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# Digital platforms across the European regional energy markets

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ABSTRACT

Digital platforms increasingly propose business models that improve economic organisation -by better coordinating supply and demand under imperfect information- and attain higher efficiency levels. At the same time, the energy generation gradually reshapes into decentralised network with lower capacity, but able to manage demand and supply in real-time. However, the penetration of online platforms within the energy sector poses policy questions that are specific to platforms' business models. This study investigates a sample of 217 digital platforms running energy-related activities across the EU regional markets. These energy platforms make about 20% of the world energy platforms. By observing their characteristics and those of their surrounding markets, it appears that the digital platforms in the European energy sector still tend to be relatively small and concentrated in specific regions, often in the neighbourhood of capital cities. Furthermore, the quantitative analysis suggests that market size, digital readiness and regulatory quality are the most important features relating to platforms' presence in the EU regional markets. This paper offers empirical evidence and reflections to provide energy policy with key information to best ripe the potential of new technologies while being aware of their inherited complexities.

## 1. Introduction

The energy industry is facing a profound transformation driven by two main forces. On the one hand, the smooth convergence towards a carbon-neutral economy, requiring a steady transition towards clean energy represents perhaps one of the greatest challenges of our time (Mediavilla et al., 2013; Moriarty and Honnery, 2016). On the other hand, the fast development and adoption of digital technologies in many areas of human activity is already changing the way in which individuals consume, firms produce, and societies communicate. The combination of these two forces creates important challenges in terms of renewable energy adoption (Bergek et al., 2013), investment and policy coordination, among others (Polzin et al., 2015). At the same time it also generates opportunities for improved energy efficiency, better resource allocation, the relationship of energy with other sectors and improved market performance, for instance (Pinkse and Groot, 2015). In Europe, both forces represent additional challenges due to, first, the resolute commitment to fix ambitious energy and climate targets and, second, as a result of the lagging technological position with respect to other areas of the world, namely the US and more recently also China.

In order to coordinate the transformation of the European energy supply, in 2015 the European Commission (EC) adopted the Energy Union strategy. Apart from promoting the use of more renewable energy, the initiative was oriented to the promotion of increased cross-border interconnections, as well as to guarantee a sufficient level of competition in all segments of the energy supply, by opening up the energy markets (Faure-Schuyer et al., 2017). Further to the Energy Union strategy, the package Clean Energy for all Europeans[1] entered into force in December 2018. This package encompasses three relevant pieces of legislation. First, the revised Renewable Energy Directive (EU) 2018/2001 to set a binding EU target of at least 32% of renewable energy by 2030, and the possibility to increase this share by 2023. Second, the revised Energy Efficiency Directive (EU) 2018/2002 sets a target of 32.5% of energy efficiency also by 2030. Third, the new Governance Regulation (EU) 2018/1999 that requires Member States to outline how they will achieve the targets by means of integrated National Energy and

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[1] https://ec.europa.eu/energy/en/topics/energy-strategy/clean-energy-all-europeanshttps://ec.europa.eu/info/news/new-renewables-energy-efficiency-and-governance-legislation-comes-force-24-december-2018-2018-dec-21_en.

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Climate Plans from 2021 to 2030. More recently, the European Green Deal[2] communicated in December 2019 constitutes a key point in the new EC strategy.[3] The Green Deal specifically states the urgent need to decarbonise the energy sector since the production and use of energy in Europe still accounts for more than 75% of the EU's greenhouse gas emissions.

Policy strategies can provide adequate incentives around digital technologies too (Wüstenhagen and Menichetti, 2012). The Digital Single Market strategy, launched in 2015, was designed to remove the existing barriers for a fully integrated internal digital market in the EU. One of the main objectives of this initiative was to enlarge the possibilities for cross-border business opportunities in a safer electronic environment. This strategy aimed at promoting electronically mediated transactions while at the same time it established concrete rules to tackle unfair practices by digital platforms (Duch-Brown and Martens, 2015a). Besides, in February 2020 the EC unveiled the new strategy for a digital Europe[4] with a strong emphasis on the benefits from technology to people and society, especially in connection with the environmental challenges and the sustainability of a successful economy. Digital technologies offer new means to the green challenges and lead policy to intertwine these two fields, thus reaping the most of benefits of a 'twin climate and digital transformations'.[5]

Traditionally, the centralised generation model adopted by most energy systems implied important economies of scale in the generation of energy, but also significant energy losses in its transmission and distribution. Given the nature of this model, grid management was mostly putting emphasis on the supply side. Now a shift is happening towards renewables-based decentralised systems. On the supply-side, this shift towards renewables is driven by the changes brought in energy supply by the introduction of renewables in the energy mix and important improvements in energy efficiency (Jacobsson and Bergek, 2004). On the other side, this shift is also determined by the increasing demand pulled by population growth with switching preferences towards more environmentally friendly consumption (Ellsworth-Krebs and Reid, 2016). Decentralised systems are characterised by distributed generation at, or close to, the consumption areas, and have enlarged energy grids with the addition of multiple and localised smaller energy networks. Distributed generation is expected to provide important environmental, economic, technical and social benefits. Nevertheless, before most of these benefits can materialise, there are important challenges to address, such as interconnection and supply coordination, decentralised energy storage, demand-response and grid stability, as well as financial considerations (Parag and Sovacool, 2016). These energy-related challenges require drastic changes to existing patterns of production and consumption to the same extent entrepreneurs with new business models appear where challenges and opportunities arise (Loock, 2012; Wüstenhagen and Wuebker, 2011).

Digital technologies have lowered the costs of collecting, sharing and using information, reducing search and transaction costs. In this respect, the costs to participate in some markets have become so little to allow peer-to-peer interactions or exchanges in collaborative economy platforms to emerge (Duch-Brown and Martens, 2015b). Moreover, rapid technological development and uptake push agents in the markets, particularly small and medium sized enterprises, to adapt their processes quickly and catch-up as fast as possible (Arendt, 2008). Finally, although market entry costs are reduced due to lower transaction and search costs, opportunities for intermediation in these markets means that the strength of indirect network externalities cause increased concentration, reducing competition and altering traditional market structures and thus organisational models and governance systems (Rochet and Tirole, 2003, 2006). Hence, digitalisation offers many benefits but also poses relevant challenges for the future.

The interplay between the energy transition and the digital transformation bring about alternative energy sources and new ways to enact and distribute them. The energy sector experiences changes via new technologies and different business models that are critical to ripe the best of the energy transition (Richter, 2013; Schaltegger et al., 2016). Digital platforms have emerged as new business models that rely on digital technology to offer novel and improved mechanisms to address the fundamental problem of economic organisation: how to coordinate supply and demand with imperfect or limited information in order to attain the highest possible efficiency (Duch-Brown, 2017). Coordination in a context of sophisticated economies where there is an increasingly varied offer of goods and services and a large dispersion of consumer preferences, requires complex matching mechanisms, making algorithms and data fundamental pieces of the digital economy (Coyle, 2016). Moreover, since online platforms exploit and match large data they entail welfare redistribution for the entire society (Martens, 2016).

Digital platforms could make many significant contributions to the digitalisation of the energy industry (Kloppenburg and Boekelo, 2019). Energy generation increasingly includes a diverse and decentralised network with lower capacity but able to manage demand and supply in real-time, where platforms could provide enhanced matching services. Digital platforms could efficiently manage grids with an ever-increasing share of renewables. From the perspective of social media and sharing economy (Van Dijck et al., 2018) the benefits of platforms come from new ways of connections at lower costs. Digital platforms are organisational innovations relying on technological solutions to tackle coordination problems in many economic activities including energy.[6]

In this paper, we look at the penetration of digital platforms in the European energy industry with the objective to identify the regional characteristics associated with their presence. The data used comes from a novel information service able to identify characteristics of firms that are normally not available, by means of sophisticated text mining techniques. We first provide a description of these relatively new operators in the markets. To the best of our knowledge, this is the first description of the geographic distribution of energy platforms in Europe. Second, we perform a series of econometric exercises in which we try to disentangle some of the factors that explain their choice of location, and their number. The results show, first, that the number of platforms active in the EU in 2017 is relatively small and highly concentrated in a handful of regions. The quantitative analysis suggests that the most important features that drive the creation of platforms in these regions are related to market size, digital readiness and regulatory quality.

The penetration of online platforms within the energy sector poses policy questions that are specific to platforms' business models and that address data regulation and social welfare. Particularly about data regulation, the EC envisages a 'Common European energy data space'[7] to stimulate higher levels of data sharing and data availability across sectors so to allow the emergence of innovative solutions for the decarbonisation of the energy system. In this respect, platforms can play a role in the fulfilment of the Common European energy data space possibly facilitating the sharing and availability of data. This paper provides evidence about the participation of online platforms in the

[2] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=COM%3A2019%3A640%3AFIN; https://ec.europa.eu/info/strategy/priorities-2019-2024/european-green-deal_en; https://ec.europa.eu/commission/sites/beta-political/files/political-guidelines-next-commission_en.pdf.

[3] https://ec.europa.eu/commission/sites/beta-political/files/political-guidelines-next-commission_en.pdf.

[4] https://ec.europa.eu/commission/presscorner/detail/en/ip_20_273.

[5] https://ec.europa.eu/commission/presscorner/detail/en/speech_20_247.

[6] Platforms optimise the use of underutilised assets (Belk, 2014), enable new collaborative lifestyles (Hamari et al., 2016), create entrepreneurial opportunities (Autio et al., 2014), and support communities in controlling their local resources (Scholz and Schneider, 2017).

[7] https://ec.europa.eu/info/sites/info/files/communication-european-strategy-data-19feb2020_en.pdf.

European energy sector. In the rest of the paper, section 2 describes the methodology used, while section 3 presents the data employed for the analysis. The results are discussed in section 4. Section 5 concludes and offers a detailed analysis of the policy implications derived from the quantitative analysis.

## 2. Empirical strategy and methodology

This section provides insights about the methodology employed in this paper. The methodology encompasses two steps. First, collecting relevant variables to account for platforms presence and characteristics at NUTS2[8] level into a unique dataset. Second, performing regression analysis on the aggregated dataset in order to check what regional characteristics mostly relate to the presence of energy platforms.

In Section 3 we specifically describe the main characteristics of the dataset as for the information about energy digital platforms (Section 3.1 and 3.2) and the additional data (Section 3.3) that we employ to perform established econometric methods with the aim to provide stylised facts and insights about the role of these new businesses in the European energy industry. Since the present research required several methodological decisions that necessarily condition its results, we explain these decisions and their implications in what follows.

A first important decision concerned the relevant geographic scope. Although our database includes worldwide energy digital platforms, we decided to focus on the European Union (EU) because of the following reasons. First, since this research aims to provide policy suggestions, then focusing on a relatively homogeneous and integrated area where policies could have a direct impact appears particularly convenient. Second, the EU is strongly promoting a carbon-neutral economy based on ambitious deployment of renewable energy installations that would increase the needs for better system coordination; therefore, digital platforms can possibly have an impact. Finally, the EU has been also promoting a deeper digital integration by means of the Digital Single Market strategy, which should help removing remaining barriers to digital cross-border transactions.

A second relevant decision dealt with the choice of geographical units: countries or regions. The decision to take a regional perspective originates from two main factors. First, since regional units are more than countries, this directly increases the number of observations and hence the degrees of freedom of our estimations. Second, a conceptual reasoning also suggests that since digital platforms in energy are still at an initial phase their business reach is still limited and circumscribed to relatively reduced areas of influence. This parallels the anecdotal evidence in other sectors where digital platforms have started with a small scale and focused on relatively small geographic markets before being able to launch a worldwide expansion. Digital platforms can actually scale up -and potentially reach millions of users all over the world-only after a sufficient number of users on the different sides join the service (Evans, 2009). This is still not the case in the energy industry. Third, in the current transition to decentralised energy systems, the role of local communities is important, and a regional approach better serves the purpose of studying these communities. Since the database includes information about the city where the energy digital platforms have located their headquarters, we use this information to allocate all our companies to NUTS2 regions. Corporations are excluded from the sample, and an additional assumption is that the location of companies correspond to their relevant markets for operation.

A third decision regards the econometric model we chose to estimate, whose motivation lies in assumptions about the digital markets' dynamics. First-mover advantages in digital markets are important, although they do not always turn out decisive. As opposed to traditional markets, these advantages arise due to the interplay of indirect network externalities, economies of scale and switching costs. This is an important policy and regulatory concern since these factors can create barriers to entry and promote concentration. There is a relatively long tradition in empirical industrial organisation to analyse entry models, starting with Bresnahan and Reiss (1991) and Berry (1992). However, entry decisions in traditional markets are not necessarily the same as those taken in multi-sided, i.e. platform, markets (Evans and Schmalensee, 2010). The empirical entry literature has focused so far on traditional markets, and a proper theoretical analysis of entry in multi-sided markets is still to be developed. Hence, any attempt to estimate an entry model would necessarily be based on some theoretical weaknesses and the results would then be conditioned to the assumptions made. In that respect, we have preferred to focus on a reduced form econometric model. The aim of the model is to explain the number of operative digital platforms in the European energy industry.

Since our dependent variable reflects the number of energy digital platforms by NUTS2 regions in 2017, there are two options for the empirical analysis, both based on the counts of firms per region, but with different implications (Arauzo-Carod et al., 2010). First, when the analysis focuses on individual decision by firms and the question is how market characteristics and firm attributes affect entry or location decisions, discrete choice modes are the most appropriate methodological approach. This is, along with a sound theoretical background, the path followed in the empirical industrial organisation literature mentioned before. Second, when the unit of analysis is instead the geographical unit that hosts the firms, and the independent variables represent the regional features that constitute the relevant location attributes, then count data models are preferred. These latter models provide information about how variations in the attractiveness of a given location impact the (conditional expectation of the) number of firms at each region. This is the approach followed in this paper.

Considering the nature of the dependent variable, i.e., nonnegative integers (counts), the best match would be the Poisson model. However, in many empirical applications, issues related to overdispersion (i.e. excessive number of zeros) arise frequently from unobserved heterogeneity in the conditional expectation parameter, and they question the validity of the Poisson model. Yet, the presence of heterogeneity causing overdispersion can be handled by relying on so called mixture models that incorporate an independent and identically distributed (i.e. an i.i. d.) variable unrelated with the covariates. Specifically, observations are considered independent events, and they are assumed to be generated by the same probability distribution. In cases like this, the most frequently used model is the Negative Binomial (NB) model (Delgado et al., 2010; Wooldridge, 2010). In addition to this, a zero-inflated model is a mixture between a binary distribution with a single possible value (i.e. zero), and a negative binomial count distribution. The zero-inflated model allows some of the zeros to be analysed along with the non-zeros as it assumes that two distinct processes drive the zeros: the sampling zeros that occur by chance because of a dichotomous process; and the inevitable structural zeros that are part of the counting process. Therefore, while the simple NB model only allows to state whether the excess zeros come from the splitting mechanism or from unobserved heterogeneity (Greene, 1994), the zero inflated negative binomial (ZINB) allows to distinguish between the effect of the splitting mechanism and the overdispersion (i.e. excess of zeros) induced by individual heterogeneity of regions (Liviano and Arauzo-Carod, 2013). All this being considered together with the fact that about 70% of the values in our dependent variable (i.e. platform counts) are zeros, we opt for estimating a ZINB model to study which regional factors mostly correlate with the number of digital energy platforms in the EU NUTS2 region.

[8] The NUTS classification (Nomenclature of territorial units for statistics) is a hierarchical system to classify the EU economic territory in order to collect, develop and harmonise the European regional statistics. The NUTS account for three levels of detail from larger to smaller geographical areas: NUTS1 are major socio-economic regions; NUTS2 are basic regions for the application of regional policies; and NUTS3 are small regions for specific diagnoses. (see https://ec.europa.eu/eurostat/web/nuts/background).

## 3. Data

In this section we describe the assembled database in order to perform the empirical analysis. First, we describe the database on energy platforms and provide a description of the European energy platforms landscape. Second, we discuss some examples of the platforms included in the data that can be representative of their activities. Finally, we explain the other variables collected for the analysis as well as their sources.

### 3.1. Overview of energy platforms

The data employed in this paper are from Dealroom.co,[9] an information service founded in 2013 in London with the aim to connect investors and high-growth companies. They collect information on companies, with a particular focus on technology, high-growth companies and venture capital. It presently tracks expanding networks of companies and investors at all investment stages, from seed to late-stages and buyout. This database also builds on a number of tools from news-flows, web scraping, machine learning, data partnerships, and data science among others to classify companies in categories not available in other firm-level sources or even national statistics. The consolidation of multiple data sources into one database is particularly useful for Europe which is a fragmented, multi-language market.

In the database, we were able to identify a total of 1062 companies worldwide that are classified as being active in energy and having adopted a platform business model. The great majority, 622 (58,6%) are located in the US and Canada, while 281 (26,5%) have their headquarters in Europe[10]. Restricting this dataset to those energy platforms located in the EU, that are active in 2017, and provide information about the location of their headquarters, we end up with a total number of 217 active digital platforms in the European energy industry in that year. Due to the availability of complementary data, particularly with a regional dimension, we were forced to focus on the year 2017. The figures below describe some of the main characteristics of these new operators in the energy sector.

Fig. 1 shows the evolution of the number of EU active platforms by founding year over the period 1995–2017. The starting year corresponds with the creation of many big and well known platforms in other sectors. The figure shows, first, that some digital platforms focusing on energy activities were established already in the 90s. The evolution shown in the figure indicates very low numbers in the period 1995–1999, a relative peak in the year 2000 due to the dot.com bubble, with the corresponding slowdown in the rate of entry of this type of firms in the early 2000s, once the bubble busted. The figure also shows that the number of platforms entering the energy industry starts to rise again from 2007 onwards.

Fig. 2 shows how these platforms are distributed across the different EU countries. As can be seen from the figure, 20 out of 28 EU Member States have at least one platform active in the energy industry. A strong majority (i.e. 25%) of the EU platforms are from the United Kingdom. In addition, France, The Netherlands and Germany host significant number of platforms, followed by Spain, Italy and Ireland. On the other hand, Hungary, Estonia, Cyprus, Bulgaria and Austria host only one energy platform each.

From a regional perspective, Fig. 3 shows the number of energy platforms in the top 15 EU NUTS2 regions. The first thing to note is that, out of the 273 NUTS2 regions in the EU, only 76 regions host at least one energy platform. Secondly, the Figure also shows that these top 15 regions represent 57% of all energy platforms, an important spatial agglomeration. The overall geographic distribution of energy platforms in the EU is shown in Map 1 confirming that most regions do not have any energy platform located in their territory. This is consistent with the fact that, despite early entrants as shown above, we are in an early stage of the digitalisation process of the energy industry. As digital technologies are increasingly adopted and new applications discovered, we should observe more entry, even in regions that do not represent profitable opportunities for these companies today. In addition, we will observe that some of the platforms already operating in these markets will scale-up as soon as the appropriate combination of users starts fuelling network externalities on the platform's different sides.

As digital technologies are developed and adopted, new business opportunities appear. These can focus on the intermediation between energy suppliers and end-users, i.e. a B2C (business to consumer) orientation, or could also target intermediation services among different companies, exclusively within the energy industry or between energy companies and firms operating in other sectors (B2B or business to business). Particularly 77% of energy platforms from our sample adopt a B2B business strategy.

These platforms are all involved with the energy sector, yet a half of them is solely involved with energy while the other half works in sectors at the border between energy and other sectors. A relatively large amount of platforms work in financial technology (i.e. fintech), transportation, enterprise software, and Internet of Things (IoT). The residual category includes platforms that connect energy with ancillary activities such as home living, legal issues, robotics, construction and travel, for instance. Fintech is the application of modern technology to any type of financial process or project, particularly renewables like wind or solar energy, in order to manage risk, improve capital costs, and maximize returns on investment. Finally, fintech enables innovative solutions that maximize the potential of decentralised energy access given that the high upfront cost for consumers is on occasion one of the heaviest barriers to buying new energy technologies. The association between energy and transport is definitely more straightforward given the call to make transport more sustainable in terms of emissions. Also software are very much needed by the energy advancements, especially of energy platforms, because of the variety of energy-related applications to provide users with utility bill tracking, real-time metering, control systems, or support to the construction and maintenance of smart grids, just to mention few examples. Finally, IoT devices also relate to energy sector and platforms as they help to manage autonomously the lighting, heating, and other energy related utilities in order to reduce energy consumption and attain higher energy efficiency.

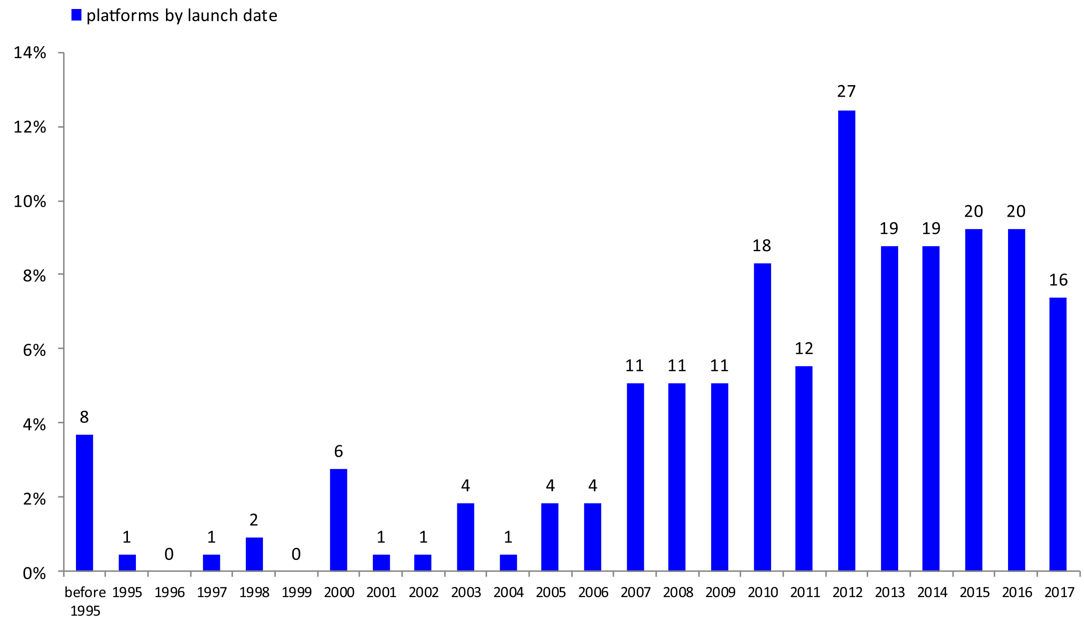
About the growth stages (i.e. seed, early growth, late growth, and mature stage) of these energy platforms, 35% of them are at a seed stage, 37% are at an early growth stage, while respectively 16% and 2% are at late growth stage and at mature stage. This information confirms that the role of platforms in energy is still at a very early stage and that we should observe strong developments in the near future. Finally, concerning their size, the majority (i.e. 85% overall) of platforms employ between 1 and 50 workers, 22 platforms have between 51 and 200 employees, and only 8 platforms (4%) have more than 201 employees. The size distribution of energy platforms also indicates that we are still in an early phase and that most of these companies are start-ups looking to make a sufficiently interesting business proposition in order to scale-up.

From the description of platforms' characteristics[11] we conclude that the European energy platform ecosystem is made of a heterogeneous set of firms, with highly diversified activities, sizes, market orientations, and geographical locations.

[9] More information at dealroom.co.

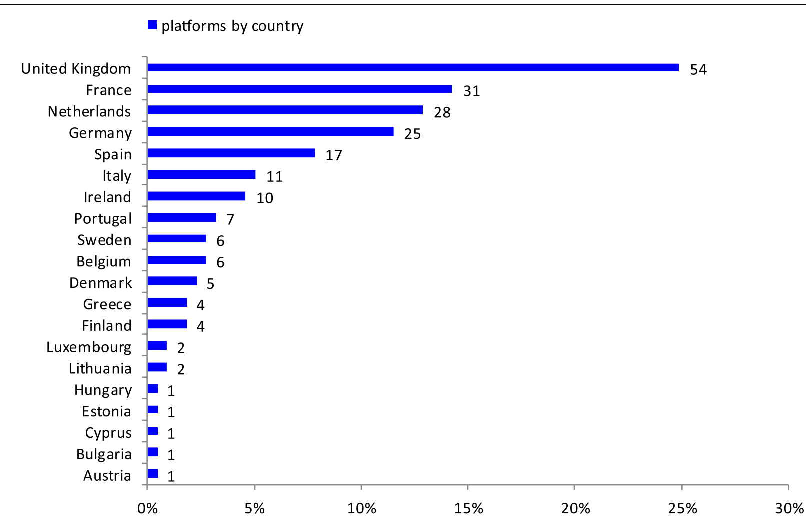
[10] To the purpose of this study we consider the EU28 as of 2017 (i.e. before BREXIT took place), therefore still including the United Kingdom.

[11] Figures about the distribution of platforms' by business model (i.e. B2B, B2C, B2B/B2C), by industry, by growth stage, and by size are available upon request although not showed in the paper for space reasons.




**Source**: Dealroom.co (last update 28/05/2019)
**Note**: Total sample of 217 EU active platforms until 2017.

**Fig. 1.** Energy platforms by launch date.




**Source**: Dealroom.co (last update 28/05/2019)
**Note**: Total sample of 217 EU active platforms until 2017.

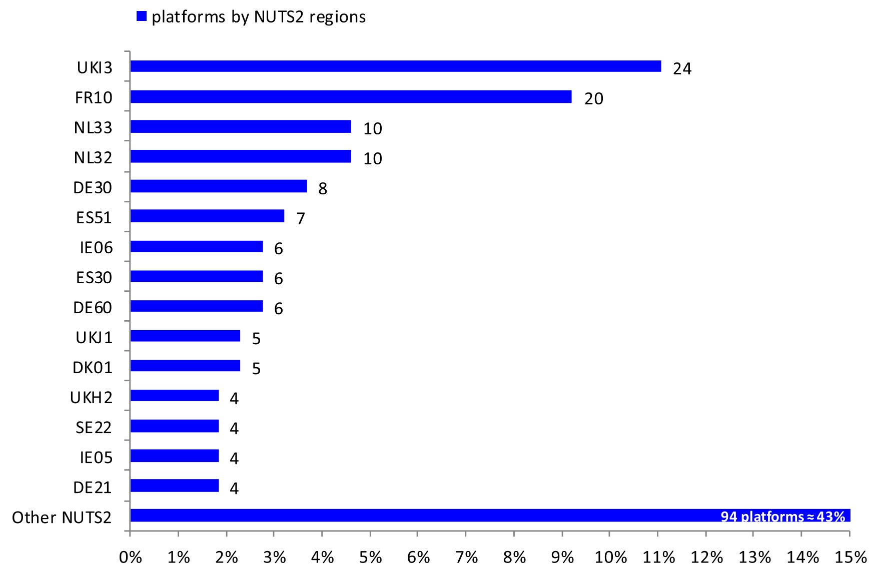
**Fig. 2.** Energy platforms by country.

### *3.2. Some examples of EU energy platforms*

This section presents some examples of EU platforms included in the database in order to better grasp how platforms operate in the energy sector, and how they link energy to new sectors (e.g., fintech, IoT, transport). Focusing on few concrete EU platforms helps to visualise how these firms operate in creating new ways to connect businesses to other businesses (i.e. B2B platforms), or businesses to consumers (i.e. B2C platforms), or both. In general, a B2B focuses on selling products, services, or information to other businesses, in contrast to the B2C business model that envisages transactions between a company that sells products or services and individual customers who are the end-users of these products. Fig. 2 shows that the United Kingdom gathers the most of the EU active platforms from the employed database, therefore the first three examples of platforms come from this country. For a larger list and more detailed descriptions of energy platforms, see Küfeoğlu et al. (2019).

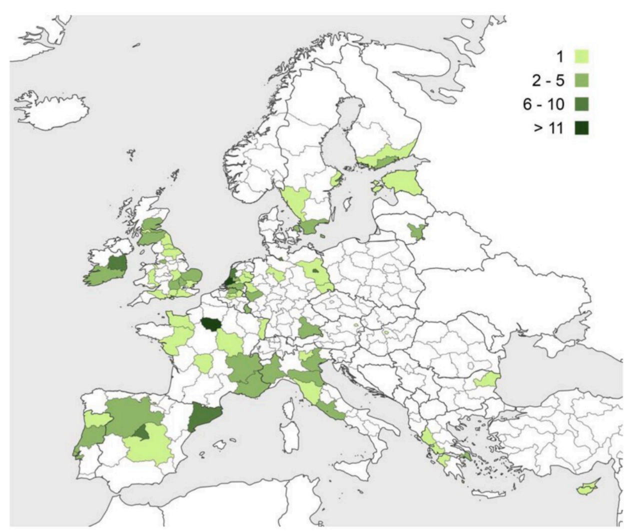
The first platform picked as example is GridBeyond,[12] a British B2B firm that offers balancing services to connect businesses among each other and to find the most financially beneficial balancing services available. In its own words, '*GridBeyond's unified platform uses machine*

[12] https://gridbeyond.com.




**Source**: Dealroom.co (last update 28/05/2019)
**Note**: Total sample of 217 EU active platforms until 2017. The NUTS2 of the Figure correspond to the following regions: ***Inner London – West*** (UKI3); ***Île de France*** (FR10); ***Zuid-Holland*** (NL33); ***Noord-Holland*** (NL32); ***Berlin*** (DE30); ***Cataluña*** (ES51); ***Eastern and Midland*** (IE06); ***Comunidad de Madrid*** (ES30); ***Hamburg*** (DE60); ***Berkshire, Buckinghamshire and Oxfordshire*** (UKJ1); ***Hovedstaden*** (DK01); ***Bedfordshire and Hertfordshire*** (UKH2); ***Sydsverige*** (SE22); ***Southern Ireland*** (IE05); ***Oberbayern*** (DE21).

**Fig. 3.** Energy platforms by region.




**Source**: own elaboration with data from Dealroom.co (last update 28/05/2019)
**Note**: Total sample of 217 EU active platforms until 2017.

**Map 1.** Energy platforms by region.

*learning technology to enable participation in a wide range of programmes for enhanced energy automation, insights and benchmarks, savings, revenues and sustainability*'. This platform focuses on the technology that brings together all areas of the energy market and analytics to offer businesses enhanced energy service programmes. Moreover, a variety of energy experts -battery providers, electricity supplier, energy brokers or consultants-partnered with GridBeyond advice upon the energy strategy of the businesses that link up to the platform.

On the side of B2C platforms, another UK example is Love Energy Savings[13] which provides customers –either businesses or homes-with a personalised service for their energy choices. Each customer has a dedicated account manager who identifies savings that can be made on

[13] https://www.loveenergysavings.com/.

the energy bill by switching to better energy deals, and subsequently negotiates with energy suppliers. The experts of this platform make comparisons of commercial gas and electric prices for their customers, providing them with instant access to a wide range of tariffs to easily compare deals. This platform also targets large businesses from various sectors (i.e. bars and restaurants, manufacturing, public, retail and leisure) to offer utility strategies tailored to their specific needs and requirements.

Some platforms bridge different sectors, like the British platform Abundance Investment[14] that takes part in both the energy and the fintech sectors. This online investment platform is at the forefront of financial innovation by creating opportunities for everyone to invest in green and social infrastructure. Specifically, this platform aims to support projects that deliver benefits for society and the environment -including renewable energy, and it is the first community finance platform/crowdfunding platform authorised and regulated by the Financial Conduct Authority. Everyone can create a free-of-charge account of 5£ and start making a portfolio of investments offering an ample choice of returns (i.e. fixed, variable, even-driven, inflation-linked). This platform offers tax-free returns and possibility to design pension plans while investing in green ventures.

A fourth example of how these platforms connect energy to other sectors is the We4Sea[15] from The Netherlands. We4Sea operates across the sectors of energy and transport as it provides devices to chartered ships to manage fuel consumption and emissions of vessels. The special feature proposed by this platform is the concept of Digital Twin they developed in-house. Specifically their algorithm uses more than 80 characteristics of the ship to create a Digital Twin, which is fed with real-time position and weather data to accurately calculate fuel consumption and emissions of conventionally powered ships within 24 h. In this way ships can –with no new hardware on board– benchmark reported vs expected consumption, optimise speed and fuel efficiency in real time, analyse past voyages online, and improve fuel consumption predictions for future voyages.

Similar examples of cross-sectoral platforms are the French Metron[16] and the Dutch Chargetrip.[17] The first platform ties the energy sector with IoT and targets enterprises to provide them with suggestions on energy optimisation. The platform connects to customers' data in real time via AI algorithms, then a virtual assistant simulates and predicts energy patterns to detect non-intuitive optimizations. The second platform instead ties the energy sector with transport by providing electric vehicles (EV) users with smart navigations during their journeys, especially long ones. This platform offers intuitive applications for EV drivers to enjoy trip planning, station overviews, live navigation and integrations with payment providers. Chargetrip also targets the EV industry with its commitment to produce innovations that EV producers may offer to their drivers in order to enhance the EV driving experience.

These examples show the multiplicity of new business opportunities created by digital technologies in the energy sector.

### 3.3. Independent variables and model specification

To complement our dependent variable, we collect a number of variables related to the regional economic conditions, as well as some energy indicators, to disentangle their effects on the number of operative platforms in each region. Specifically, the variables we use as independent controls in our regressions are at the regional (NUTS2) level in order to detect which features play a role in the entry decisions of energy platforms. The aim of this exercise is to suggest areas in which existing energy policies could be improved by the use of digital technologies and, at the same time, identify the most salient features of the penetration of platforms in the energy industry in Europe.

Table 1 presents the variables employed in the quantitative exercises of the next section. As described in section 3.1 above, the dependent variable is the number of energy platforms at regional NUTS2-level from Dealroom.co. The independent variables are taken mostly from Eurostat indicators at NUTS-2 level[18] that are meant to provide proxies for digital infrastructure, market size, quality of government and income effects. Specifically, the regressions account for the participation in the digital infrastructure as measured by the percentage of individuals using internet inside NUTS2 regions. This covariate represents an important factor to measure in regions since it appears that 'ICT platforms recognize the growth of many communities and offer tools that allow users within such communities to manage membership' (Yu et al., 2017). While, on the other hand, the lack of digital skills may considerably hamper both entrepreneurial (Lucendo-Monedero et al., 2019) and individual ability (Van Deursen et al., 2014) to benefit from new technologies.

In addition, both the market size constituted by the population of individuals (i.e. potential final users) of NUTS2 regions, and the market size constituted by the business population of active enterprises (i.e. the potential businesses liaised by digital platforms) within NUTS2 regions are controlled for. A bigger population of users can potentially empower the platforms and trigger their presence, while at the same time powerful platforms can connect larger populations (Messinger et al., 2008). While as for the population of active enterprises, this variable grasp the business opportunities for platforms to match previously unconnected markets (Täuscher and Laudien, 2018).

**Table 1**
Summary statistics.

| Variable | Year | Obs | Mean | Std. Dev. | Min | Max |
|---|---|---|---|---|---|---|
| platforms (number) | 2017 | 273 | 0.79 | 2.37 | 0 | 24 |
| individuals using internet (% of individuals) | 2017 | 266 | 73.1 | 12.05 | 40 | 95 |
| population (Million) | 2017 | 273 | 1.9 | 1.5 | 0.03 | 12.2 |
| European Quality of Government Index - EQI (scores) | 2017 | 273 | 0.2 | 1 | −2.26 | 2.32 |
| business population (Thousands) | 2016* | 152 | 145.8 | 151.8 | 3.0 | 1122.6 |
| GDP per person (Thousand euro per inhabitant) | 2017 | 273 | 29.2 | 17.6 | 4.6 | 209.9 |
| capital (dummy) | 2017 | 273 | 0.1 | 0.3 | 0 | 1 |
| operational nuclear reactors (number) | 2017 | 273 | 0.46 | 1.48 | 0 | 14 |

***Note***: Data sources are Dealroom for the variable 'platforms'; Eurostat for the variables 'population', 'business population', 'individuals using internet', 'GDP per person'; Charron et al. (2019) for the EQI; own calculations from internet public information (i.e. Wikipedia) about operational nuclear reactors. * or last available year.

Additional controls include regional scores[19] of the European Quality

[14] https://www.abundanceinvestment.com/.
[15] https://www.we4sea.com/.
[16] https://www.metronlab.com/.
[17] https://www.chargetrip.com/.

[18] Values at NUTS1 and NUTS0 level are occasionally employed for the 'individuals using internet' in absence of NUTS2 values.
[19] NUTS1 scores are occasionally employed in absence of NUTS2 values.

of Government Index (EQ I[20]) (see Charron et al., 2019) and the GDP per person at NUTS2-level. We considered the EQI as a quite relevant variable since high-quality regional governments can facilitate economic interactions (Rodríguez-Pose and Garcilazo, 2015), foster the level of entrepreneurship of European regions (Nistotskaya et al., 2015) and boost the effectiveness of regional development strategies like those prompted by the EU. Moreover, the EQI allows testing the relative strength of regulatory conditions vis-à-vis market characteristics. The GDP per person at NUTS2-level is also included in the regression analysis as evidence suggests the presence of income effects in the participation of individuals to platforms (Anderson, 2018), because of this platforms may opt for richer regions to establish their activities.

Finally, in some specifications we have also included a dummy variable to indicate those regions that host the countries' capitals. This is so because most of the energy utilities, as well as energy regulators tend to be located there. This may create a peculiar atmosphere where platforms could thrive. Finally, we also include the number of operational nuclear reactors by region. This variable allows controlling for the old energy system based on fossil fuels and strong economies of scale in generation. Our conjecture is that this variable and the number of platforms should be negatively correlated.

## 4. Results and discussion

As explained in section 2, we ran a series of zero-inflated negative binomial (ZINB) models (Greene, 1994). Table 2 shows the main results. The decision to adopt this model is determined by testing the goodness of fit for the distribution of platforms across the EU regional markets. This test indicates that the negative binomial distribution is a better fit than a simpler Poisson for the spatial distribution of digital energy platforms in the sample. The same test also shows the presence of overdispersion (i.e. excess of zeros) in the dependent variable. Intuitively this means that many regions have no platforms at all, while the majority of platforms spread across a minority of regions. The overdispesion of platforms calls for the adoption of the ' zero-inflated' model. The ZINB addresses the overdispersion (i.e. the excessive presence of zeros) of 'platforms', assuming that a specific process determines the presence of the excessive zeros (i.e. for a platform the choice of not selecting a region is not random, as much as the choice to select a region to establish its activity).

The distribution of the ZINB employed in this analysis is a mixture of a binary distribution that is degenerate (i.e. has a single possible value) at zero, and an ordinary count distribution such as negative binomial. Therefore, our ZINB model encompasses a negative binomial model to fit the non-zero values of 'platforms', and a logit model to fit the zeros of the variables 'platforms'. The variables selected for the logit model (i.e. the model that fits the absence of platforms within the regional markets) are representative of regional infrastructure and of the business market size, similarly to the count model to fit the presence of platforms within the regional markets. In addition the logit model also includes the regional number of 'operational nuclear reactors' since unfavourable economic conditions and strong presence of traditional energy-generation plants (like nuclear reactors) are believed to hinder the activities proposed by novel digital energy platforms. All regressions employ the above-described variables in the logit part.

Concerning the negative binomial part of the regressions, the first

**Table 2**
Zero-Inflated Negative Binomial regressions.

| | *platforms (1)* | *platforms (2)* | *platforms (3)* | *platforms (4)* |
|---|---|---|---|---|
| individuals using internet | 0.102*** | | 0.106*** | |
| | *(4.91)* | | *(5.82)* | |
| population (ln) | 1.887*** | 0.638 | 0.598 | |
| | *(13.35)* | *(0.78)* | *(1.10)* | |
| EQI | 0.0386 | 0.956*** | 0.152 | 0.501* |
| | *(0.19)* | *(4.04)* | *(0.70)* | *(1.99)* |
| business population (ln) | | 0.959 | 1.131* | 1.253*** |
| | | *(1.28)* | *(2.40)* | *(3.49)* |
| GDP per person (ln) | | | | 1.558** |
| | | | | *(3.11)* |
| Constant | −35.63*** | −20.98*** | −30.61*** | −31.24*** |
| | *(-11.37)* | *(-4.46)* | *(-9.13)* | *(-4.66)* |
| | **Inflation model = logit** | | | |
| business population (ln) | 2.288 | −0.0596 | 4.200 | −0.160 |
| | *(0.59)* | *(-0.09)* | *(0.91)* | *(-0.14)* |
| individuals using internet | −0.223 | −0.0973 | −0.257 | −0.0491 |
| | *(-0.93)* | *(-1.49)* | *(-1.09)* | *(-0.69)* |
| operational nuclear reactors | −0.182 | 0.0854 | −0.790 | 0.0758 |
| | *(-0.19)* | *(0.65)* | *(-0.31)* | *(0.48)* |
| Constant | −15.46 | 6.876 | −38.84 | 4.312 |
| | *(-0.42)* | *(1.01)* | *(-0.77)* | *(0.36)* |
| *Number of observations* | *148* | *148* | *148* | *148* |
| *Non-zero observations* | *35* | *35* | *35* | *35* |
| *LR chi2* | *53.37* | *40.41* | *58.3* | *49.4* |
| *Prob > chi2* | *0.0000* | *0.0000* | *0.0000* | *0.0000* |
| *Log likelihood (inflation model)* | *−105.76* | *−112.24* | *−103.29* | *−107.74* |

t statistics in parentheses; *$p < 0.05$, **$p < 0.01$, ***$p < 0.001$.

regression specification includes a proxy for the digital infrastructure represented by the percentage of individuals using internet, the regional market size constituted by the population of individuals (in logarithm) and the regional regulatory characteristics as measured by the EQI. It emerges a strong correlation between presence of energy platforms at regional level with both market size and regions' digitization. As with more sophisticated entry models, market size plays a strong role in the firm's decision to enter a given market since it generates expectations of high profits. However, larger markets attract more companies, so there may be associated competition effects. On the other hand, the level of digitalisation of the industry is also relevant to explain digital energy platforms entry since it provides a better infrastructure and a sufficient level of skills to adopt these technologies. On the contrary, the quality of the regulatory environment does not play a role in this specification.

The second specification compares the regional market size as for both consumers and business sides with the regional regulatory characteristics measured by the EQI. In this case a strong correlation emerges between platform counts and quality of regional government, indicating that platforms may take advantage of legal and regulatory certainty, as well as a stable environment where to start a business. Here, the model does not discriminate between the different markets sizes that would constitute two potential different sides for energy platforms. This can be explained by the fact that although it's true that platforms require two or

[20] The EQI index builds on three pillars: impartiality, quality and corruption of public services in the regions. The scores of the three EQI pillars have less variability (i.e. sometimes they are only available at NUTS1 or NUTS level) than the EQI index scores. However, we performed some regressions (available upon request) by substituting the EQI with its three pillars. The outcome highlights that service quality is positively (and significantly) correlated with platforms' presence. This may point to the fact that platforms are more concerned about whether a quality service is provided than about its impartiality or corruption.

more sides in order to exploit indirect network externalities, it's also true that a minimum threshold of users in both sides in necessary for network externalities to ignite.

The third regression specification includes digital infrastructure, both types of market size (i.e. the regional populations of individuals and of enterprises) and the EQI. In this specification, controlling for all these factors, a strong correlation arises between platforms' presence and both digital infrastructure and the population of active enterprises. Possibly, this latter effect is determined by the relative abundance of B2B energy platforms with respect to B2C within the employed database. Since the majority of energy platforms in our sample operate according to a B2B model, seems that entry or location decisions in this case is better explained by the presence of adequate digital infrastructure and the size of the market composed by potential business users. However, the statistical significance of this is relatively low, which would recall also the importance of bringing the two sides to the platform in order to trigger the network effects.

The fourth regression specification includes the EQI, market size on the business side and the GDP per person (in logarithm) as a measure of population's purchasing power. All these three covariates appear much correlated with the presence of digital energy platforms within regional markets. Distributional effects as for individuals' income could be acting too on the consumers' side of energy platforms since it would indicate the ability to pay for energy and ancillary services where platforms could eventually operate.

Overall, the regional digital infrastructure appears in a stable positive and significant correlation with the number of digital energy platforms in the regional markets, so do the market size related to the business side and the quality of government. On one side, digital infrastructures and market opportunities are a key trigger for platforms' decision to operate in a certain region. On the other side, European regions may benefit from specific government actions aimed to improve their attractiveness to thrive in terms of digital hubs.[21]

Table 3 shows the same estimation strategy of Table 2 with the inclusion of a dummy variable controlling for NUTS2 regions that host the country capital city. This check confirms the results and highlights a mild positive relation between the two variables. Since capitals tend to concentrate most headquarters of energy utilities and financial entities, big tech firms, as well as relevant universities and research centres and venture capital, can be considered as ideal locations for these energy digital start-ups, which may suggest the existence of digital hubs attracting digital platforms in the regional energy markets. All the results from the original regressions are maintained when including the capital dummy.[22]

**Table 3**
Zero-Inflated Negative Binomial regressions (with dummy for NUTS2 regions of countries' capitals).

| | *platforms (1)* | *platforms (2)* | *platforms (3)* | *platforms (4)* |
|---|---|---|---|---|
| *individuals using internet* | *0.0940**** | | *0.102**** | |
| | *(4.35)* | | *(5.14)* | |
| *population (ln)* | *1.783**** | *1.062* | *0.676* | |
| | *(11.11)* | *(1.31)* | *(1.19)* | |
| *EQI* | *0.0869* | *0.832**** | *0.159* | *0.539** |
| | *(0.43)* | *(3.52)* | *(0.74)* | *(2.10)* |
| *business population (ln)* | | *0.478* | *1.025** | *1.282**** |
| | | *(0.64)* | *(1.97)* | *(4.75)* |
| *GDP per person (ln)* | | | | *1.363** |
| | | | | *(2.48)* |
| *capital (dummy)* | *0.311* | *0.725** | *0.124* | *0.309* |
| | *(1.27)* | *(2.27)* | *(0.47)* | *(0.87)* |
| *Constant* | *−33.57**** | *−21.63**** | *−30.22**** | *−29.71**** |
| | *(-9.65)* | *(-4.97)* | *(-8.77)* | *(-4.66)* |
| | **Inflation model = logit** | | | |
| *business population (ln)* | *2.647* | *0.0616* | *4.172* | *0.0908* |
| | *(0.53)* | *(0.10)* | *(0.91)* | *(0.08)* |
| *individuals using internet* | *−0.243* | *−0.116* | *−0.259* | *−0.0647* |
| | *(-0.93)* | *(-1.70)* | *(-1.12)* | *(-0.86)* |
| *operational nuclear reactors* | *−0.351* | *0.0795* | *−0.820* | *0.0540* |
| | *(-0.13)* | *(0.58)* | *(-0.31)* | *(0.29)* |
| *Constant* | *−18.91* | *6.549* | *−38.36* | *2.156* |
| | *(-0.37)* | *(0.96)* | *(-0.76)* | *(0.19)* |
| *Number of observations* | *148* | *148* | *148* | *148* |
| *Non-zero observations* | *35* | *35* | *35* | *35* |
| *LR chi2* | *54.99* | *45.46* | *58.52* | *50.16* |
| *Prob > chi2* | *0.0000* | *0.0000* | *0.0000* | *0.0000* |
| *Log likelihood (inflation model)* | *−104.95* | *−109.71* | *−103.18* | *−107.36* |

t statistics in parentheses; $*p < 0.05$, $**p < 0.01$, $***p < 0.001$.

## 5. Conclusions and policy implications

Digital technologies have created new markets and business opportunities. Since the appearance of the first fully digital companies in the mid-90s, a dynamic digital business ecosystem has emerged at a global scale and sectors such as entertainment and travel booking have been absolutely disrupted. There, digital platforms became major players in a relatively short period of time. Gradually, other sectors are becoming also target for new business models and types of firms based on digital technologies. In this paper, we have documented that, according to our source of information, there are already more than 1.000 digital platforms worldwide operating in the energy industry, and slightly more than 200 are currently active in the EU. The European energy digital platforms tend to be relatively small and concentrated in particular regions, where they can find some favourable conditions to try to scale-up.

The emergence of digital platforms provides benefits for consumers and firms. Specifically, platforms generate easier access to a wider variety of products and services, often at better prices and convenient delivery conditions for consumers. Platforms give firms the possibility to access a larger users market and they add a new dimension to traditional models of online operating firms. As discussed in the paper, platforms rely on network effects to attract more users on several sides of the market. They also profit from collecting data on their users' behaviour to strengthen their own competitive position.

Policy makers, particularly in Europe but also more recently in the US, have been considering regulatory interventions for platforms. In the EU, the EC's Digital Single Market strategy (May 2015) announced a comprehensive assessment of the role of platforms in the economy with a focus on several types of consumer and producer concerns. A regulation to bring transparency and ensure responsible behaviour of online

[21] These effects have emerged in a very high number of estimates performed during the exploratory stage of this study, and available upon request. Some specifications alternate different covariates also for the logit part of the model.

[22] When controlling for all the independent variables at once, strong evidence remains about the share of individuals using internet (i.e. the proxy of the consumers' side of platforms) and moderate evidence stays about the business population (i.e. the proxy of business' side of platforms). These estimates are available upon request although not showed in the paper for space reasons.

platforms entered into force in July 2019.

At the same time, Europe has embarked in a deep transformation of its energy system. The transition to a more decentralised and at the same time more decarbonised energy system implies important challenges. It is clear that this energy transition will require the uptake of digital technologies. For instance, digitalisation can be at the core of guaranteeing that energy supply remains competitive and affordable my means of offering tools for the efficient coordination of an enlarged and more complex system. Similarly, it will be crucial to achieve high standards in terms of security supply, in which platforms can play a decisive role.

There are several examples where digital technologies are already playing important roles in the energy system. Smart grids and smart metering, for instance, are the most salient examples. Others would include smart home appliances, smart cities to name just a few. Clearly, digital technologies offer multiple opportunities to improve the performance of the new energy system, such as allowing the active participation of consumers in the system, while at the same time it will be possible to use energy more efficiently; or by fostering and optimising the use of renewables-based energy.

On the other hand, competition policy authorities have been paying attention to digital businesses for some time. However, competition law is based on specific cases and mainly looks at issues related to possible market dominance and the distortions this may generate. While competition policy examines market positions, regulators may want to enquire into other issues such as data collection and use and the welfare implications that these may entail.

Platforms commodify private skills and resources by breaking markets' delimitations (Murillo et al., 2017). The new energy business models make the energy policy shift from challenges of scale/scope to new ones about regulating networks and dominant platforms (Midttun and Piccini, 2017) as dominant platforms may consolidate their market positions into oligopolies/monopolies. Furthermore, since decentralised energy production/consumption calls for higher storage/balancing capacity then policy bears the pressure from the incumbent industry for investments in supplementary capacity. Yet, local prosumers may rather request policies to secure and stabilise the energy bottom-up, or to strengthen the interconnections among markets in order to balance surplus/deficits across regions. So, policy needs to promptly reshape into dynamic and more iterative approaches with different platforms' sides (Acemoglu et al., 2012) to balance public and private interests, to better enhance welfare, innovation (Nill and Kemp, 2009) and safeguard public interests from exploitation.

In order to achieve a full and efficient digitalisation of the energy industry, synergies between the Energy Union and the Digital Single Market strategies have to be further developed and promoted, perhaps with the help of specific and tailor-made smaller and focused initiatives. This seems to be the new strategic objective of the new EC, that placed the twin climate and digital transformations at the core of the political priorities for the new mandate. As mentioned before, digitalisation and energy pose enormous challenges to societies at large, and it would be extremely risky to keep them separate. Both initiatives have a special focus on cross-border issues, like calling for a truly European dimension of both the problem and the solutions. These will have to tackle, necessarily, the issues of interoperability -of energy and information systems-assuring sufficient levels of cybersecurity.

This paper is not exempt of limitations. For instance, despite the novelty of the data, hardly any useful information about the platforms is provided beyond location and some characteristics on their operations. In order to better understand how these platforms evolve and the strength of the indirect network effects, information about users joining the platform on the different sides would be required. Similarly, information about fees charged, revenues and the proportion of users mutihoming could reveal important aspects of market structure and competition. All these topics remain areas for future research and may have relevant policy implications.

## Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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