in greater control of their side of the process, for example by managing their benefits, encoding their time-off, or filing reviews. HR digital platforms allow the efficient conversion of fixed costs into variable costs. Without digital platforms, HR functions were performed by an HR department, even in cases where the number of employees was relatively small. Digital platforms, however, charge fees based on the number of users (i.e., employees) which creates more flexibility and control over the firm's cost structure.

Recruitment platforms are commonly integrated with other platforms, including other recruiting platforms, HR management tools, or even social media tools. These interconnections increase the platform's own reach but also allows it to offer integrated services to companies, such as the management of the whole recruitment process or additional HR functions.

b. Improvement in the Marketplace Reach and Efficiency

Before platforms, recruitment was done through either recruiting agencies or internally by posting job ads on the company website, newspapers or through personal networks. The emergence of platforms brought new reach and capabilities to the recruiting teams, as well as to the candidates. Firms are not limited to local labour markets anymore, and they can reach a much broader, yet specialised pool of potential candidates. In addition, platform services allow them to better present the company to job-seekers, improving the likelihood and quality of a match s. Employees also benefit fromdigital platforms as online job search has been associated with reduced unemployment spells and salary growth.[64]

There are several platforms that businesses can utilise in their recruitment activity. Some allow recruiters to post job openings and reach out to a big pool of potential candidates. Platforms can filter applicants across numerous profiles based on, inter alia, location, education, or past work experience to increase the candidate fit. Platforms have brought several innovations such as the ability of workers to signal they are "open to work" even though not searching, or the use of analytics to optimise the response rates of candidates and improve the efficiency of the recruitment process.

Recruitment platforms are differentiated. Some provide lower capabilities with their base service delivered free of charge. Others offer a rich set of features and can charge higher fees. Candidate pools across platforms can also vary and different platforms are often used for different types of jobs. For example, platforms like *Indeed* provide a base service that allows companies to post their job opening and scout for the right candidates for free. This option is valued by some as a cost-efficient solution for the search of candidates with more generic skills. The search of more specific types of capabilities may lead businesses to prefer platforms that facilitate more interactions and exchange of information. *Welcome to the Jungle*, for example, is a specialised website for skilled positions in tech and business services that enhances matching by allowing companies to represent their brands with their own pages. The service helps company with content creation, including videos, so that they can share their values and workplace culture in order to attract compatible job seekers. Other recruitment platforms such as *Manatal* base their matching on data analytics and AI. It uses integrations with social media companies to augment a candidate profile and can provide a matching score for candidates for a position. There is research evidence that filtering and AI technologies increase the quality of the match.[65]

c. Illustrative Quantification

The benefits of HR platforms on businesses are many and hard to enumerate and quantify. Welcome to the Jungle is taken as an example of a recruiting platform that attracts qualified professionals and invests in generating the right fit for applicants and recruiters. It is considered a premium service, and costs in the vicinity of €4,500[66] per year.

Obtaining screening capabilities that are comparable to that of a platform (albeit not fully) requires hiring a specialised recruitment agency. Recruiting services can charge approximately 22% of the annual salary of each recruited person or €8,646 for a median salary. The implied approximate cost saving is therefore €4,146 or 48% for the first hire. Hiring more than one employee per year, significantly increases the savings.[67]

2. Marketing

Marketing helps firms to find new customers and increase the potential market of the firm. Marketing includes functions starting from designing a marketing campaign, the execution of the marketing strategy, and ending with the collection and analysis of marketing data. Marketing spending has been shown to be a strong predictor of firm profitability[68] and brand awareness.[69] In addition, the impact of marketing has been shown to be long-lasting,[70] which implies that marketing costs are more akin to long-term investment rather than a current expense.

Digital platforms, and in particular ad tech platforms, have had a large impact on how firms can market their products and services to consumers. Platform services such as Meta Business Manager or Google Ads[71] allow companies to develop their digital marketing strategy from a single platform and reach a large audience.[72] Advertisement through ad tech platforms is paid by ad impressions or ad clicks. The cost per click will vary with the quality of the ad, the platform effectiveness and matching advertisers and potential customers.[73]

a. Process Improvements

Ad tech platforms offer user-friendly tools for creating advertising campaigns: all a businessperson must do is choose the subject, schedule, budget, and format of their ad, which is then generated by the platform. Platforms also provide data relating to the audience that engages with a business' advertising, including data about consumers' subsequent interaction with the businesses' website. The performance analytics from these data are shared with the businesses that use them to improve their contents, websites, and products. Some functions that in the past required the employment of a marketing specialist can now be undertaken by any firm employee, or the founders themselves. For example, market research once required the collection or procurement of data (both internal and external). This data had to be analysed by a professional and the results of the analysis were transmitted to management. Digital platforms generate data, perform the data analytics, and provide clean and user-friendly output for an employee to consider.

Platforms also create much shorter feedback loops from the marketing campaign to the business. Marketing service platforms typically provide live market analytics in the form of performance metrics. In the past, a significant amount of time needed to pass until the business could analyse sales data for evidence of impact. Today digital platforms provide live information on the effectiveness of the marketing campaign, which allows the business to rapidly adjust the parameters of the marketing campaign.

Enterprise solution platforms sometimes integrate with marketing platforms to supply enhanced marketing capabilities. HubSpot Marketing Hub[74] for example uses integrations to offer businesses the possibility of tracking their advertising campaigns across various

online surfaces from one place. Like its competitors, the platform also offers tools for the automatic creation of ads that can be personalised based on company data and data collected in previous campaigns.

Online platforms also offer alternative avenues for marketing. For example, founders and executives often post on their own personal *LinkedIn* account to advertise the company among their vast professional network. Digital marketing strategies can coexist with physical marketing. Advertising in local newspapers, television and even radio is still useful to reach demographics less exposed to digital media (such as the elderly).

> Digital platforms allow businesses to reach potential consumers that would have been otherwise inaccessible.

Since digital platforms operate on the internet protocol, they can reach every user they serve on the internet regardless of physical location. Platforms integrate tools that allow a seamless automatic translation between most of the existing languages in the world, which allows businesses to market their services or products internationally.

Ads can be designed to appeal to a specific target audience based on insights from data collected. Machine learning and AI tools used by digital platforms allow targeted marketing such that the right potential consumer sees the right ad at the right time.[75]

b. Illustrative Quantification

We focus on a very straightforward metric of the cost of digital marketing—the cost per click, which is the cost per user that clicks the ad link to the marketer website. This metric combines both the monetary cost of reaching out to a potential customer and the probability that they perform the action the business desires (like going to their web shop), which can be considered a measurement of the quality of the match. To compare marketing campaigns that are similar in terms of potential reach, we compare the cost per click using a mass email campaign to "cold" leads and marketing using the Meta ads platforms.[76] We calculate the cost per click for an email campaign to be approximately €0.81.[77] We compare it to the cost per click of Meta ads, which approximate cost is €0.47.[78] We assume that once the consumer clicked on the hyperlink, the probability of finalising the deal will be the same whether the hyperlink was clicked in an email or the digital platform.

The documented cost per click using the platform is almost half of what the estimated cost would be using the email campaign. Based on our calculations, the potential cost saved per click on an advertisement from using a platform can be around €0.34 per click equivalent to a cost reduction of 42%.[79]

We do not measure the increase in sales due to the increased market reach effects discussed above. A randomised experiment with 1.6 million customers found a 5% increase in sales caused by online advertising.[80] Another study found that a randomised sample of restaurants that received digital advertising observe on average a 7%–19% increase in a purchase intention outcomes, as well as a 5% increase in customer reviews.[81] Interestingly, the same study shows the impact was more prominent to independent restaurants that restaurants owned by larger national chains.

3. Customer Relationship Management

Customer Relationship Management is the process governing the firm's interactions with existing and potential customers. CRM allows firms to create a loyal customer base and increase customer satisfaction, customer retention, and subsequently sales. Existing evidence from the literature shows that effective and efficient CRM has a positive impact both on sales[82] and profits.[83] In the past, firms have utilised CRM software solution.[84] More recently, platform-based solutions have emerged offering a variety of tools that have increased CRM efficiency.

a. Process Improvements

CRM services enable companies to manage their entire CRM function from a single point.[85] The shared interface, which can typically be accessed by an entire team, includes all the tools and data needed to effectively manage customer relations and identify leads, such as inboxes, service agreements, ticketing, or tracking. Efficiency is improved with the automation of repetitive tasks, elimination of manual data entry, and the automatic generation of answers to the most frequent questions from customers. Also in this case, multiple integrations can augment the platforms with added features such as improved messaging system, or feedback tools. CRM functions centralise the work of the CRM team, increase their coordination capacity and employee's agency. For example, CRM platforms can produce the entire history of a customer's communication across channels and enable rapid contextualisation of the customer issue. Data analytics can also be used to identify and score potential leads. Pricing is typically a monthly fee per desk.[86] The tools used in CRM usually rely on cutting-edge information technology, like software development and AI.

Platforms create more efficient CRM processes. CRM services typically streamline communications between businesses and their customers. For example, they generally include the option of an automatic-reply software (a chatbot) that becomes a first easy point of contact when a customer approaches the business to communicate. Simple cases can be resolved automatically without human intervention. More complex cases can be redirected by the software to the appropriate representative. Integrations can also allow businesses to interact with customers through the messaging systems of social media platforms. Generally, communication becomes easier, streamlined, and efficient. Response times become shorter.

CRM platform solutions provide economies of scope. As in the case of most platform services, they often come with complementary services or tools. These may include enterprise resource planning solutions (ERP) such as inventory management, electronic verifications, or invoicing tools, which can also be linked to third-party providers. They can also integrate with outside providers, like when an invoicing tool offers an integration with the company's chartered accountant. These services can be contracted from a single platform under one contract and an integrated interface.

b. Increase in Market Reach and Matching Efficiency

CRM platforms facilitate more efficient expansion of the existing customer base. CRM analytics enable the curation of the interaction between the firm and the customers so that the right offers or sales are sent to the right customer at the right time. CRM tools can even predict the most optimal time for an interaction or the estimated interval for repeated sales. Overall, sellers and buyers are more likely to be matched at the right time with the right offer.

c. Reduction in Asymmetric Information

Platform CRM services can enhance the reputation and the trustworthiness of the business. Tools can allow customers to post their opinions of the firm activity and read the opinions of others. Customers are more likely to form a long-term relationship with the products of the company.[87]

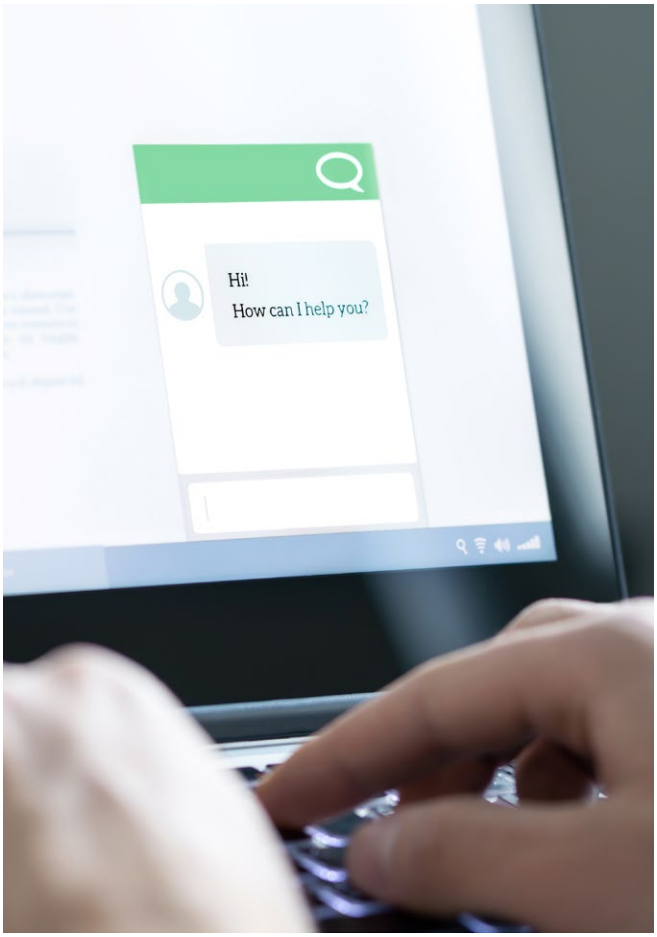
d. Illustrative Quantification

This section quantifies the cost savings from a single tool typically provided by CRM services: the customer chatbot. A chatbot is a piece of software that relies on an AI-based language recognition technology. This piece of software is constructed in such a way that it mimics the interaction with a customer representative without employing a person to do it. The chatbots are usually a first point of contact for the customer. They are designed to identify the question raised by the customer and then propose a solution if the issue is common and easily solvable or forward the question to a representative if the problem is too complex. Chatbots reduce the required human labor needed to address customer's concerns and allow a more efficient navigation of the customer to the appropriate representative.[88]

We quantify how much cheaper it would be to employ the toolset available in the platform Hubspot relative to a solution of a similar quality without the utilisation of a platform. For this we assume that the in-house replication of such functionality includes three components. First is labour cost required for maintaining the chatbot.[89] Second, a chatbot would require a software platform. Third, to quantify the cost associated with other CRM tools, we assume that the firm will purchase a license of a legacy CRM solution, which in our case is SAP for service.[90]

> Our estimates show that using a chatbot from CRM platform rather than building one in-house reduces the cost of operating a chatbot by around €6,601 per annum or by around 67%.[91]

Hence in this case platforms allow the access to technology that can be at least twice as expensive to replicate without using platform tools. Note that the estimate for the cost of replication is, most probably, biased downward as the contracting of services and asset may not be flexible in the non-platform setting. The cost flexibility provided by digital services reduces the barriers of adoption for small firms.



4. Cloud Computing

IT is an indispensable part of the framework on which any business, big or small, operates. Evidence shows that good IT practices foster higher profitability[92] and growth.[93] There is also evidence that the benefits of IT investments grow over time.[94] All in all, investments in IT infrastructure have been considered unavoidable for any small business, especially the ones that look to grow in the future.

a. Process Improvements

The digital world made it possible for the entire IT architecture to be transported to the cloud without any need for investment in physical infrastructure. Cloud technology allows firms to perform tasks that previously could be achieved only by investing and maintaining IT servers. This includes large, shared office applications or data storage and processing, which no longer require a significant investment in IT capital. The same applies even to computationally intensive tasks such as big data analytics or the development of AI models that can be accommodated by specialised offerings.[95]

Cloud services are typically delivered for a monthly fee that gives access to a pre-determined storage size. The service grants flexibility, scalability, as well as service reliability. Integration in cloud services include programming and data management tools, machine learning and AI tools. These tools are sometimes charged by usage ("as you pass"). Cloud services and supporting tools, such as machine learning, can also be integrated in other services of the service provider. Cloud services are often supplied as part of larger enterprise suites that offer a series of productivity and collaboration online tools to perform everyday tasks.[96] These can include communication and collaboration tools, document management tools, or data processing tools. Cloud services can support the integration of a variety of collaborative processes.

Businesses can use cloud-based services instead of setting up their own physical infrastructure and therefore avoid the acquisition and maintenance of servers. This not only decreases the upfront setup costs, which can be substantial, but also subsequent maintenance costs, power consumption and the personnel required to maintain the servers. Cloud services reduce the risk of business disruption due to IT issues.[97]

The emergence of tools based on machine learning and artificial intelligence require immense computation power. No one small (or even medium) firm has the financial ability to build such infrastructure from scratch. The digital cloud-based platforms fill this gap by "renting" the computation power that they hold. To sum up, the benefits of digital platforms go beyond the ability to make existing firms more productive or efficient. It can be argued that some firms could not exist in the first place due to the very large required up-front investment in computation power.

b. Illustrative Quantification

The benefits of digital IT services can be seen both in terms of a decrease in costs for "simple" IT solutions and the removal of barriers for "advanced" IT solutions. As the latter is extremely hard to quantify and is very business-specific, we focus on the former. We start from taking the cost of an online office suite (Google Workspace). We then try to replicate the same cloud service package by using in-house offline alternatives.

We assume that to replicate the digital cloud solution, the firm would need to maintain a server and purchase a license for an office suite. In the cost we add up costs required to set up the server every 5 years (the average life of a server), the cost of server maintenance and the cost of an offline office suite software.[98] To quantify both costs we assume that the small business has 10 employees.[99] Under our assumptions, the annual cost of an in-house IT solution is estimated to be around €1,815.[100] Under the same assumptions, the annual cost of using Google Workspace is €660.[101]

The saving in cost of using cloud services for simple computing processes can be up to €1,155 per annum or 64%. The cost of the cloud-based solution can be almost a third relative to the cost that would be incurred while setting up the infrastructure in-house.[102]

Note that we probably underestimate the real cost of replicating the service since the replication of a cloud-based service in terms of reliability and security would entail building a server of a much higher quality and cost.

5. Procurement

Procurement is the sourcing of products that the firm needs in its operation. Procurement can relate to both the input materials for manufacturing firms and the items needed to run the business (like office supplies). An efficient procurement system saves time, prevents disruptions, and sources efficiently in terms of price-quality. The literature documented that sourcing strategies can affect the general performance of the business.[103]

a. Process Improvements

Because digital market platforms (e.g., Amazon) increases choice and facilitates competition among the sellers on the platform, the prices of products tend to be lower, which directly affects the cost of conducting business. Also, the variety of supplies on the platform enables the business to buy the exact product mix that it needs.

Platforms usually provide tools for businesses to manage their recurrent purchases. These can be easily organised and automated. Some of these sites allow companies to decentralise purchases across the organisation with a centralised account management at the platform-level associated with multiple accounts within the company and an approval screening process. Although purchases are decentralised, the company obtains from the platform service an aggregate picture with analytical metrics to monitor both expenditures and spenders. These services are charged through yearly fees.[104]

The centralisation and automation of the management of the sourcing together with the provision of analytics increases efficiency without the need for many human resources. In addition, as the business uses a particular digital platform, the platform (with the help of AI tools) can suggest to the business certain products that are aligned with the needs of the business, which can reduce the time spent on sourcing.

b. Marketplace Benefits

For example, marketplaces for businesses[105] provide reach, search functionalities, and create the necessary trust to engage with new sellers and products that may offer the best value for money. They can bring together thousands of sellers who are evaluated by buyers to guarantee their quality. Their products can be compared with comparison tools to find the most suitable product at the best price for the company.

Through digital platforms, companies can connect with suppliers spanning different geographies, industries, and specialties, breaking down traditional barriers to procurement. One of the primary advantages of digital platforms is their ability to centralise and streamline the procurement process. By leveraging these platforms,

companies can access comprehensive databases of suppliers, search for specific products or services, compare prices and quality, and even negotiate terms and contracts—all within a single, integrated environment. This consolidation of procurement activities not only saves time and resources but also promotes greater transparency and standardisation across the procurement lifecycle.

c. Illustrative Quantification

We quantify the benefit of using platforms by focusing on the reduction of costs associated with sourcing office equipment[106] from Amazon relative to two big wholesale stores for business equipment in France: "Metro" and "Bureau Vallée". For each category we identify an item that is sold both in the store and on Amazon. From the prices on Amazon, we deduct the Value-Added Tax ("VAT")[107] to make the prices comparable to the wholesalers' prices.[108] We furthermore apply a discount of 10% for orders that are needed on an ongoing basis (like printer ink) as these orders get an additional discount on Amazon.[109] According to our calculations,[110] the prices on Amazon are approximately 30% lower than Metro's prices and approximately 18% lower than Bureau Vallée's prices. On average, the cost saving is around 24%[111] from the price paid on procurement from non-platform sources.

6. Summary

To exemplify the cost savings from using a platform across several business functions, we provide a hypothetical scenario in which assume a small business and quantify the annual cost reduction from using just some of the platform services we described.

To do so we make the following assumptions for the firm in a given year. We assume the company has 10 employees needing access to software tools. It hires two new employees at the median salary in France.[112] The marketing budget on an ad tech is set at €100,000 per year,[113] and the company uses a chatbot within its CRM activities. It spends €9,600 worth of supplies a year, which is the equivalent of €80 per employee per month.[114] We assume sales revenues of €2,000,000 per year.[115]

We apply the same quantifications of benefits used in the illustrative examples to show the aggregate cost savings from using just these illustrative set of platform tools. We calculate the number of clicks the marketing budget generates on the ad tech platform and then calculate the required budget to achieve the same number of clicks with an email marketing campaign. We compare the in-house setup of a CRM solution and the CRM solution using Hubspot. We compare the annual cost of setting up IT in house to using Google Workspace. And we assign the 24% savings to the office supplies sourced on platforms to the procurement budget.

Table 1 below summarises the results of our calculations. The cost savings enabled by platform services to our hypothetical firm due to process efficiencies in just the selected subset of important business operations tasks represent €95,776 a year or just short of 5% of the revenues. For a firm that is just starting and producing much lower revenues, these savings can be critical.

Table 1: Process cost savings from selected tasks for a small firm

TASK	COST WITHOUT PLATFORM	COST WITH PLATFORM	ANNUAL COST REDUCTION
Human Resources 2 Specialised Hires	Using a professional recruiting firm: **€17,292**	Using Welcome to the Jungle: **€4,500**	**€12,792**
Marketing Ad clicks (212,766)[1]	Using email campaign: **€172,340**	Using Meta Ads: €100,000	**€72,340**
Customer Relationship Management Providing a Chatbot	In-house setup **€9,841**	Using Hubspot **€3,240**	**€6,601**
Information Technology Document management services for 10 seats	In-house solution setup **€1,815**	Using Google Workspace **€660**	**€1,155**
Procurement Sourcing supplies for 10 employees	Sourcing from wholesalers **€11,904**	Sourcing from Amazon **€9,600**	**€2,304**
Total (% of revenues)	-	-	**€95,192 (5%)**

Notes:

[1] Detailed computations are presented in the above sections. The number of clicks obtained with €100,000 spent on Meta Ads is 212 766. One would have to spend €172,340 on an email campaign to obtain the same number of clicks.

[2] Analysis is conducting comparing platform and non-platform options for everyday tasks. Specifically, we compare the cost of hiring using a platform and hiring using a recruitment firm, the potential reach of cold email leads versus targeted marketing campaigns, the differences between CRM software and CRM platforms, the cost to replicate in-house a digital cloud solution and directly adopting a digital cloud solution, and finally the procurement of office supplies from stores versus buying them from an online marketplace.

Sources: Provided in footnote.[116]

It is important to keep in mind that we have only described the process efficiency gains from some important business tasks. The real benefits from platforms may be significantly higher. As we discussed, marketplace benefits may be much larger. Firms enter into transactions that would otherwise not occur. A platform might be more efficient at locating a well-matched worker, an AI powered CRM service may detect the appropriate offer to make, targeted advertisement may be more efficient.

> Platforms innovate on tools increasing trust and transparency leading to more engagements and transactions. This helps small firms overcome information asymmetries from customers and partners that hesitate to engage with a lesser-known company.

To the extent that these benefits exist, they will add to the performance and productivity of firms. In addition, the extent to which the high degree of process integration across tasks may positively impact the organisational capacity of the firm is a subject of further research.

We should emphasise that our attempts to quantify the benefits of using platform services have been based on estimating the average gains of a representative firm choosing between using platform services or developing in-house alternatives. They do not necessarily apply to all firms in all contexts. The costs and benefits of developing in-house solutions may vary for different firms for various reasons. Platform solutions provide access to standard solutions at a very low cost, but some firms may benefit more from developing customised solutions instead of relying on standard solutions provided by platforms. This could be due to the unique needs and requirements of the firm, which may not be fully met by standard platform solutions.

Additionally, we acknowledge that the estimates above are highly imprecise and rely on several assumptions and simplifications. More work is needed to pinpoint the size of the efficiency gains and cost savings that platform allow in different industries and for different functions. Also, note that there are growing concerns that some digital platforms are natural monopolies or oligopolies, and that their owners may exercise in some cases significant market power over some users. Here we do not take a stance on the extent to which some potential welfare gains are appropriated by the platforms due to market power. Our analysis aims to take that market power as given, and quantify, at current prices, the platforms benefits and efficiency gains for businesses.

III.

ESTIMATING THE IMPACT OF DIGITAL PLATFORM ADOPTION ON EU FIRM-LEVEL PRODUCTIVITY

The previous section provided concrete examples supporting the cost-decreasing impact on business tasks of using platform technologies. This section complements that analysis with the results of a systematic study of the relationship between firm adoption of new technologies and firm-level labour productivity in the EU.

A. DATA

We use data from the European Investment Bank Investment Survey. EIBIS is an annual semi-panel survey of around 12,000 EU non-financial corporations conducted since 2016. The survey has been administered annually to a stratified random sample of firms in each country member of the EU and is designed to be representative of the business population for each country at different firm sizes and sectors, including manufacturing, construction, services, and infrastructure.[117]

EIBIS contains information on firm characteristics (such as revenue, number of employees, and age), firm's financial data as well as more qualitative information that captures the firm's perception regarding its managerial capabilities, investment constraints and investment behaviour. Data is self-reported by senior employees that form part of the team making investment decisions (e.g., CFO or CEO[118]).[119] Data is complemented by administrative financial data from Bureau van Dijk Orbis, which has been used in the past to validate EIBIS self-reported financial data and allows us to use balance sheet information when needed.[120]

EIBIS is a unique dataset measuring firm-level adoption of modern digital platforms over time. A new module on technology adoption was introduced in 2019, where firms are asked about the use and use intensity[121] of advanced digital technologies that are specific to their sector. This allows us to not only measure technology adoption directly (which is already an improvement from previous research),[122] but also to separate adoption of different digital technologies, including digital platforms. In EIBIS, a digital platform is defined as an entity that connects customers with businesses or customers with other customers.

The survey is collected across multiple countries, sectors, and types of technology. The use of a direct measure of firm-level modern technology adoption makes this dataset unique. Historically, researchers have typically relied on proxies for modern technological adoption such as industry-level measures, firm-level financial data, self-reported use of older technologies (e.g., using email for communications), or a mix of these. Direct industry-level measures of specific industries used include the stock of industrial robots in a given country and year.[123] Technology adoption (or likelihood thereof) has also been proxied using indirect measures, such as the degree of repetition of tasks (i.e. how automatable a task can be) in a given sector.[124]

Firm-level productivity studies have also used industry-level data,[125] indirect measures such as whether a firm has a website and use email for communications,[126] or financial data on investment in research & development ("R&D") or ICT technologies.[127] In the few instances that firm-level information is available, such as in the case of Nucci et al. (2023),[128] samples are smaller and specific to only certain geographical areas and/or industries.

1. Technology Adoption in the EIBIS Database

Table 2 provides descriptive statistics on technology adoption by firm size. Within country years, firms are divided into three groups of equal size sorted by their size, measured by the quantity of fixed assets. The data is a subset of EIBIS focusing only on firms in the services sector (the only ones who were posed the platform adoption question). Adoption of digital technology in our sample, measured as adoption of IoT (internet of things), AI, or platform technologies within the EU, stands at 70% for large firms, 58% for medium ones, and 53% for the smallest firms. A similar disparity of adoption rates by firm size occurs if we look only at the adoption of platforms, with the adoptions rates being respectively 52%, 42%, and 39% for large, medium, and small firms. Platform adoption is also associated in our data with a higher average productivity, measured as labour productivity.[129]

The data are consistent with the view that firm-level digital adoption is generally correlated with superior managerial skills and organisational capital, which are in turn correlated with size. The impact on productivity of platform adoption compared to that of other digital tools is smaller for medium-sized and large companies but is larger for small firms. Platform adoption has a much larger impact on small firms' productivity than the adoption of other digital tools.

Table 2: Technology adoption descriptive statistics by firm size

FIRM SIZE	% DIGITALISED	% PLATFORM	AVERAGE PRODUCTIVITY	DIFFERENCE IN AVERAGE PRODUCTIVITY ASSCOCIATED	
				WITH DIGITALISATION	WITH PLATFORM ADOPTION
Small firms	53.6%	39.1%	11.40	0.13	0.16
Medium firms	58.2%	42.1%	11.75	0.08	0.07
Large firms	70.1%	51.7%	11.98	0.02	0.0

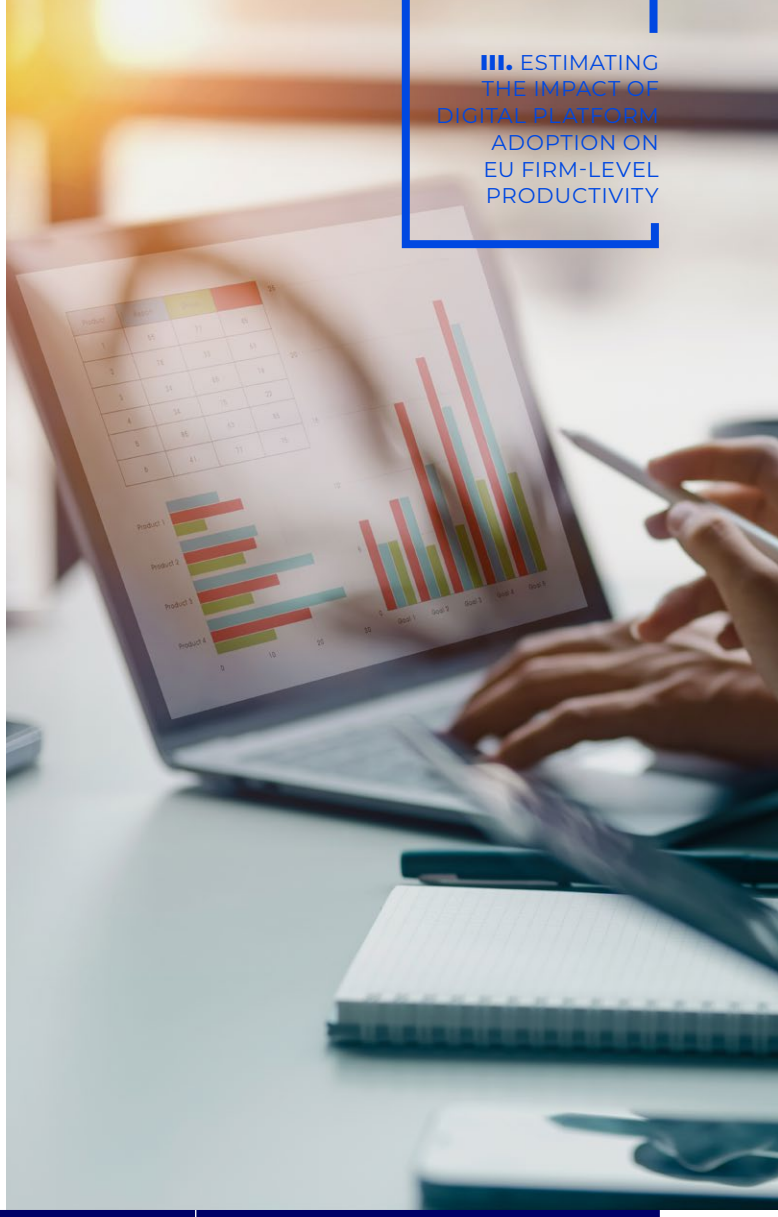


Table 3 provides descriptive statistics for firms in our sample split by their adoption of digital platforms. We observe that, on average, firms that adopt digital platforms have a slightly higher productivity, higher revenues, more intangible assets (measured as expenses in R&D, goodwill, or training), and are more likely to export compared to their peers. They are also larger in the sense that they employ more workers and are also more likely to adopt modern management practices.

Table 3: Firm characteristics by platform adoption

FIRM CHARACTERISTICS	FIRM DO NOT ADOPT DIGITAL PLATFORM	FIRM ADOPT DIGITAL PLATFORM
Labour productivity (average revenue per employee)	€113,644	€127,463
Revenue	€2,926,856	€5,461,149
Number of employees	27	44
Fixed assets	€606,711	€1,136,971
Age (in years)	21.4	21.7
Firm is less than 10 years old	14.4%	14.3%
Firm exports	37.3%	49.2%
Firm uses monitoring systems	34.8%	55.3%

B. EMPIRICAL RESULTS

1. Econometric Model

We estimate a regression to measure the impact of platform adoption on firm-level labour productivity controlling for the characteristics of the firm so that the effect is estimated comparing similar firms. Technically, we estimate the following generic equation:[130]

$$y_{ijct}=\alpha_{jc}+\alpha_{t}+\beta\, Platform_{ijct}+\lambda X_{ijct}+\epsilon_{ijct}$$

where the dependent variable, y_{ijct}, refers to productivity of firm *i* in industry *j* operating in country *c* at time *t*. $Platform_{ijct}$ represents the firms' adoption of digital platforms in their operations. The vector X_{ijct}, denotes independent control variables, α_{jc} denotes country-industry fixed effects, and α_{t} denotes year fixed effects. The ϵ_{ijct} denotes a random error term.

The parameter of interest, β, captures the relationship between the variable capturing platform adoption $Platform_{ijct}$, and firm-level productivity. We measure firm-level productivity as labour productivity, measured as total revenue by employee.

We are careful about conditioning on factors (included in X_{ijct}) that might also be directly influenced by platform adoption. Consequently, we consider specifications with very basic controls as well as those with a more extensive set of characteristics. Controls include a firm's age (variable identifying firms that are less than 10 years old), firm's size measured by the number of employees[131] and total fixed assets, measures of quality of management practices, and export status.[132]

Finally, our estimates should be interpreted as cross-sectional differences in firm outcomes within country-industry pairs that are driven by platform adoption. We include industry-country (α_{jc}), and year (α_{t}) fixed effects in all our estimations. This means that the results are net of time-specific shocks and industry-country (e.g. industry technology intensity) factors that may affect both platform adoption and productivity.

2. Basic Results

In line with our results from the analysis of the impact of platforms on different business functions of the firm (section II) and with the descriptive statistics in Table 3, smaller firms benefit the most from the labour productivity gains generated by platform adoption. Table 4 summarises the results for different specifications of our econometric model.[133]

Table 4 presents the total effect associated with platform usage for 4 types of firms, the average firm, a firm with fixed assets in the top 25th percentile, a firm with fixed assets in the top 50th percentile, and a firm with fixed assets in the bottom 25th percentile of the distribution of fixed assets which correspond to our definition of large, medium, and small firms.[134]

The results in Table 4 show a systematic positive correlation between platform adoption and labour productivity across firms of the same industry within a country, although the productivity gains are smaller and less robust for medium-sized and are null or slightly negative for larger firms. Results appear to confirm significant productivity gains from platform technology adoption for small firms.

The effect of platform adoption on the labour productivity of an average-sized firm is an increase between 3.6% and 5.3% across specifications. For smaller firms, the total effect of platform adoption on labour productivity is an increase between 6.4% and 10.5% across specifications.[135]

A comment of endogeneity: clearly, since we do not have an experiment, we could be picking up reverse causality. The firms that are unobservably (for whatever reason) more productive could be the ones adopting this technology. However, the fact that the productivity effect is mostly found in smaller firms is reassuring about a causal interpretation: one would need to postulate a source of unobserved heterogeneity/higher productivity that is more present in small firms than larger firms. This does not fully assuage our concerns, and we pursue an instrumental variable strategy to further probe this relation—essentially, we aim to construct an experiment, by finding a source of variation that affects adoption, but not, directly, productivity.

Table 4: Platform effect on labour productivity summary of basic results

TYPE OF FIRM	SPECIFICATION 1	SPECIFICATION 2	SPECIFICATION 3	SPECIFICATION 4
Average Fixed Assets	0.035** (0.015)	0.052** (0.015)	0.004** (0.015)	0.021** (0.015)
Small Fixed Assets	0.100*** (0.020)	0.099*** (0.020)	0.062*** (0.020)	0.063*** (0.020)
Medium Fixed Assets	0.038** (0.015)	0.054*** (0.015)	0.006 (0.015)	0.023 (0.015)
Large Fixed Assets	-0.040** (0.019)	-0.003 (0.018)	-0.062*** (0.018)	-0.027 (0.018)

Table Notes:
We estimate four specifications with a different combination of control variables. Specification 1 controls for the use of monitoring systems; Specification 2 corresponds to Specification 1 plus employment size indicator variables and an indicator variable for a firm with less than 10 years old; Specification 3 corresponds to Specification 1 plus an exporter indicator variable and an indicator variable for a firm with less than 10 years old; and finally, Specification 4 includes all control variables. All specifications include an indicator variable for platform adoption, the log of fixed assets, and an interaction term between the two.
Robust standard errors in parentheses. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively.

3. Identification Strategy

Whether a firm adopts or not a digital technology is a decision that is likely correlated with the firm's inherent productivity, even after controlling for country, industry, and firm characteristics. For this reason, a simple correlation may fail to capture a causal effect of platform adoption on productivity. This is because more productive firms are also more likely to adopt digital technologies and invest in intangibles, as both aspects may be linked to superior managerial skills, organisational capacity, or stronger financial means. In addition, common factors might drive productivity and digital adoption. For instance, firms with better management may be more likely to use new technologies (Andrews et al., 2018) and may be more productive for this reason (Bloom, et. al, 2012).[136] If not properly addressed, this correlation may lead to an upward-biased estimate for the relationship between platform adoption and productivity. On the other hand, if platforms allow productivity increases and are particularly useful, as it appears, to small firms, since they avoid large fixed investments, firms with lower productivity may be precisely the ones that have higher incentives to use platforms. If unaddressed, this negative correlation would suggest a downwards bias when estimating the relationship between platform adoption and productivity.

The effective adoption of digital platforms for each type of firm requires a minimum level of access available to the firm. Access conditions to platform technology should not be correlated with firm-level productivity but determine whether a firm can adopt and use these services. Therefore, we use an instrumental variable ("IV") approach that relies on two aspects of the digital platforms market; whether there are appropriate solutions available to the firm, and whether there exists the minimum infrastructure to implement them.

Firms can only adopt platform technologies if there exist appropriate platform services for firms in the industry the firm operates. We compute adoption of firms in the same industry but in a different location to capture the degree to which the technology has been generally adopted in that industry. Given that we are focusing on firms in the EU, we use adoption of digital platforms in firms of the same industry and operating in the US.

Also, to successfully implement the use of digital platforms that are both available and appropriate, firms require a stable and fast internet connection. Operating in a location with lower internet connectivity would make adoption of platform technologies more difficult. Therefore, our second instrument is geographical variation in internet speed over time from Ookla's Speedtest open-source dataset.[137]

The identification rests on the assumption that firms in industries and locations with higher adoption of digital platforms and high internet speed are not affected by other productivity shocks or trends that simultaneously affect digitalisation and productivity. Effectively, that the impact of our instruments on productivity are materialised only through the adoption of platform technologies.[138]

a. Causal Results

Our results from the study of business functions of the firm (section II), the descriptive statistics, and the correlations found in Table 4, all point to labour productivity gains from platform adoption, and these gains appear to be concentrated in smaller firms. Table 5 summarises the results of our estimation accounting for endogeneity.[139]

As in Table 4, Table 5 presents the total effect associated platform usage for four types of firms; the average firm, a firm with fixed assets in the top 25th percentile, a firm with fixed assets in the top 50th percentile, and a firm with fixed assets in the bottom 25th percentile of the distribution of fixed assets.[140]

Results in Table 5 seem to confirm a systematic positive correlation between platform adoption and labour productivity across firms of the same industry within a country. Results are again consistent with larger productivity gains for smaller firms.

For an average-sized firm, the total effect of platform adoption varies between 110% and 123% across specifications. For a larger firm, the total effect of platform adoption on labour productivity varies between 74.2% and 107.9% across specifications. In contrast, for a smaller firm, the total effect varies between 82.8% and 145.2% across specifications.[141]

Across all specifications, productivity gains for smaller firms significantly surpass the gains for larger firms. In addition, depending on the specification, effects are non-significant for average to larger firms whereas they are always significant for smaller firms. The lack of significance in the impact of platform on large and medium-sized firms is consistent with a downward bias in the Ordinary Least Squares ("OLS") estimation driven by the fact that firms with lower productivity ex-ante may be the ones with higher incentives adapt platform services to address their lack of productivity.

Table 5: Platform effect on labour productivity summary of casual results

TYPE OF FIRM	SPECIFICATION 1	SPECIFICATION 2	SPECIFICATION 3	SPECIFICATION 4
Average Fixed Assets	0.742** (0.348)	0.8062** (0.341)	0.473 (0.343)	0.504 (0.338)
Small Fixed Assets	0.897** (0.352)	0.868** (0.343)	0.629* (0.345)	0.603* (0.338)
Medium Fixed Assets	0.752** (0.348)	0.810** (0.341)	0.484 (0.343)	0.510 (0.338)
Large Fixed Assets	0.555 (0.348)	0.732** (0.345)	0.285 (0.344)	0.383 (0.343)

Notes:
We estimate four specifications with a different combination of control variables. Specification 1 controls for the use of monitoring systems; Specification 2 corresponds to Specification 1 plus employment size indicator variables and an indicator variable for a firm with less than 10 years old; Specification 3 corresponds to Specification 1 plus an exporter indicator variable and an indicator variable for a firm with less than 10 years old; and finally, Specification 4 includes all control variables. All specifications include an indicator variable for platform adoption, the log of fixed assets, and an interaction term between the two. Robust standard errors in parentheses. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively.

b. Mechanism

We have done an exploratory analysis to investigate the dynamic mechanisms through which platform adoption may lead to higher productivity using the subsample of firms in the EIBIS that are present at least for two consecutive years. Unfortunately, the survey data is not a panel data and less than one third of the firms in the sample are surveyed for two consecutive years. Table 13 in the appendix includes results in which the dependent variable corresponds to characteristics of the firm one year after the implementation of a digital platform technology. These results shed light on the mechanisms through which the use of platform technologies may influence firm productivity. We include results for whether a firm becomes an exporter (i.e., increasing market reach) and whether a firm becomes financially constrained (i.e., access to financial markets).[142]

Although in a reduced sample, results in the appendix hint that adoption of new technologies is positively associated with a higher probability on becoming an exporter in the next year with a mitigated effect for larger firms, a signal of the increases in productivity (and the heterogeneities) identified throughout this paper.

Consistent with the idea that these platforms are cost-saving implementations, results also show that the use of digital platforms is not associated with an increase in the perceived likelihood of becoming financially constrained during the next year.

IV.
CONCLUSIONS

An extensive literature has documented the main obstacles that keep European firms small and unproductive. Among them are regulatory constraints and labour regulations making firm growth expensive; inefficiencies in capital markets; skill gaps; inefficient R&D systems.

> Can the widespread adoption of platform services among small firms mitigate these obstacles and bolster firm productivity across Europe?

Digital platforms allow firms to attain significant process improvements, particularly through the use of automation and artificial intelligence tools. Additionally, platforms help businesses reach a wider market by efficiently connecting buyers and sellers and overcoming geographical barriers. Improved search functions and the collection of users in one place reduce costs and the difficulties of finding the right business partners. Online reviews and ratings help small businesses build trust and visibility, allowing them to compete with bigger brands. Overall, digital platforms help businesses operate more effectively, access broader markets, and use global resources.

These gains are particularly valuable for smaller firms. Previous research has found that digitalisation in the form of IT investment is hard, and expensive. It requires large capital investments as well as complementary investments in human capital and managerial skills. In contrast, we find that the use of platform technologies increases relatively more the productivity of smaller firms. Platform services allow small firms to "share" IT investments with other firms, and enjoy, through the platform, the benefits of the AI and big data revolution. Platform services have the potential to help firms overcome these barriers to successful digitalisation, and allow firms to attain process efficiencies and increase market reach. That is, in a context where EU companies appear to fail to obtain the benefits from digitalisation, platform tools appear to lower the requirements for accessing the productivity benefits from digital technologies.

By leveraging platforms, small firms can operate at a level of cost efficiency previously unattainable, thereby enhancing their competitiveness. This expanded reach facilitated by platforms not only enables easier access to European and global markets but also mitigates the inefficiencies stemming from underdeveloped capital markets. Additionally, platforms streamline access to highly skilled labour, as the standardisation of off-the-shelf tools for production serves as a substitute for hard-to-find human capital skills. Moreover, platform adoption facilitates access to remote talent pools, further enriching the labour force available to firms.

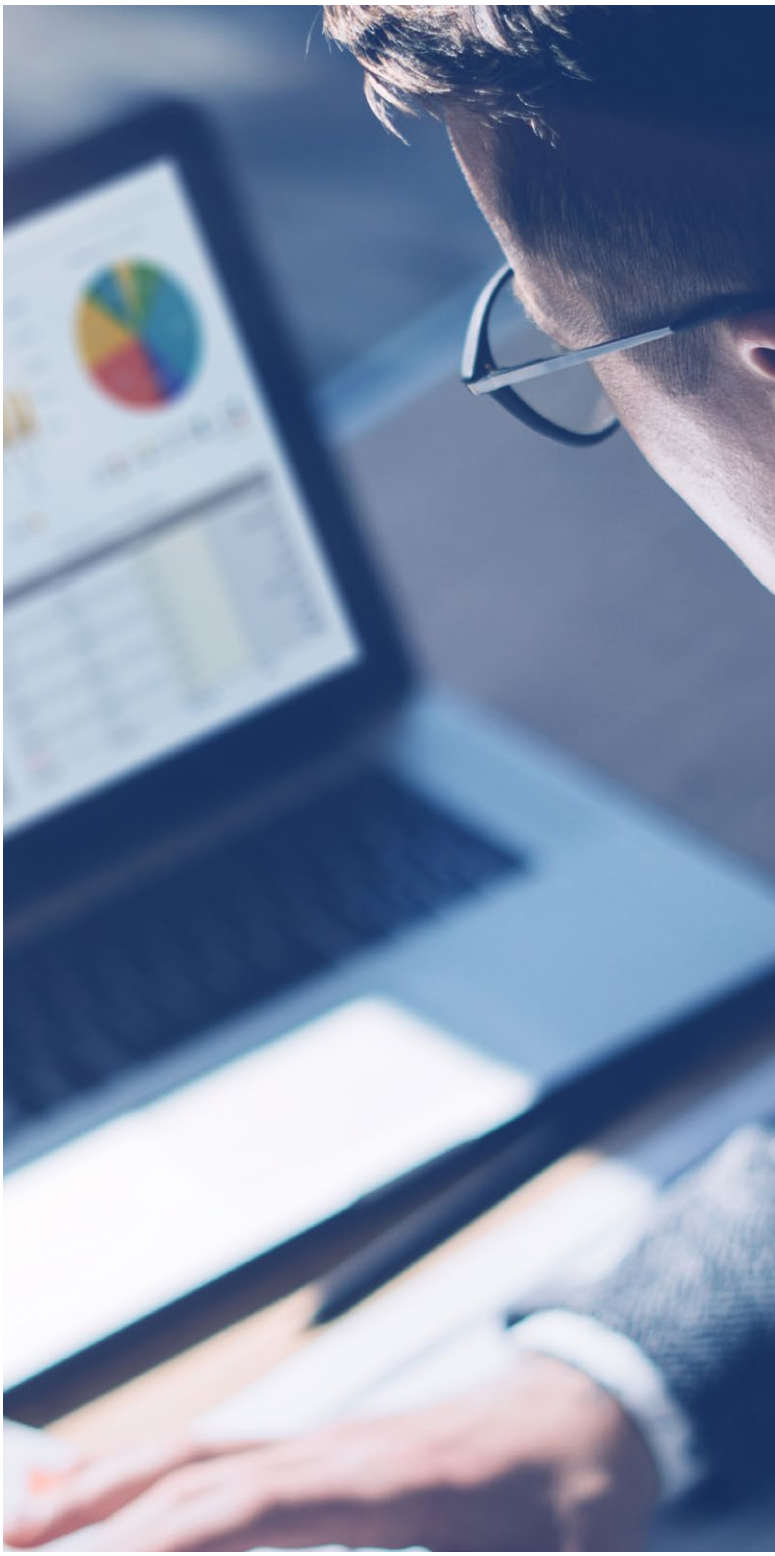
If the key obstacles to obtaining the productivity growth from digitalisation are skills, capital and fragmented markets, platforms facilitate access to skills, reduce capital requirements of digitalisation and increase market scale. Hence the diffusion of platform services can have the beneficial effect of accelerating digitalisation and accompanying productivity gains.

The recent Letta report points out the importance of achieving a large scale, continental, single market in Europe.[143] Certainly, in a world where large IT investments matter, scale is essential. However, a complementary path is also possible: ensuring that small firms also have access to markets and technologies (particularly AI technology) allow firms to achieve market reach and efficiency levels otherwise only attainable with a larger scale.

A few caveats are in order. First, we do not find in EIBIS data lower platform adoption by EU than US firms. Hence differential adoption of platform technologies cannot explain, in our data, the productivity differential between the US and the EU.

Second, while our empirical analysis uses an instrumental variable strategy to deal with causality concerns, we cannot rule out that our effects are driven by better firms using more platforms. Such explanation however would not account for smaller firms enjoying this productivity benefits to a larger extent than larger firms. It is hard to conceive unobserved heterogeneity explanations that have this form of scale bias.

Third, while strategies to promote the wider adoption of platform services have the potential to strengthen firm productivity, the dissemination of these services must naturally be accompanied by the appropriate regulation and competition frameworks at EU and country levels to ensure companies can extract the benefits that these digital services can offer.



v. APPENDIX

A. MEASURING THE IMPACT OF PLATFORM DIGITAL TOOLS AND SERVICES ON FIRM ORGANISATION AND OPERATIONAL EFFICIENCY

Table 6: Comparison prices of office supplies between Amazon and Metro

PRODUCT	Metro price	Amazon price	Amazon price without VAT	Amazon after discount	% difference
Office desks	€353.74	€259.99[4]	€216.66	€216.66	-38.75%
Office chairs	€47.61	€45.99	€38.33	€38.33	-19.50%
Whiteboards	€48.02	€24.99	€20.83	€20.83	-56.63%
Office laptops	-	-	-	-	-
Office printers	€132.00	€84.99	€70.83	€70.83	-46.34%
Commercial coffee makers	€1,124.98	€1,055.94	€879.95	€879.95	-21.78%
Printer ink and toner*	€61.70	€74.95	€62.46	€56.21	-8.89%
Paper rime*	€0.016	€0.011	€0.009	€0.008	-47.41%
Coffee and tea*	€17.75	€12.76	€10.63	€9.57	-46.08%
Toilet paper*	€0.0014	€0.0021	€0.0017	€0.0015	12.05%
Average (% difference in price)					**-30.32%**

Notes:
[1] Some of the products are marked with * because they are recurrent purchases made by company. For these products Amazon offers an additional 10% discount to be applied to the Amazon price without VAT.
[2] VAT for these products is 20% of the price.
[3] Percentage difference in prices is computed comparing the Metro prices with the Amazon prices after the discount.
[4] The Amazon price for the office desks differs between Table 6 and Table 7 because the prices correspond to two different models.

Sources: Metro website and Amazon website.[144]

Table 7: Comparison prices of office supplies between Amazon and Bureau Vallée.

PRODUCT	Bureau Vallée price	Amazon price	Amazon price without VAT	Amazon after discount	% difference
Office desks	€332.50	€139.99[4]	€116.66	€116.66	-64.91%
Office chairs	€58.33	€45.99	€38.33	€38.33	-34.30%
Whiteboards	€31.91	€24.99	€20.83	€20.83	-34.74%
Office laptops	€374.17	€439.00	€365.83	€365.83	-2.23%
Office printers	€74.92	€84.99	€70.83	€70.83	-5.47%
Printer ink and toner*	€49.92	€74.95	€62.46	€56.21	12.61%
Paper rime*	€0.009	€0.011	€0.009	€0.008	-9.90%
Toilet paper*	€0.0016	€0.0021	€0.0017	€0.0015	-4.95%
Average (% difference in price)					**-17.99%**

Notes:
[1] Some of the products are marked with * because they are recurrent purchases made by company.
For these products Amazon offers an additional 10% discount to be applied to the Amazon price without VAT.
[2] VAT for these products is 20% of the price.
[3] Percentage difference in prices is computed comparing the Bureau Vallée prices with the Amazon prices after the discount.
[4] The Amazon price for the office desks differs between Table 6 and Table 7 because the prices correspond to two different models.

Sources: Bureau Vallée website and Amazon website.[145]

B. ESTIMATING THE IMPACT OF DIGITALISATION AND PLATFORM TECHNOLOGY ON EU FIRM-LEVEL PRODUCTIVITY

This section complements the results of the econometric analysis of the relationship between labour productivity and the adoption of digital platforms.

1. Complete OLS Results

Table 8 presents the main results of different specifications:

To establish a baseline, Column (1) presents a simple correlation between labour productivity and an indicator variable that is equal one when the firm has adopted a digital platform technology. As controls, it includes the log of fixed asset and the indicator variable that is equal one when the firm has implemented a business strategy monitoring system.

- Column (2) adds the following controls to the specification in Column (1): (i) indicator variable that is equal one when the firm is less than 10 years old firm and (ii) indicator variables for firm size. These indicator variables are defined in terms of employment, small being firms with 10 to 49 employees, medium being firms with 50 to 249 employees, and large being firms with 250 employees or more. Coefficients are with respect to the base category, which corresponds to micro firms that have less than 10 employees.
- Column (3) adds the following controls to the specification in Column (1): (i) indicator variable that is equal one when the firm is less than 10 years old firm and (ii) indicator variable that is equal one when the firm is exporting
- Column (4) includes all controls mentioned above.

The main results are:

- Adoption of digital platform technology has a positively and statistically significant correlation with labour productivity in all specifications that do not control for export status. Firms that adopt platform technologies have, on average, between 5% and 12.4% higher labour productivity that the ones that do not.[146]
- Firms that adopt business strategy monitoring systems, a signal that we interpret as implementing modern management practices, have positive and significant correlation with labour productivity. On average, firms that adopt these business practices, have between 10.3% and 18.1% higher labour productivities that firms that do not.

- Exporting firms have positive and significant correlation with labour productivity, a well-known result in the international trade academic literature. On average, exporting firms have around 50% higher labour productivities that firms that don't. Including export status as a control discipline both the level of the coefficient on platform adoption and its significance. This indicates that there is a portion of the coefficient on platform adoption that may be contaminated by its correlation with export status. Platform use can increase productivity by facilitating firms' increased sales through exports. In specifications that include export status, there is no significant direct correlation between platform adoption and labour productivity.

Following our results from the study at the business function level on section II and our interpretation of the descriptive statistics in Table 3, labour productivity apparent gains from platform adoption are concentrated in smaller firms. To that end, we extend the baseline model to include an interaction term between firm's fixed assets, a measure of the size of the firm, and platform adoption. Table 9 presents the main results of this exercise.

Table 8: OLS model of labour productivity

	(1) Ln(1+Labor Prod.)	(2) Ln(1+Labor Prod.)	(2) Ln(1+Labor Prod.)	(2) Ln(1+Labor Prod.)
1*(Platform)	0.031** (0.015)	0.049*** (0.015)	0.001 (0.015)	0.019 (0.015)
Log of Fixed Assets	0.089*** (0.004)	0.131*** (0.005)	0.079*** (0.004)	0.125*** (0.005)
1*(Use Monitoring Systems)	0.126*** (0.016)	0.166*** (0.016)	0.098*** (0.016)	0.141*** (0.015)
1*(Small Relative to Micro Firm)		-0.051*** (0.020)		-0.078*** (0.019)
1*(Medium Relative to Micro Firm)		-0.183*** (0.024)		-0.217*** (0.024)
1*(Large Relative to Micro Firm)		-0.637*** (0.035)		-0.640*** (0.034)
1*(Less than 10 Years Old firm)		-0.102*** (0.023)	-0.082*** (0.023)	-0.101*** (0.023)
1*(Exporter status)			0.407*** (0.015)	0.403*** (0.015)
Observations	20,929	20,929	20,876	20,876
R-squared	0.342	0.357	0.365	0.379
Year Fixed Effects (5-1)	x	x	x	x
Country-Industry Fixed Effects	x	x	x	x

Notes:
Robust standard errors in parentheses. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively.

Relative to the baseline results, the coefficients in Table 9 are consistent with lower productivity gains for larger firms or, conversely, larger productivity gains for smaller firms. This shows that there is a systematic positive correlation between platform adoption and labour productivity across firms of the same industry within a country, and that this correlation is lower in larger firms.

The economic magnitude of these results are as follows. For an average-sized firm, the total effect of platform adoption varies between 3.6% and 5.3% across specifications..[147] For a larger firm, a firm with fixed assets in the top 25th percentile of the distribution of fixed assets, the total effect of platform adoption varies between -6.0% and -3.9% across specifications.[148] In contrast, for a smaller firm, a firm with fixed assets in the bottom 25th percentile of the distribution of fixed assets, the total effect of platform adoption varies between 6.4% and 10.5% across specifications.[149]

Table 9: Expanded OLS model of labour productivity

	(1) Ln(1+Labor Prod.)	(2) Ln(1+Labor Prod.)	(2) Ln(1+Labor Prod.)	(2) Ln(1+Labor Prod.)
1*(Platform)	0.565*** (0.092)	0.438*** (0.091)	0.473*** (0.090)	0.359*** (0.090)
1*(Platform) x Log of Fixed Assets	-0.039*** (0.006)	-0.028*** (0.006)	-0.035*** (0.006)	-0.025*** (0.006)
Log of Fixed Assets	0.107*** (0.005)	0.144*** (0.006)	0.095*** (0.005)	0.136*** (0.006)
1*(Use Monitoring Systems)	0.126*** (0.016)	0.166*** (0.016)	0.098*** (0.016)	0.141*** (0.015)
1*(Small Relative to Micro Firm)		-0.056*** (0.020)		-0.082*** (0.019)
1*(Medium Relative to Micro Firm)		-0.186*** (0.024)		-0.220*** (0.024)
1*(Large Relative to Micro Firm)		-0.627*** (0.035)		-0.632*** (0.034)
1*(Less than 10 Years Old firm)		-0.102*** (0.023)	-0.082*** (0.023)	-0.101*** (0.023)
1*(Exporter status)			0.404*** (0.015)	0.402*** (0.015)
Observations	20,929	20,929	20,876	20,876
R-squared	0.343	0.357	0.366	0.379
Year Fixed Effects (5-1)	x	x	x	x
Country-Industry Fixed Effects	x	x	x	x

Notes:
Robust standard errors in parentheses. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively.

2. Complete IV Results

Given that platform adoption is a binary measure, we use these instruments in an, effectively, three stage procedure. Applying two stages least squares, the traditional way to implement instrumental variables with continuous dependent variables, using a nonlinear first stage to predict the probability of adoption would lead to a forbidden regression and inconsistent estimates (Angrist and Pischke, 2009).[150] The solution is to estimate the model in three stages as described in Wooldridge (2010, p.938) and Angrist and Krueger (2001).[151] In the first stage, we estimate platform adoption as a nonlinear function (Logit) of the instrumental variables and the set of controls. Then, we obtain the fitted probabilities of the model that we use as instrument in a traditional two stages least squares ("2SLS") method.

This section includes the results of the estimation of platform adoption as a function of the instrumental variables and the set of controls (i.e., our logit first-stage), and the results of the second stage of the traditional 2SLS procedure, in which the fitted values of the logit first-stage are used as instruments. The results of the traditional first stage (i.e., our 2SLS first stage using logit fitted values) are summarised as well.

Table 10 presents the marginal effects associated with the estimation of a model of platform adoption as a function of the log of download speed in the location the firm is located, the lagged level of platform adoption in firms in the same industry, but located in the US, the two instrumental variables we used in this setting. This regression corresponds to the first step in the three-stage procedure described above, and as such we use the same set of controls as in the baseline specifications.

The main result shows the following that the instruments are suitable candidates for explaining firm's adoption of platform technologies. In fact, the effect of the two instruments on digital platform adoption is positive and economically and statistically significant:

- There is a strong and positive correlation between mobile download speed and the adoption of digital platforms. The average marginal effect, across specifications, of a 1% increase in download speed is associated with a statistically significant 10.7% increase in the probability of a firm to adopt a platform technology.
- There is also a strong positive correlation between the proportion of firms in the same industry operating in the US that adopted the use of digital platforms the year prior. The average marginal effect, across specifications, of an increase of one standard deviation of the lagged US platform adoption of firms in the same industry operating is associated with a 2.0% increase in the probability of a firm to adopt a platform technology.

Table 10: Logit model of platform adoption

	(1) 1*(Platform)	(2) 1*(Platform)	(3) 1*(Platform)	(4) 1*(Platform)
Log of mobile download speed, by NUTS region	0.117*** (0.028)	0.111*** (0.028)	0.103*** (0.028)	0.097*** (0.028)
Lagged use of platform in the US, by NACE 2 digit sector	0.141*** (0.030)	0.141*** (0.030)	0.140*** (0.030)	0.141*** (0.030)
Log of Fixed Assets	0.017*** (0.002)	0.008*** (0.002)	0.016*** (0.002)	0.007*** (0.002)
1*(Use Monitoring Systems)	0.168*** (0.008)	0.158*** (0.008)	0.162*** (0.008)	0.152*** (0.008)
1*(Small Relative to Micro Firm)		0.038*** (0.010)		0.032*** (0.010)
1*(Medium Relative to Micro Firm)		0.082*** (0.012)		0.122*** (0.017)
1*(Large Relative to Micro Firm)		0.121*** (0.017)		-0.632*** (0.034)
1*(Less than 10 Years Old firm)		0.034*** (0.011)	0.029** (0.011)	0.034*** (0.011)
1*(Exporter status)			0.078*** (0.008)	0.077*** (0.008)
Observations	15,752	15,752	15,710	15,710
Year Fixed Effects (5-1)	x	x	x	x
Country-Industry Fixed Effects	x	x	x	x

Notes:
Average marginal effects at means. Robust standard errors in parentheses. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively.

3. IV Results

Table 11 presents the results of the second stage. To reiterate, this stage utilises the fitted values of the model of platform adoption discussed above as instrument in a 2SLS estimation of the productivity effect of platform adoption. It means there is an additional first-stage in which platform adoption is estimated linearly using the fitted values of the nonlinear model estimated above. For brevity, we omit the results of the first-stage and, instead, include some statistics associated to it at the bottom of Table 11.

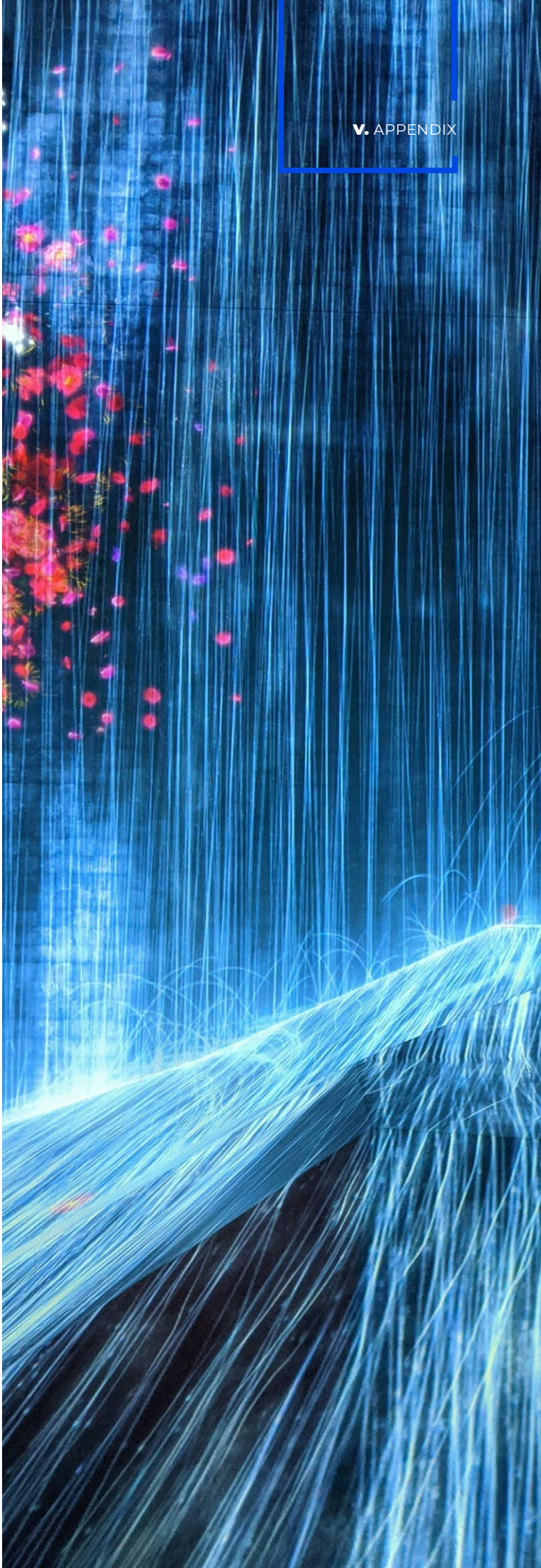
The main results are as follow.[152]

- The coefficients of most controls remain qualitatively unchanged. However, the coefficient on the use of monitoring systems lost significance and are an order of magnitude smaller than their OLS counterparts. Conversely, the coefficients on platform adoption are one order of magnitude larger and more precisely estimated.
- In terms of magnitude, the positive and significant coefficients on the adoption of digital platform technologies are consistent with an effect of digital platforms on labour productivity that fluctuate between 76.7% (Column 1) and 112.8% (Column 2).

Table 11: 2SLS model of labour productivity

	(1) Ln(1+Labor Prod.)	(2) Ln(1+Labor Prod.)	(3) Ln(1+Labor Prod.)	(4) Ln(1+Labor Prod.)
1*(Platform)	0.569* (0.337)	0.755** (0.340)	0.237 (0.336)	0.387 (0.338)
Log of Fixed Assets	0.078*** (0.007)	0.124*** (0.006)	0.074*** (0.007)	0.120*** (0.006)
1*(Use Monitoring Systems)	0.038 (0.062)	0.053 (0.059)	0.064 (0.059)	0.085 (0.056)
1*(Small Relative to Micro Firm)		-0.064** (0.027)		-0.080*** (0.025)
1*(Medium Relative to Micro Firm)		-0.234*** (0.041)		-0.240*** (0.038)
1*(Large Relative to Micro Firm)		-0.713*** (0.059)		-0.668*** (0.057)
1*(Less than 10 Years Old firm)		-0.108*** (0.031)	-0.067** (0.029)	-0.093*** (0.030)
1*(Exporter status)			0.404*** (0.032)	0.386*** (0.032)
Observations	15,752	15,752	15,710	15,710
Statistics First Stage with Logit Fitted Values				
F-Statistic	82.39	78.27	78.27	91.92
Cragg-Donald Wald F statistic	43.602	43.618	40.755	39.791
Year Fixed Effects (5-1)	x	x	x	x
Country-Industry Fixed Effects	x	x	x	x

Notes:
Robust standard errors in parentheses. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively.



Following our results from the study of the business functions of the firm (section II), our interpretation of the descriptive statistics, and the correlations found in Table 4, there exists labour productivity gains from platform adoption, and these gains are concentrated in smaller firms. To that end, as in Table 9, we extend the baseline model to include an interaction term between firm's fixed assets, a measure of the size of the firm, and platform adoption. Table 12 presents the main results of this exercise.

Relative to the baseline results, the coefficients in Table 12 are consistent with lower productivity gains for larger firms or, conversely, larger productivity gains for smaller firms. This shows that there is a systematic positive correlation between platform adoption and labour productivity across firms of the same industry within a country, and that this correlation is lower in larger firms.

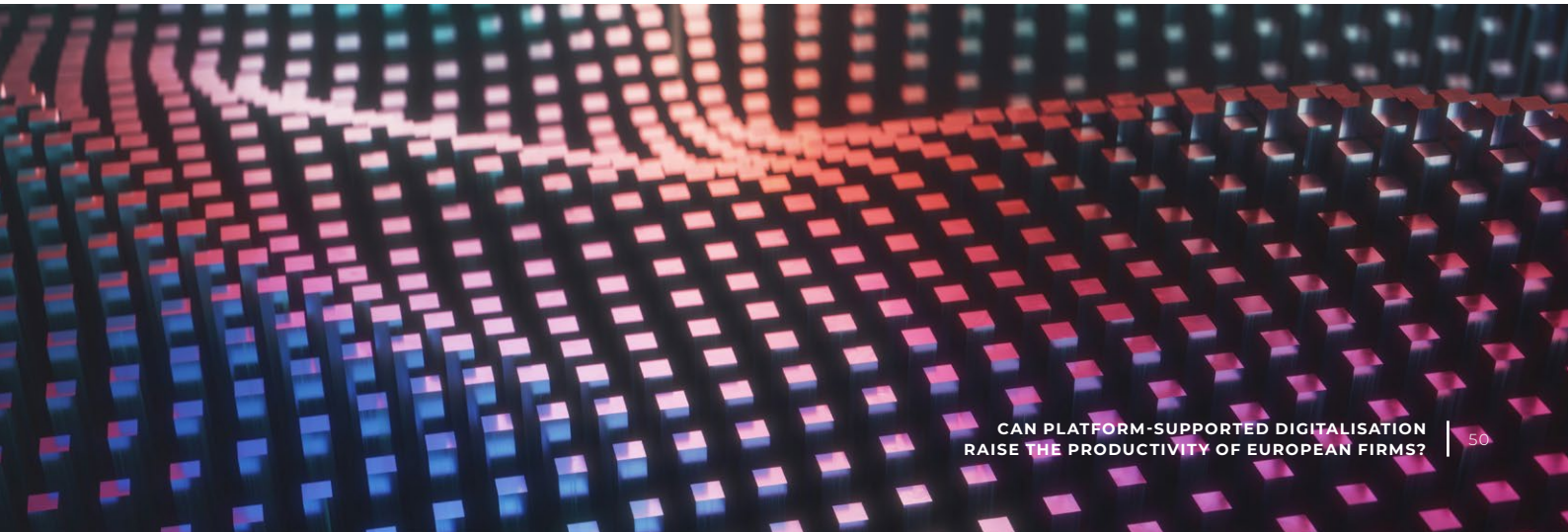
The economic magnitude of these results are as follows. For an average-sized firm, the total effect of platform adoption varies between 110% and 123% across specifications.[153] For a larger firm, a firm with fixed assets in the top percentile of the distribution of fixed assets, the total effect of platform adoption varies between 74.2% and 107.9% across specifications.[154] In contrast, for a smaller firm, a firm with fixed assets in the bottom 25th percentile of the distribution of fixed assets, the total effect of platform adoption varies between 82.8% and 145.2% across specifications.[155]

Across all specifications, productivity gains for smaller firms significantly out pass the gains for larger firms. In addition, depending on the specification, effects are non-significant for average to larger firms whereas they are always significant for smaller firms. These results are consistent with a downward bias in the OLS estimation driven by the fact that firms with lower productivity (i.e., smaller firms) may be precisely the ones that have higher incentives to use platforms.

Table 12: Expanded 2SLS model of labour productivity

	(1) Ln(1+Labor Prod.)	(2) Ln(1+Labor Prod.)	(3) Ln(1+Labor Prod.)	(4) Ln(1+Labor Prod.)
1*(Platform)	2.094*** (0.483)	1.344*** (0.461)	1.833*** (0.461)	1.373*** (0.439)
1*(Platform) x Log of Fixed Assets	-0.099*** (0.023)	-0.039* (0.023)	-0.100*** (0.022)	-0.064*** (0.022)
Log of Fixed Assets	0.120*** (0.013)	0.141*** (0.012)	0.115*** (0.012)	0.147*** (0.012)
1*(Use Monitoring Systems)	0.011 (0.064)	0.045 (0.059)	0.028 (0.061)	0.068 (0.057)
1*(Small Relative to Micro Firm)		-0.072*** (0.027)		-0.092*** (0.025)
1*(Medium Relative to Micro Firm)		-0.243*** (0.041)		-0.256*** (0.038)
1*(Large Relative to Micro Firm)		-0.704*** (0.059)		-0.659*** (0.058)
1*(Less than 10 Years Old firm)		-0.111*** (0.031)	0.029** (0.011)	-0.099*** (0.030)
1*(Exporter status)			0.078*** (0.008)	0.372*** (0.032)
Observations	15,752	15,752	15,710	15,710
Statistics First Stage with Logit Fitted Values				
F-Statistic	75.74	75.91	86.56	87.82
Cragg-Donald Wald F statistic	21.89	22.171	20.752	20.752
Year Fixed Effects (5-1)	x	x	x	x
Country-Industry Fixed Effects	x	x	x	x

Notes:
Robust standard errors in parentheses. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively.



4. Mechanism

Adoption of new technologies may have lasting effects. Table 13 includes results in which the dependent variable corresponds to characteristics of the firm one year after the implementation of a digital platform technology. These results shed light on the mechanisms through which the use of platform technologies may operate. We include results for whether a firm becomes an exporter (i.e., increasing market reach) and whether a firm becomes financially constrained (i.e., access to financial markets).[156]

Columns (1) and (2) show that adoption of new technologies is positively associated with a higher probability on becoming an exporter in the next year with a mitigated effect for larger firms, a signal of the increases in productivity (and the heterogeneities) identified throughout this paper.

Columns (3) and (4) show that there is no evidence that the use of digital platforms is associated with a change in the perceived likelihood of becoming financially constrained during the next year.

Table 13: Model of platform adoption and short-term outcomes

	(1) Ln(1+Labor Prod.)	(2) Ln(1+Labor Prod.)	(3) Ln(1+Labor Prod.)	(4) Ln(1+Labor Prod.)
1*(Platform)	0.134** (0.064)	1.146*** (0.356)	0.014 (0.038)	-0.028 (0.181)
1*(Platform) x Log of Fixed Assets	-0.005 (0.005)	-0.043** (0.020)	-0.001 (0.003)	0.002 (0.010)
Log of Fixed Assets	0.011*** (0.004)	0.022** (0.010)	0.000 (0.002)	-0.003 (0.005)
1*(Use Monitoring Systems)	0.048*** (0.012)	-0.028 (0.044)	-0.011 (0.007)	-0.010 (0.023)
1*(Small Relative to Micro Firm)	0.088*** (0.015)	0.063*** (0.022)	-0.014 (0.010)	-0.010 (0.012)
1*(Medium Relative to Micro Firm)	0.122*** (0.019)	0.084*** (0.029)	-0.040*** (0.011)	-0.030** (0.015)
1*(Large Relative to Micro Firm)	0.029 (0.026)	-0.008 (0.041)	-0.050*** (0.015)	-0.038* (0.020)
1*(Less than 10 Years Old firm)	-0.025 (0.017)	-0.034 (0.025)	0.028** (0.014)	-0.093*** (0.030)
Observations	7,064	5,130	6,958	5,062
R-squared	0.151		0.042	
Statistics First Stage with Logit Fitted Values				
F-Statistic	-	11.63	-	12.70
Cragg-Donald Wald F statistic	-	10.84	-	11.82
Year Fixed Effects (5-1)	x	x	x	x
Country-Industry Fixed Effects	x	x	x	x

Notes:
Robust standard errors in parentheses. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively.

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89 We estimate at 5 hours per week and we assign it a monetary value based on the average salary of a programmer in Paris which is set on €41,000, See Daniel Threlfall, "Chatbot Pricing: Everything You Need to Know About Chatbot Prices for SMBs," 2022, https://customers.ai/blog/chatbot-pricing/, accessed 15 March, 2024. We also abstract from the initial set-up cost of the chatbot that are estimated at 50 hours as this would constitute a one-time investment. For our calculation we assume 216 working days per year and an 8 hour long working day. Glassdoor.com, "How much does a Programmer make in Paris, France?," 2024, https://www.glassdoor.com/Salaries/paris-programmer-salary-SRCH_IL.0,5_IM1080_KO6,16.htm, accessed 13 March, 2024.

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96 Google Workspace and Microsoft 365 are examples of such solutions.

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98 The cost of a license for a physical copy of Microsoft Office. Note that the service is different from Microsoft 365, which is a cloud service.

99 This assumption affects both the cost of platform alternative as the cost of Google Workspace depends on the number of users and the cost of the non-platform alternative as it determines the number of licenses of Microsoft Office purchased.

100 We estimate the cost of an average (collocated) server at €2,504 (see Raju Chatla, "How Much Do Servers Cost to Run?," Serverbasket.com, 5 November, 2022, https://www.serverbasket.com/help/how-much-do-servers-cost-to-run/, accessed April 19, 2024), the cost of Microsoft Office at €218.99 (see Amazon.fr, "Office Famille et Petite Entreprise 2021," https://www.amazon.fr/Office-Famille-Entreprise-d%C3%A9finitif-T%C3%A9l%C3%A9chargement/dp/B09BPGX5KV/?th=1, accessed 19 April, 2024), the monthly maintenance cost at €73 and that the server (and the software license) needs to be re-expensed every 5 years (see Kharmela Mindanao, "How Much Does a Server Cost in 2024? (All Factors Explained) [Updated]," Itsasap.com, 2 August, 2023, https://www.itsasap.com/blog/server-cost, accessed 19 April, 2024). The calculation is thus (€2,504+€218.99×10)/5+€73×12=€1,815.

101 The monthly cost of Google Workspace is €5.5 per user (Business Starter package).

102 Note that under our estimates, if the firm grows to approximately 60 employees, the cost of the in-house solution becomes cheaper. However, this estimate assumes that the cost of server remains fixed, which is also improbable. As the firm grows, it will require better equipment.

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109 Business.amazon.com, "Here's how we've helped customers save," https://business.amazon.com/en/find-solutions/reduce-costs/savings-discounts#:~:text=30%25,on%20Amazon%20Business, accessed 4 April, 2024:~:text=30%25,on%20Amazon%20Business.

110 Our calculations are details in Appendix V.A.

111 According to one of the interviewed founders, Amazon is not always the cheapest option when other platforms are considered. For example, AliExpress can, most of the time, offer cheaper prices. This however comes at the cost of lower quality and longer delivery times.

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114 Rob Errera, "Office Supplies Cost: A Detailed Review of Market Trends and Cost Reduction Strategies," 20 July, 2023, https://www.tonerbuzz.com/blog/office-supplies-cost/, accessed 12 April, 2024.

115 The threshold of €2,000,000 in revenues is sometimes used to distinguish between small and micro firms. See EUR-Lex, "Micro-, small- and medium-sized enterprises: definition and scope," 11 January, 2016, https://eur-lex.

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117 EIB Group Survey on Investment and Investment Finance: A technical note on data quality EIB Working Paper 2020/08, September 2020.

118 Chief Financial Officer (CFO). Chief Executive Officer (CEO).

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120 Pana Alves, Daniel Dejuán, and Laurent Maurin, "Can survey-based information help assess investment gaps in the EU?," Banco de Espana, Occasional Papers 1908, 2019.

121 For each technology, surveyed firms have the choices between the following replies: Not used in the business; Used in parts of the business; Entire business is organised around this technology; Don't know; Refused.

122 Technologies include (i) 3-D printing, (ii) augmented/virtual reality, (iii) automation via advanced robotics, (iv) big data/AI, (v) drones, (vi) digital platform technologies and (vii) internet of things ("IoT").

123 Daron Acemoglu and Pascual Restrepo, "Robots and Jobs: Evidence from US Labor Markets," *Journal of Political Economy,* Vol. 128, No. 6, June 2020, https://doi.org/10.1086/705716.

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126 Cusolito et al. (2020) consider the adoption of email and website technologies on the productivity of manufacturing firms in developing countries. Ana Paula Cusolito, Daniel Lederman, and Jorge Peña, "The Effects of Digital-Technology Adoption on Productivity and Factor Demand: Firm-level Evidence from Developing Countries," No. 9333, 2020, https://doi.org/10.1596/1813-9450-9333.

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128 The paper uses 2016–2018 survey data for nine types of digital technologies: 1) Optic-fiber ultra-broadband connection, 2) Mobility connection (4G and 5G), 3) internet of things, 4) Immersive technologies, 5) Elaboration and analysis of big data, 6) Advanced automatization, collaborative robots, and smart systems, 7) 3D printing, 8) Simulation of interconnected machines, 9) Cyber-security. Francesco Nucci, Chiara Puccioni, and Ottavio Ricchi, "Digital technologies and productivity: A firm-level investigation," *Economic Modelling*, Vol. 128, 2023, https://doi.org/10.1016/j.econmod.2023.106524.

129 Average productivity is higher for larger firms. Labour productivity is measured as ln(1+revenue/employees).

130 Please refer to the Appendix V.B for technical details about the methodology and complete results.

131 Micro (5-9 employees), Small (10-49 employees), Medium (50-249 employees), Large (250+ employees).

132 In EIBIS, firms are asked about the usage of formal strategic business monitoring systems. We consider the use of these systems to be an indicator of better management practices.

133 Table 8 in the appendix presents the coefficients associated with these results.

134 Considering that all characteristics of the firm, besides level of fixed assets and platform usage, are equal to the average firm.

135Given that the dependent variable is in logarithms, the effect of digital platform adoption is computed as e^(Platform Effect)-1.

136Dan Andrews, Giuseppe Nicoletti, and Christina Timiliotis, "Digital technology diffusion: A matter of capabilities, incentives or both?," European Economic Review, 2020, https://dx.doi.org/10.1787/7c542c16-en. Nicholas Bloom, Raffaella Sadun, and John Van Reenen, "Americans Do IT Better: US Multinationals and the Productivity Miracle," *The American Economic Review*, Vol. 102, No. 1, 2012, pp. 167-201, http://dx.doi.org/10.1257/aer.l02.1.167.

137 Data is available quarterly from 2019 to 2023 at Github.com, "Teamookla, ookla-open-data," https://github.com/teamookla/ookla-open-data, accessed 4 April, 2024., data portraited at European Data Journalism Network, "Average internet speed across Europe," https://datavis.europeandatajournalism.eu/obct/connectivity/, accessed 4 March, 2024.

138 Please refer to the Appendix V.B for technical details about the methodology and complete results.

139 Table 12 in the appendix presents the coefficients associated with these results.

140 Considering that all characteristics of the firm, besides level of fixed assets and platform usage, are equal to the average firm.

141 Given that the dependent variable is in logarithms, the effect of digital platform adoption is computed as e^(Platform Effect)-1.

142 We consider a firm financially constrained if it reports in the survey that it has asked for external financing and it has been rejected or if the firm got external finance but considers that it got too little or it was too expensive. We consider that a firm did not have access to skill labour

143 Enrico Letta, "Much More Than A Market," European Council, April 2024, https://www.consilium.europa.eu/media/ny3j24sm/much-more-than-a-market-report-by-enrico-letta.pdf, accessed 2 May, 2024.

144 Metro.fr, "Metro Website," https://www.metro.fr/, accessed 27 February, 2024. Amazon.fr, "Amazon Website," https://www.amazon.fr/ref=nav_logo, accessed 27 February, 2024.

145 Bureauvallée.fr, "Bureau Vallée Website," https://www.bureau-vallee.fr/, accessed 27 February, 2024. Amazon.fr, "Amazon Website," https://www.amazon.fr/ref=nav_logo, accessed 27 February, 2024.

146 The effect of digital platform adoption is computed as $Exp^{\beta\,Platform_{ijct}}$-1.

147 From Column (1) and (2). Marginal effects of platform adoption at average size level are statistically insignificant for specifications in Columns (3) and (4).

148 From Column (1) and (3). Marginal effects of platform adoption at average size level are statistically insignificant for specifications in Columns (2) and (4).

149 From Column (1) through (4).

150 Joshua D. Angrist and Jörn-Steffen Pischke, Mostly Harmless Econometrics: An Empiricist's Companion, Princeton University Press, 2009, https://doi.org/10.2307/j.ctvcm4j72.

151 Jeffrey M. Wooldridge, *Econometric Analysis of Cross Section and Panel Data*., The MIT Press, 2010. Joshua D. Angrist and Alan B. Krueger, "Instrumental Variables and the Search for Identification: From Supply and Demand to Natural Experiments," *Journal of Economic Perspectives*, Vol. 15, No. 4, 2001, pp. 69-85, 10.1257/jep.15.4.69.

152 On a technical note, for instruments to effectively account for endogeneity they need to satisfy two conditions. The instrument must be correlated with the endogenous explanatory variables, conditionally on the other factors, and the instrument cannot be correlated with the error term in the explanatory equation, conditionally on the other factors. The first condition is testable in our setting. For each specification, Table 11 includes two additional statistics, the F-Statistic of the first stage and the Cragg-Donald Wald F Statistic. Both statistics are useful to test for valid instruments. When the F-Statistic is, generally, above 10, and in this case then the Cragg-Donald test is higher than 16.38 we say that the instruments are strong enough. This is the case in all of our four specifications. The second condition is not testable, but it was discussed in the identification section.

153 From Column (1) and (2). Marginal effects of platform adoption at average size level are statistically insignificant for specifications in Columns (3) and (4).

154 From Column (1) and (3). Marginal effects of platform adoption at average size level are statistically insignificant for specifications in Columns (2) and (4).

155 From Column (1) through (4).

156 We consider a firm financially constrained if it reports in the survey that it has asked for external financing and it has been rejected or if the firm got external finance but considers that it got too little or it was too expensive. We consider that a firm did not have access to skill labour if it declares that access to skills was an obstacle for its investment policy.

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The views expressed in this report are exclusively those of the authors, and not of either of these institutions. The authors of this report acknowledge financial support from Google for the research on which this report is based, as described in our paper "Technology Equalizers: How Digital Platforms Level the Playing Field For Small Firms," with our coauthor Christopher Weiss from the European Investment Bank.
We thank him for the bulk of the empirical work we present here.
We also thank the European Investment Bank for granting us access to the EIBIS data.

RECOMMENDED CITATION:
Garicano, L., & Santaló, J. (2024). *Can Platform supported digitalisation raise the productivity of European firms,* Working Paper, IE Center for the Governance of Change.

IE CGC, July 2024