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AN EMPIRICAL ANALYSIS WITH A WORLDWIDE CROSS-SECTIONAL DATASET

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The determinants of legislation for radiofrequency electromagnetic fields (RF-EMF) with the onset of 5G:

AN EMPIRICAL ANALYSIS WITH A WORLDWIDE CROSS-SECTIONAL DATASET[1]

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ABSTRACT:

Mobile communications are increasingly pervasive, leading to an unprecedented exposure of RF-EMF to humans. This article is the first empirical analysis on the determinants of RF-EMF exposure legislation, using a novel cross-sectional database of 164 countries worldwide.

In order to investigate the existence of a 5G-specific effect, the determinants of RF-EMF exposure legislation for 164 countries are compared with 61 countries within the sample that have deployed the 5G technology. The analysis shows that RF-EMF exposure limits are influenced by decentralization, competition, and technological factors. Political and fiscal decentralization, and mobile competition (for low levels of initial deployment) have a positive and significant impact on RF-EMF exposure limits across all the countries. Moreover, the smaller the area covered by local government and, more importantly, the smaller the population living in that area, the higher the RF-EMF exposure limits. These results are consistent with the changes observed following the advent of mobile technology in the 2000s.

In more decentralized countries, the regions had a greater influence on national legislation and could accommodate local demands. In contrast, political and fiscal decentralization, and mobile competition (for high levels of initial deployment) have a negative and significant impact on the limits of RF-EMF exposure in the sample of countries with 5G technology. Restrictive RF-EMF exposure limits are constraining 5G deployment in a context of widespread adoption of mobile broadband technologies. In addition, some efforts have been made at the local level to accommodate the concerns of the population regarding mobile network stations.

These results should be useful for policymakers and mobile operators alike, to anticipate the outcome of legislation in countries which have yet to introduce 5G technology. The results should also be useful when reviewing policies and strategies in the implementation of the upcoming 6G technology in frequency bands that will be increasingly higher (above 6 gigahertz up to terahertz for very local usage), and hence where the health effects on humans are less well studied..

Keywords: Keywords: Electromagnetic fields, 5G, decentralization.
JEL classification codes: D81, O33, O38, O50.

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1. Introduction

Mobile communications are pervasive worldwide. According to data from the International Telecommunications Union (ITU, 2021a), by 2020, 75% of the population had active mobile-broadband subscriptions, and 78% were covered by at least an LTE/WiMAX mobile network, the latter increasing to 95% when considering any type of mobile network. With the substantial increase in this type of radiofrequency electromagnetic field (RF-EMF) emissions, particularly around 1 gigahertz, from natural levels by about 10^{18}, there is an unprecedented human exposure (Bandara and Carpenter, 2018).

This context brings potential hazards linked to RF-EMF exposure to the forefront, particularly with the onset of the fifth-generation mobile network (5G).[2] 5G technology is typically associated with the use of more directive antennas, smaller cells, and higher frequencies than those used with previous mobile technologies (ITU, 2021b). In turn, these changes have raised questions about the impact of 5G technology on human health at supranational levels (ICNIRP, 2020; SCHEER, 2022), as well revived the social unrest witnessed in the 2000s at the onset of mobile technology (see, for instance, CADAS, 2000).

Within this framework, central public administrations and mobile operators have sought to anticipate international trends in policy outcome to make the most appropriate regulatory and strategic decisions regarding 5G technology (ANFR, 2019). However, there are few analytic publications available to make such choices, despite over twenty years of historical data on the topic (Borraz et al., 2005; Salomon and Borraz, 2005). The article explores the determinants of legislation to the exposure of RF-EMF. This unique empirical analysis uses a novel cross-sectional database to investigate the existence of a 5G specific effect. A selection of 164 countries worldwide with 5G and older technologies were considered (the whole dataset). Then, 61 countries with the 5G capacity were extracted from this dataset (the 5G dataset) and the determinants of RF-EMF exposure legislation were compared to those of countries in the whole dataset.

The next section describes lessons learned on RF-EMF exposure legislation since the emergence of mobile technology and the contribution of this article to the academic literature. Section 3 presents the econometric methodology based on Ordinary Least Squares (OLS) and probit models, the testable hypotheses, and the data and discusses the results of a preliminary analysis. Section 4 discusses the results obtained with the OLS and probit models applied to the whole dataset and to the 5G dataset. Section 5 gives some concluding remarks. The appendix provides a detailed description of the data, some descriptive statistics, and some estimation results that are discussed in the main text.

2. What have we learned so far?

To date, the International Commission for Non-Ionizing Radiation Protection (ICNIRP) has concluded that there is no evidence of RF-EMF harmful effects to the health of exposed humans or their offspring, albeit thermal effects (tissue heating) were cited as a possibility for high levels of exposure.[3] Given technological progress, the ICNIRP has recently published new guidelines in 2020 to update the level of exposure to emissions in the new frequency bands being attributed (above 6 gigahertz) and to take into account the specificities of 5G technology (ICNIRP, 2020).[4] According to these guidelines, an

[2] According to Starr (1969), the acceptable level of risk is inversely related to the number of persons exposed to the risk. Current 5G network rollout across the world is accessible at Ookla 5G Map website: https://www.speedtest.net/ookla-5g-map.

[3] The ICNIRP is an international non-governmental organization bringing together independent scientific experts. Although some researchers have questioned the independence of this organisation (see, for instance, Starkey, 2016), most countries base their legislation on the ICNIRP guidelines (ICNIRP, 1998) and on the Institute of Electrical and Electronics Engineers (IEEE) guidelines (IEEE, 1991), both being relatively similar (ITU, 2021b).

[4] The ICNIRP published its guidelines for human exposure to time-varying EMF emissions up to 300 gigahertz for the first time in 1998, which included the radiofrequency EMF spectrum (ICNIRP, 1998). Amongst other things, the changes introduced by the ICNIRP in 2020 result in a reduction in the maximum magnitude of local exposure that a person can receive by a factor of five in frequency bands above 6 gigahertz. The IEEE also reviewed its guidelines recently (IEEE, 2019). The Scientific Committee on Health, Environmental and Emerging Risks (SCHEER), which provides opinions on questions related to health, environmental and emerging risks on request of the European

electric field intensity threshold at 61 V/m measured over an interval of 6 minutes applies, in particular, to 5G frequencies in the 3.5 and 26 gigahertz bands.

The values set by the ICNIRP to shield from RF-EMF exposure have been largely adopted into domestic law by many countries throughout the world (WHO, 2017). Nevertheless, some countries have chosen to implement stricter exposure limits at the national level since the advent of mobile communications in the 2000s (Madjar, 2016; ITU, 2017). So far, irrespective of the country, the year and the type of mobile technology, exposure levels due to RF-EMF from mobile network stations were well below the general public exposure limits defined by the ICNIRP (see, for instance, Rowley and Joyner, 2012; 2016; Joyner et al., 2014; Huang et al., 2016). However, the arrival of 5G has raised questions about whether RF-EMF exposure would remain below the limits set at national levels for the countries applying tighter thresholds.

5G technology is commonly associated with the use of multiple-input multiple-output (MIMO) antennas and small cells (ITU, 2021b). Since MIMO antennas are directive, the maximum time-averaged power per beam direction is often used for the assessment of RF-EMF exposure for 5G mobile network stations (Thors et al., 2017). This measure is well below the theoretical maximum and contributes to alleviate RF-EMF emission restrictions (Colombi et al., 2020). Concerning small cells, they are typically used to boost capacity in densely populated areas and hence are often employed in 5G networks. Generally, a network for minimizing RF-EMF exposure has a dense mobile network infrastructure, and therefore smaller cells and lower transmitted power (Lewicki, 2017; Deruyck et al., 2021).

Some studies have been conducted on the effects of 5G technology based on data from simulations, non-commercial trials, and preliminary commercial deployment (OFCOM, 2020; ANFR, 2020a; 2020b; 2021; 2022; Wali, 2022). The maximum exposure values in the 26 gigahertz band were 3.2 V/m in trials and 5.7 V/m in simulations, whereas in the 3.5 gigahertz band they were about 1.3 V/m (outdoor) in simulations. While these are moderate RF-EMF exposure levels compared to the ICNIRP exposure limits, they reinforce existing emissions in current mobile bands.[5]

Mean outdoor exposure values in Europe ranged from 0.07 to 1.27 V/m between 2015 and 2018 (Jalilian et al., 2019). According to simulations for the French market, if 5G technology is added to current emissions, its mean contribution would be 1.36 V/m (outdoor) and 0.76 V/m (indoor) (ANFR, 2020a). Given that 4G networks will gradually migrate to 5G MIMO technology, a trend towards lower overall RF-EMF exposure is expected (by a factor of 4 from the mobile phone to the mobile network station) if pre-existing 4G networks are not using MIMO antennas (Deruyck et al., 2021). Moreover, some studies show that RF-EMF exposure levels associated with small cells remain well below the threshold level for the general public, as defined by ICNIRP (Van Wyk et al., 2019).

Whereas the arrival of 5G technology is therefore not constrained by RF-EMF exposure limits in countries following the ICNIRP guidelines, the same statement does not necessarily apply to countries with stricter exposure limits. Indeed, some countries and certain sub-national regions apply exposure limits that are ten to a hundred times lower than the exposure limits defined by the ICNIRP guidelines, as well as very strict measurement methodologies (ITU, 2018). For instance, the exposure limit for power density at 900 megahertz was up to recently 2% of the reference level in the European Union (EU) recommendation (EC, 1999) based in the ICNIRP guidelines in the Brussels region, Bulgaria, and Poland, 10% in Lithuania, 22% in Italy, 70% in Greece, and 90% in Croatia (RIVM, 2018).

The RF-EMF exposure limits already impacted the deployment of 4G and older technologies. Restrictive RF-EMF exposure regulations result in lower maximum transmission power on a site and

Commission, advised positively on the need to revise the recommendation 1999/519/EC about radiofrequency electromagnetic fields (100 kHz to 300 GHz), to recognize the recent changes introduced by the ICNIRP (2020).

5 The frequency bands that have been typically attributed at the global scale for public and/or private mobile communications networks are the following: 700 megahertz, 800 megahertz, 900 megahertz, 1,800 megahertz, 2,100 megahertz and 2,600 megahertz.

therefore more antennas are needed to provide the same level of service (PWC, 2013; GSMA, 2014a).[6] Besides, there are additional costs involved, since there are fewer options as to place the antennas (PWC, 2013; GSMA, 2014a). Some estimates suggest that RF-EMF exposure limits represent the largest driver for the variation in deployment costs between Switzerland and neighbouring countries applying ICNIRP exposure limits, with a relative share of the overall cost difference of around 30% (PWC, 2013).

The onset of 5G technology could exacerbate the impact of RF-EMF exposure limits on network deployment. Some forecast studies suggest that between 44% and 77% of existing sites would not be suitable for the implementation of 5G technology, given the antenna peak-power and the limit of 6 V/m applied by Switzerland (GSMA, 2014b). Moreover, in countries with restrictive national exposure limits, exclusion zones with no access for the general public around the mobile network stations are large enough to prohibit new emissions such as 5G (ITU, 2018; Lewicki, 2020). In consequence, there is a risk of saturation of the existing network in dense urban areas.

Some estimates suggest that in the period 2018-2021 about 60% of mobile data traffic demands may have been constrained in countries and regions with restrictive RF-EMF exposure limits (ITU, 2019). Overall, there can be constraints in network densification and new spectrum deployment, but also in the use of MIMO antennas and small cells.[7] An assessment carried out by the Swiss government on 5G deployment, confirmed that the more restrictive the exposure threshold to RF-EMF, the higher the costs of network deployment, due to the use of smaller cells to ensure coverage (DETEC, 2019). However, an additional study argued that 5G networks could be deployed in Switzerland without an increase of RF-EMF exposure limits, since the number of mobile network stations is mainly due to quality and coverage requirements (Deruyck et al., 2021).[8]

With the onset of 5G technology and the use of higher frequency bands for mobile services, public debates concerning the health effects on humans associated with this kind of deployment have been held in parliaments and in other public institutions in countries such as Austria, Luxembourg, the Netherlands, and the United Kingdom.[9] In the Netherlands, the government postponed the allocation of 5G licenses in the 26 gigahertz band because of the uncertainty associated with the health risks of RF-EMF exposure to this new frequency band.[10] Complaints have already been filed against the deployment of 5G technology in countries such as Belgium, France, and the Netherlands.[11]

Since the 2000s, a stream of literature has been published on consumers' perception of the risk of exposure to RF-EMF from mobile frequencies. According to some Eurobarometer surveys, well over 50% of the population in Europe believe that their health is affected by mobile phone masts and mobile phone handsets (EC, 2010).[12] Higher risk perceptions are not always aligned with greater RF-EMF exposure. For example, the population typically attributes higher risk levels to mobile phone stations with less attention paid to the risk of mobile phone handsets (Siegrist et al., 2005; EC, 2007). Nevertheless, for active users, the exposure from mobile phones can be ten times higher than the exposure from mobile network stations (Deruyck et al., 2021).

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6 For instance, 21.5% more antenna sites are needed in Switzerland under a specific national RF-EMF exposure regulation compared the deployment that would be required with the ICNIRP exposure limits (PWC, 2013).

7 The use of MIMO would involve narrowing an antenna beam, which could result on emissions exceeding restrictive RF-EMF exposure limits. The deployment of small cells in hot spot areas could be limited by the short distance between the antenna and people (ITU, 2019).

8 According to Deruyck et al. (2021), compared to 4G speeds, coverage with 5G speeds requires on average three times more mobile network stations.

9 See, for instance, the debate at Westminster Hall in the United Kingdom on electromagnetic fields and their effects on health (UK Parliament, 2019).

10 The 26 gigahertz band has been commonly used in Europe for point-to-point fixed link connections and satellite stations (ECC, 2019a; 2019b). It is only recently that the European Commission has adopted harmonized technical conditions to deploy mobile technology in this band (EC, 2020a). In contrast with existing technologies in the band, mobile services cover relatively large and populated areas.

11 In France, for example, two environmental associations brought a case before the Council of State concerning the impact of 5G authorisations in the 3.5 gigahertz band with regards to the environmental and to the RF-EMF exposure impacts. The cases were lost (see, for instance, ARCEP, 2021).

12 In other countries, risk perception concerning mobile technology can be relatively small and mostly related to malevolence, societal problems, and financial issues (Van Kleef et al., 2010).

Given misinformation and the media hype associated with this topic, many public administrations have embarked on communication strategies with the public about potential hazards (see, for instance, WHO, 2002). Given the recent substantial media coverage of 5G including associating it with the COVID-19 pandemic and fake news (ACMA, 2021; Demortain, 2021; Elzanaty, 2021), there has been an appraisal to renew communication strategies with the public (RSPG-BEREC, 2020; ITU, 2021c). Nevertheless, there is evidence that when precautionary information is shared with the public, there is a heightened perception of risk (Wiedemann et al., 2006; Nielsen et al. 2010; Boehmert et al., 2017).

In contrast with the relatively prolific literature on risk perception associated with RF-EMF exposure according to technology, legislation, and individual characteristics such as age or gender, little is known about the underlying determinants of this perception, related for instance, to culture and values.[13] .In addition, there are few analyses published on the determinants of RF-EMF exposure legislation. At the macroeconomic level, Mazar (2008) explores the role of the geopolitical influence in shaping mobile technology rules, which stands out in Eastern Europe's choices regarding RF-EMF exposure legislation. There is also a strong correlation between the type of EMF legislation applied to high-voltage power lines and that applied to mobile technology (RIVM, 2018).

According to Borraz et al. (2005) and Salomon and Borraz (2005), the outbreak of social unrest in the 2000s at the beginning of mobile technology was relatively comparable across Belgium, France, Spain, Switzerland, and the United Kingdom. This social unrest originated at a local level due to the emergence of these networks in the individual's daily environment, which caused annoyance and raised aesthetic concerns, with possible impact on land or house values. This disquiet was never really resolved, given that local authorities usually had no rights to implement measures against deployment and so central administrations followed international guidelines.

Through a qualitative analysis based on an extensive number of interviews, Borraz et al. (2005) suggest that the divergent outcome in terms of RF-EMF exposure legislation across the five European countries can be mainly explained by the different institutional frameworks and, in particular, by the role of intermediate levels of government, whereby regions in federal states could illustrate their autonomy in favor of their local constituencies. Moreover, contrasting expert advice and different leading ministries also influenced the choice concerning RF-EMF exposure limits. For instance, the ministries of environment or health oversee RF-EMF exposure regulation when the emphasis is placed on public health.

This article proposes the first empirical analysis of the determinants of RF-EMF exposure legislation. It provides a comparison of a broad worldwide dataset with a dataset available for countries with 5G technology and paves the way to clarify the specifics of this new technology

3. Econometric analysis

3.1. Econometric specification

To empirically investigate the determinants of RF-EMF exposure legislation, a set of regressions were run with the dependent variable representing the type of RF-EMF exposure limits associated with mobile network stations that were implemented in the country.[14] The explanatory variables were chosen to test some hypotheses derived from the literature on the determinants of RF-EMF exposure legislation.

The generic form of the regressions, where the response is modeled as a linear function of the predictor variables, is as follows:

$$y_i = \gamma_0 + \beta' x_i + \pi' z_i + \varepsilon_i, \qquad (1)$$

[13] Boehmert et al. (2020) suggest that prior risk perception shapes the individual's evaluation of information about RF-EMF exposure and influences the communication's effect on risk perception.

[14] Mobile phone handset exposure limits are fairly homogeneous across the world (GSMA, 2022).

where the subscript $i = 1,2,\cdots,N$ indicates the country, y_i designates the type of RF-EMF exposure limits, x_i is a vector of explanatory variables that allows analysis of RF-EMF exposure legislation determinants' proxies associated with some hypotheses, z_i is another vector of explanatory variables that enables control for some features that may be deemed important when defining RF-EMF exposure legislation determinants, γ_0 is an unknown scalar parameter, β and π are unknown vector parameters, and ε_i is an error term.

Standard regression techniques produce OLS estimations of the parameters $\hat{\beta}$ and $\hat{\pi}$. The common rule of thumb of 10 or more events per variable is used, where an event is an observation amongst the sample.[15] Moreover, to address potentially endogenous explanatory variables, the instrumental variables two-stage least-squares (2SLS) technique is used (Greene, 2012).[16] The Durbin-Wu-Hausman specification test is used to evaluate the consistency of the estimator when compared to the alternative based on instrumental variables, which although less efficient, is consistent.

A probit model is typically used when predicting mutually exclusive dichotomous choices.[17] In the article, the dependent variable designates whether there are restrictive RF-EMF exposure limits compared to those defined by the international ICNIRP guidelines or the common US national exposure limits (ICNIRP, 1998; ICNIRP, 2020; FCC, 1996). In such a case, the observed dependent variable d_i is a function of the unobserved score y_i and an unobservable value μ which can be estimated by:

$$d_i = \begin{cases} 1 & \text{if } y_i > \mu \\ 0 & \text{otherwise.} \end{cases} \quad (2)$$

The parameters associated with the probit model are estimated through a maximum likelihood technique. In probit models, at least five events per explanatory variable are necessary, where the number of events is given by the size of the smallest of the outcome categories of the dependent variable.[18][19] Potentially endogenous explanatory variables are considered through the use of instruments using a two-stage technique (Wooldridge, 2012).[20] The Wald specification test helps evaluate the consistency of the estimator when compared to the alternative based on instrumental variables, which is less efficient but consistent.

When dependent variables are dichotomous and the sample size is large, probit models are preferred to OLS models since OLS estimates of the parameters $\hat{\beta}$ and $\hat{\pi}$ are inefficient in the presence of binary explained variables (Hagerman and Zmijewski, 1979).[21] When the functional form describing the relationship between the dependent and the explanatory variable is non-linear, OLS can result in less powerful tests statistics of estimates of the parameters.[22]

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15 This implies that in our regressions based in the OLS model there are 16 or less variables for the whole dataset with 164 observations, and 6 or less variables for the 5G dataset with 61 observations (Tables A.1 and A.2 in the appendix).

16 When an endogenous continuous explanatory variable is present in a regression with a binary dependent variable, the 2SLS estimator in the OLS model does not estimate the average partial effect of the explanatory variable in general although test statistics still apply (Chuhui et al., 2022).

17 Probit and logit models perform similarly independently of the sample size, the correlation structure, and the proportion of the outcome, particularly concerning the Root Mean Square Error (RMSE). Logit models often predict outcomes better than probit models, but this is not the scope of this article (Amrutha et al, 2020).

18 The rule of thumb of 10 or more events per variable in probit regressions can be relaxed which enables to account for statistically significant associations with a larger number of regressors (Vittinghoff and McCulloch, 2007).

19 This implies that in our regressions based in the probit model there are 6 or less variables for the whole dataset (the size of the smallest of the outcome categories is 30), and 3 or less variables for the 5G dataset (the size of the smallest of the outcome categories is 15) (Tables A.1 and A.2).

20 The two-step estimator is more robust than the maximum likelihood estimator for most applications, particularly when the sample is small (Chiburis and Lokshin, 2007).

21 Probit models facilitate the analysis of the effect of changes in the values of explanatory variables on probability estimates. With OLS models, the estimated parameters are constant for all values of the explanatory regressor. Furthermore, under probit models the probability estimates fall under the range [0.1] and result in smaller Type I error rate (probability of rejecting the null hypothesis given that it is true) than OLS models (Stone and Rasp, 170).

22 The error term ε_i is heteroskedastic and nominal significance levels associated with the test statistics may not be reliable. See McFadden (1982) for a more detailed discussion.

However, for samples of small size such as those used in this article, OLS models can perform as well as probit models. Indeed, probit tests tend to reject the null hypothesis that a parameter is not significant too frequently for sample sizes between 50 and 100 (Noreen, 1988).[23] These conservatively biased t-statistics can lead to the conclusion that a relationship between the dependent and an explanatory variable does not exist while it is present.[24] The chi-square test statistic for the overall probit model is anticonservatively biased but this statistic is of secondary interest in this analysis.

The disparate response group sizes in the data exacerbate the miscalibration of the probit model (Stone and Rasp, 1991).[25] In addition, skewness in explanatory variables results on the miscalibration of test statistics both for OLS and probit models. Otherwise, multicollinearity between explanatory variables does not have a significant impact on the performance of OLS and probit models with dichotomous variables and small sample sizes.

To summarize, for the cross-sectional estimation in this article, OLS and probit models are applied to reflect both the nature of the dependent variable and the sample size. OLS estimates are better calibrated than probit estimates given the asymmetric group response sizes in the dependent variables. In both OLS and probit models, nominal error rates can be larger than empirical error rates for test statistics between the dependent variable and an explanatory variable which can lead to the underestimation of the relationship between the two variables. The OLS models can have at most six variables for the 5G dataset. In this article, the probit models can have at most six variables for the whole dataset and three variables for the 5G dataset.

3.2. Testable hypotheses

To empirically analyse the determinants of RF-EMF exposure legislation, three main hypotheses are considered in this article, namely, federalism and decentralization, competition, and technology hypotheses (see Table 1 on testable hypotheses, proxies for determinants, and references). Concerning federalism and decentralization, these two concepts are distinct. Indeed, federal states can be very concentrated while unitary states can be highly decentralised (Blume and Voigt, 2011). While federalism is related to a constitutional decision, the extent of decentralization in a country depends on policy choices. In fact, the analyses exploring the economic impact of institutions often measure instead the economic impacts of policy choices (Glaeser, 2004).

Concerning policy choices, according to Voigt and Blume (2009), the existence of local elections for municipal governments, the possibility of veto at the federal state for federal-level legislation, and the fractionalization of parliament in terms of the heterogeneity of interests have a strong impact on variables such as satisfaction and government effectiveness, the latter variable based, among other factors, on the perceptions of the quality of public service provision and the independence of the civil service from political pressure.[26] These analyses suggest the following hypothesis:[27]

[23] In this article, the sample size for the whole dataset and for the 5G dataset is 164 and 61, respectively (Tables A.1 and A.2). These sample sizes with dichotomous dependent variables are common in accounting studies.

[24] When the alternative hypothesis is true, that is, a parameter is significant, OLS and probit models demonstrate similar performance.

[25] In this article, the dependent variable for the whole dataset and for the 5G dataset is characterized by group response sizes of 30 cases (restrictive RF-EMF exposure limits) versus 134 cases (standard RF-EMF exposure limits) and 15 cases (restrictive RF-EMF exposure limits) versus 46 cases (standard RF-EMF exposure limits), respectively (Tables A.1 and A.2).

[26] Literature on the relationship between fiscal decentralization and economic performance is prolific (see, for instance, Boadway and Dougherty, 2018 and Sow and Razafimahefa, 2017).

[27] Mazar (2008) analyses the relationship between cultural values (proxied through civil or common law, religion, language) and policies in the mobile sector at the national level. A casual look at the relationship between these variables and RF-EMF exposure legislation shows no trend when comparing worldwide countries at the national scale. Hypothesis 1 enables nevertheless, to account for sub-national cultural differences that can be reflected through the degree of decentralization (Shair-Rosenfield et al., 2021).

Hypothesis 1. *Countries with a higher degree of decentralization are more likely to choose restrictive RF-EMF exposure legislation, and even more so in countries with a higher degree of political decentralization. It is likely that federalism does not play a major role in determining RF-EMF exposure legislation.*

Decentralization indicators do not fully capture the actual proximity between the local government and its population (Ivanyna and Shah, 2012). Indeed, there are wide differences in terms of the population and the area covered by local governments depending on the country. Local governments subject to a smaller population and coverage area are more likely to be responsive and accountable to the local population. For instance, the average population size in India and Switzerland is below 5 thousand per local government area, while in Indonesia and United Kingdom it is above 0.3 million. Local governments' average area in thousands square kilometres can range from less than 0.02 in India and Switzerland to over 0.20 in Indonesia and Australia. These features translate into the following hypothesis:

Hypothesis 2. *Countries characterized by local governments with a relatively small population and area are more likely to favor restrictive RF-EMF exposure legislation.*

Table 1. Determinants of RF-EMF exposure limits:
Testable hypotheses, proxies for determinants, and references

Federalism and decentralization	Proxies and references
Decentralization	Time-invariant continuous indexes that incorporate the relative importance of the local government, that is, the decentralization and the regulatory authority indexes (Ivanyna and Shah, 2012; Hooghe et al., 2016; Shair-Rosenfield et al., 2021). The indexes can also capture the authority exercised by a regional government over those who live in the region or in the country as a whole (self-rule and shared rule indexes, respectively).
Political decentralization	Time-invariant continuous and discrete variables that measure the degree of political decentralization, that is, the existence of directly elected local governments, direct democracy provisions for citizen participation at the local level, and legislative safeguards against the dismissal of the local government by the central government (Ivanyna and Shah, 2012), as well as institutional depth with a regional administration not subject to central government veto, regional policy autonomy, independently elected regional representation, regional law-making power to co-determine national legislation, regional executive control to co-determine national policy, and regional capacity to co-determine constitutional change (Hooghe et al., 2016; Shair-Rosenfield et al., 2021).
Federalism	Time-invariant binary variables that measure whether a country is federal or unitary (Norris, 2008).
Local government population	Time-invariant continuous variables measuring the local government average population in thousands (Ivanyna and Shah, 2012).
Local government area	Time-invariant continuous variables measuring the local government average area in thousands sq.km (Ivanyna and Shah, 2012).
Competition	Proxies and references
Mobile-broadband subscriptions	Continuous variables that measure mobile-broadband subscriptions per 100 inhabitants and Compound Annual Growth Rates (CAGR) in mobile-broadband subscriptions per 100 inhabitants (ITU, 2022).
Mobile-broadband prices	Continuous variables that measure mobile-broadband prices (data-only for 1.5 GB and mobile data and voice low-consumption and high-consumption baskets (US $, purchasing power parity as a percentage of Gross national income per capita) (ITU, 2022).
Technology	Proxies and references
5G technology (dummy)	Time-invariant binary variable where the value 0 indicates no 5G and the value 1 indicates that 5G is present (Chiaraviglio et al., 2022).
5G technology (high frequency)	Time-invariant binary variable where the value 0 indicates no 5G in frequencies > 6 gigahertz and the value 1 indicates that 5G is present > 6 gigahertz (Chiaraviglio et al., 2022).
5G technology (intensity)	Time-invariant discrete variable where the value 0 indicates no 5G, the value 1, 2, and 3 indicate that 5G is present in 1, 2 or 3 frequency ranges, respectively.[28]

[28] The value 1 indicates that 5G is present in 1 frequency range (5G < 1 gigahertz, or 1 gigahertz < 5G < 6 gigahertz, or 5G > 6 gigahertz), the value 2 indicates that 5G is present in 2 frequency ranges (5G < 1 gigahertz and 1 gigahertz

Considering the competition hypothesis, it is widely acknowledged that competition in the mobile sector has fostered network deployment across both fixed-line and mobile segments, and has been associated with price reductions (Gasmi and Recuero Virto, 2010). In turn, the growth in the number of mobile subscriptions impact in a positive way the adoption of RF-EMF exposure legislation in a country (Dhungel et al., 2014). The more pervasive the technology deployed across the country, the more likely that it will be regulated. When competition is high, however, it is more likely that a relaxation in the RF-EMF legislation will ensue to enable full deployment whatever the generation of technology.(PWC, 2013; GSMA, 2014a).[29]

Hypothesis 3. *For low levels of competition in the mobile sector, higher network deployment and lower retail prices will tend to favor more restrictive RF-EMF exposure legislation. For high levels of competition in the mobile sector, higher network deployment and lower prices will tend to relax RF-EMF exposure legislation.*

With regards to the technological hypothesis, as already mentioned in the previous section, while the onset of 5G technology is not constrained by RF-EMF exposure limits in countries following the ICNIRP guidelines, the deployment of 5G networks can be instead affected by the restrictive RF-EMF exposure legislation. In particular, in countries with restrictive RF-EMF exposure limits, a large percentage of existing sites do not appear suitable for the implementation of 5G (GSMA, 2014b) and the deployment of new installations should also be limited (ITU, 2018; Lewicki, 2020). When deployment is feasible, costs can significantly be higher to enable compliance with the legislation not only due to the need to install a larger number of mobile network stations, but also by requiring more flexibility in network configurations and in the choice of sites for the antennas (DETEC, 2019).

Hypothesis 4. *The onset of 5G technology will tend to relax legislation for exposure to RF-EMF.*

3.3. Data and preliminary examination

The data consists of one novel unbalanced cross-sectional dataset of the RF-EMF mobile network station exposure limits applied to 164 worldwide countries (the whole dataset). In particular, the data covers 134 countries with standard RF-EMF exposure limits (the international limits ICNIRP, 1998 or ICNIRP, 2020, or the US national limits FCC, 1996) and 30 countries with restrictive RF-EMF exposure limits (Table A.1 in the appendix). An additional cross-sectional dataset identifies the RF-EMF mobile network station exposure limits applied to 61 countries with 5G technology (the 5G dataset). In this case, the data covers 46 countries with standard RF-EMF exposure limits and 15 countries with restrictive RF-EMF exposure limits (Table A.2).

Out of the 30 countries with restrictive RF-EMF exposure limits in the whole dataset, 23 countries are in Europe and Central Asia. Nevertheless, there is at least one country with restrictive RF-EMF exposure limits in each of the regions defined by the World Bank classification except for Sub-Saharan Africa. These countries are Canada, Chile, China, India, Indonesia, Israel, Kuwait, and Turkey. In the 5G dataset, although most countries with restrictive RF-EMF exposure limits are also located in Europe and Central Asia, there are five countries located in other regions: Canada, Chile, China, India, and Israel.

In this article, three indicators characterize the RF-EMF mobile network station exposure limits in the whole dataset: the Global System for Mobile Communications association indicator (GSMA, 2022) (EMF_GSMA), the indicator developed by Chiaraviglio et al. (2022) ($EMF\_Chiaraviglio$), and an indicator based on the authors' elaborations (EMF).[30] One indicator characterizes the RF-EMF

< 5G < 6 gigahertz, or 5G < 1 gigahertz and 5G > 6 gigahertz, or 1 gigahertz < 5G < 6 gigahertz and 5G > 6 gigahertz), and the value 3 indicates that 5G is present across 3 frequency ranges (5G < 1 gigahertz and 1 gigahertz < 5G < 6 gigahertz, and 5G > 6 gigahertz) (Chiaraviglio et al., 2022).

[29] According to Deruyck et al. (2021), human exposure to RF-EMF is similar when comparing a unified mobile network with the combination of networks associated with multiple operators. A unified mobile network could nevertheless require between 13% to 50% less mobile network stations.

[30] Data from GSMA and Chiaraviglio et al. (2022) differ on the country coverage. There are divergent values between those sources for Bulgaria and Iraq (the latter is excluded from the datasets in this article).

exposure limits in the 5G dataset based on the authors' elaborations (EMF_5G). For the proxies of the determinants of RF-EMF legislation, data was collected according to the three hypotheses considered in this article, namely, federalism and decentralization, technology, and competition hypotheses (Table 1), and some control variables regrouped under the label Others (controls) and some instruments were added. Table A.2 in the appendix gives the data content and the sources.

Concerning the decentralization data, many decentralization indexes have been developed since the 1970s (Harguindéguy et al., 2019). There is no dataset that is considered as a reference, however, since there are a variety of conceptual and empirical approaches mainly depending on the focus of research (Shah and Thompson, 2004). This article is concerned with the degree of decentralization through the political, administrative, and fiscal powers at the sub-national level which is a common theoretical setting (Elazar, 1987). In addition, since the country coverage needs to be as large as possible, this article uses data from Ivanyna and Shah (2012) covering 182 countries drawn from data in 2005, and from Hooghe et al. (2016) covering 81 countries drawn from data in 2018. Given that these available indexes of decentralization are admittedly imperfect either in the sampling date or in the country coverage, both datasets in the analysis are included in the analysis.

Compared to the countries with standard RF-EMF exposure limits, the countries with restrictive RF-EMF exposure limits are characterized by a higher degree of political, administrative, and fiscal decentralization, and smaller local government population and areas (Tables A.5 and A.6 in the appendix). The difference in political decentralization is particularly large when comparing countries with standard and restrictive RF-EMF exposure limits across the 5G dataset. There are more federal states with restrictive RF-EMF exposure limits than with standard exposure limits across both the whole dataset and the 5G dataset, but the difference is not very large. These statistics are consistent with the hypotheses in the previous subsection. Table 2 below shows these statistics.

Table 2. The whole dataset versus the 5G dataset
Main differences in representative variables' median values

Hypotheses & variables	Variable names	The whole dataset		The 5G dataset	
		Standard RF-EMF limits	Restrictive RF-EMF limits	Standard RF-EMF limits	Restrictive RF-EMF limits
Federalism and décentralisation					
Décentralization	$decentr$	2.44	3.88	4.94	6.31
Regional authority index	RAI	10.39	14.65	12.82	13.09
Political decentralization	$political$	0.47	0.59	0.57	0.70
Administrative decentralization	$admin$	0.31	0.51	0.46	0.55
Fiscal decentralization	$fiscal$	0.35	0.47	0.49	0.57
Federalism	$federal$	0.35	0.40	0.39	0.46
Local government population	$LG\_population$	0.11	0.05	0.09	0.05
Local government area	LG_area	134.20	27.64	82.41	28.95
Competition					
Mobile-broadband subscriptions	MBB_subs	78.87	88.20	112.43	93.83
Mobile-broadband subscriptions (CAGR)	MBB_subs_CAGR	14.93	10.98	7.06	13.30
Mobile-broadband prices (high consumption)	MBB_prices_high	6.66	1.56	1.55	1.11
Technology					
5G technology (dummy)	$tech\_5G$	0.36	0.50	-	-
5G technology (intensity)	$tech\_intensity$	0.65	0.90	1.73	1.80
Others (controls)					
Population density	$population$	288	767	344	1458

Compared to the countries with standard RF-EMF exposure limits, countries with restrictive exposure limits tend to have a higher probability of having 5G technology, lower mobile-broadband prices, larger compounded annual growth rates (CAGR) in mobile-broadband subscriptions, and between two to three times more population density (Tables A.5 and A.6).[31] Indeed, wealthier countries have been early adopters of 5G technology and amongst these countries there are many nations with restrictive RF-EMF exposure limits (Table A.2). There has been also an earlier adoption of previous technological generations, more competition between operators, and lower retail prices in wealthier countries.

In this preliminary analysis some other properties of the data are also checked. Skewness needed to be considered in the analysis.[32] Correlations concerning decentralization and federalism variables conveyed some useful information.[33] More specifically, decentralization and federalism variables are not strongly correlated (Tables A.8 and A.9). Ivanyna and Shah (2012) and Hooghe et al. (2016)/Shair-Rosenfield et al. (2021) indicators are not strongly correlated neither, which comforts the choice of using two sets of indicators to proxy decentralization (Table A.10). Some variables within Ivanyna and Shah (2012) and Hooghe et al. (2016)/Shair-Rosenfield et al. (2021) indicators have high levels of correlation and should not be used simultaneously in regressions (Tables A.8 and A.9).[34]

4. Empirical results

Tables A.12-A.31 in the appendix present the results obtained by applying the OLS and probit estimation methodologies to equations (1) and (2), respectively, incorporating the proxies of the determinants of RF-EMF exposure limits to the whole dataset and to the 5G dataset. The inspection of the statistics presented in the previous section showed noticeable differences in the following hypotheses when examining countries with and without RF-EMF standard exposure limits across the whole dataset and the 5G dataset: federalism and decentralization (Tables A.11-A.18), competition (Tables A.19 and A.26), and technology (Tables A.27-A.30).

In addition to showing the estimated values of the parameters associated with the explanatory variables listed in the first column, Tables A.19-A.30 include four additional items. First, the number of observations (Obs.) used in each regression are indicated. Second, an F-statistic (F), in the case of the OLS models, and a likelihood ratio statistic (LR-chi2), in the case of the probit models to test the joint significance of the explanatory variables is provided. Third, a Hausman statistic (Hausman-chi2), in the case of the OLS models, and a Wald statistic (Wald-chi2) in the case of the probit models to test the endogeneity of the competition and technology variables is shown. Fourth, the variables used as instruments are presented.

To cater for endogeneity problems which seem likely to arise in the estimation of equations (1) and (2), the two-step procedure previously described is used. Endogeneity can be an issue since, for example, RF-EMF restrictive exposure limits might prevent the deployment of broadband technology, as well as constrain or delay the allocation of new frequency bands associated with the 5G such as the 3.5 gigahertz and 26 gigahertz bands. The relationship between the variables of interest is, in these examples, running in the opposite direction to that shown in equations (1) and (2), that is, from competition and technology proxies to RE-EMF exposure limits. Institutional endowments are used as instruments since they are highly correlated with the potentially endogenous explanatory variables.[35] In the regressions, OLS and probit exogenous models outperformed OLS and probit endogenous models.[36]

[31] The high growth in mobile-broadband subscriptions and the large population density may constrain network deployment in countries with restrictive RF-EMF exposure limits.

[32] A casual look at Table A.4 conveys information about the presence of skewness when the mean is significantly lower than the median. In particular, control variables such a GDP per capita and population density are avoided. Special attention should be paid when analyzing the impact of the local government area variable.

[33] There are no significant correlations between our variables of interest, namely, the type of RF-EMF exposure limits and the proxies for determinants described in the previous subsection (Table A.7).

[34] Moreover, certain variables proxying technology, competition and other control factors should not be included in the same regression for the same reason. Data is available upon request.

[35] Gasmi and Recuero Virto (2010) identify institutional and financial endowments as determinants of telecommunications performance through the reforms that these factors trigger in the sector.

[36] In Tables A.19-A.30, Hausman statistics (Hausman-chi2), in the case of the OLS models, and Wald statistics (Wald-chi2), in the case of probit models, are non-significant.

For the case of the whole dataset, the Tables A.19-A.24 (competition) and A.27-A.29 (technology) show in their columns 2-4 and 6-8 OLS and probit results for the different dependent variables that capture RF-EMF exposure limits (EMF_GSMA, $EMF\_Chiaraviglio$, and EMF). The parameter estimates of the explanatory variables for the regressions on the three dependent variables proxying RF-EMF exposure limits (EMF_GSMA, $EMF\_Chiaraviglio$, and EMF) are very similar which suggests that the results with the elaborated EMF indicator are relatively robust.[37]

Concerning the 5G dataset, Tables A.24-A.26 (competition) and A30 (technology) present results for the dependent variable capturing RF-EMF exposure limits in countries with 5G technology. Given the number of explanatory variables, in Tables A.11-A.18 (federalism and decentralization), the parameter estimates are only reported for the dependent variable EMF, and when they convey significant estimates or are necessary to inform the tested hypotheses.[38] Tables A.11-A.18 include the previously described first two additional items, and exclude information related to endogeneity also due to the high number of explanatory variables being analyzed.[39]

Tables 3 and 4 below summarize the estimated results reported in Tables A.11-30. Comparing these two tables, results are fairly similar for the OLS and probit models, except when the number of samples is particularly low. In such cases, probit models tend to underestimate the impact of explanatory variables (law_making, law_making_c, and $borrow\_control$). Let us turn to the empirical evidence concerning the hypotheses on the determinants of RF-EMF exposure limits discussed in the previous section. Concerning hypothesis 1, the type of decentralization matters: aggregate indicators such as decentralization ($decentr$), regional authority index (RAI), self-rule ($self\_rule$), and shared rule ($shared\_rule$) are not statistically significant, while specific components of these indicators are relevant determinants of RF-EMF legislation (Table 3).

Table 3. The whole dataset versus the 5G dataset:
Impact of federalism and decentralization on RF-EMF exposure limits $^{+}$

		The whole dataset		The 5G dataset	
Hypotheses & variables	Variable names	OLS	probit	OLS	probit
Hypothesis 1					
Decentralization	$decentr$	NS	NS	NS	NS
Regional authority index	RAI	NS	NS	NS	NS
Self-rule	$self\_rule$	NS	NS	NS	NS
Shared rule	$shared\_rule$	NS	NS	NS	NS
Administrative decentralization	$admin$	+***	+***	NS	NS
Fiscal decentralization	$fiscal$	NS	NS	NS	NS
Political decentralization	$political$	+*	+*	NS	NS
Local government security of existence	$LG\_existence$	+**	+**	NS	NS
Relative importance of local government	$LG\_expenditures$	+**	+**	NS	NS
Institutional depth	$inst\_depth$	+*	+*	NS	NS
Law-making	law_making	NS	NS	-*	NS
Law-making (c)	law_making_c	NS	NS	-*	NS
Borrow control	$borrow\_control$	NS	NS	-**	NS
Federalism	$federal$	NS	NS	NS	NS
Hypothesis 2					
Local government population	$LG\_population$	-***	-***	NS	NS
Local government area	LG_area	-*	-***	NS	NS

37 The variables proxying decentralization loose significance when the dependent variable is $EMF\_Chiaraviglio$. This can be explained through the lower number of countries in this sample compared to those included when the EMF indicator is used.

38 Results on EMF_GSMA and $EMF\_Chiaraviglio$ dependent variables, and on the full set of decentralization explanatory variables are available upon request. Certain variables such as decentralization indexes ($decentr$, RAI, $self\_rule$, and $shared\_rule$), fiscal decentralization ($fiscal$), and federalism ($federal$) are reported to inform the tested hypotheses, even though they are not statistically significant.

39 Results considering the potential endogeneity of competition and technology proxies when analyzing the impact of federalism and decentralization variables are available upon request. Again, in our estimations, OLS exogenous models outperform OLS endogenous models, and probit exogenous models also outperform probit endogenous models.

⁺ NS stands for non-significant, +/– indicates that the impact of the federalism or decentralization proxy on RF-EMF exposure limits is positively/negatively significant, and */ **/*** stands for significance at the 10%/5%/1% level. Table 3 reports values from Tables A.11-A.18.

Hypothesis 1 regarding the role of decentralization is only partially confirmed by the estimation results. There is empirical support to it since the variables on administrative decentralization ($admin$), political decentralization ($political$), local government security of existence ($LG\_existence$), relative importance of local government ($LG\_expenditures$), and institutional depth ($inst\_depth$) have a positive and significant impact on the decision to introduce RF-EMF exposure limits when analysing the whole dataset. However, these variables are not significant for the countries in the 5G dataset (Table 3).

In addition, in the 5G dataset, three variables proxying the authority exercised by a regional government or its representatives in the country as a whole (law_making, law_making_c, and $borrow\_control$) have a significant and negative impact on RF-EMF exposure limits. The variable law_making_c is one of the components of the law_making index, and takes a higher value when regions have a majority representation in the national legislature. Whereas decentralization is positively correlated with more restrictive RF-EMF exposure limits, the arrival of the 5G technology reverses the trend with more decentralised states relaxing legislation to enable deployment.

The degree of political decentralization plays an important role in the choice of RF-EMF exposure limits as expected. Whereas the decentralization variables that have a significant impact on RF-EMF exposure limits are not limited to the political dimension, they are predominant in number. In the whole dataset, political decentralization, local government security of existence, and institutional depth contribute to explain policy choices concerning RF-EMF exposure limits. Administrative and fiscal decentralization also determine RF-EMF exposure limits in this dataset (see $admin$ and $LG\_expenditures$ variables in Table 3). In the 5G dataset, political (law_making and law_making_c) and fiscal variables ($borrow\_control$) are significant determinants of RF-EMF exposure limits. What about the impact of federalism on choices concerning RF-EMF legislation? As expected, the federalism variable ($feder$) is statistically insignificant throughout all the regressions in Tables A.11-A.30.

Hypothesis 2 says that countries characterized by local governments with a relatively small population and area are more likely to favour restrictive RF-EMF exposure limits. The empirical analysis is supportive of this hypothesis, but only concerning the whole dataset. The local government population ($LG\_population$) and the local government area (LG_area) have a negative and significant impact on RF-EMF exposure limits when considering the whole dataset (Table A.3). It is worth noting that the impact of the local government population on RF-EMF exposure limits is much larger than that of the local government area when examining coefficient estimates in Tables A.15 and A.16. In contrast with this output, the results concerning the role of the size of the population and of the area covered by local governments are not statistically significant in the 5G dataset.

Let us now examine the empirical evidence on the role of competition in the mobile sector on RF-EMF exposure limits. Hypothesis 3 states that for low levels of competition in the mobile sector, higher network deployment and lower prices will tend to increase RF-EMF exposure limits. For high levels of competition in the mobile sector, higher network deployment and lower prices will tend to relax RF-EMF exposure limits. The results confirm the claim of this hypothesis for the whole dataset. First, the explanatory variables mobile-broadband subscriptions (MBB_subs) and mobile-broadband prices (MBB_prices_data, MBB_prices_low, and MBB_prices_high) have a positive and significant, and a negative and significant impact on RF-EMF exposure limits, respectively (Table 4). In contrast, when these variables proxying broadband deployment and prices are squared (MBB_subs_sq, $MBB\_prices\_data\_sq$, $MBB\_prices\_low\_sq$, and $MBB\_prices\_high\_sq$) they have a negative and significant, and a positive and significant impact on RF-EMF exposure limits, respectively. That is, for low levels of competition proxied through low levels of mobile network deployment and high mobile prices, greater competition has a positive and significant impact of RF-EMF exposure limits. However, when there is a high degree of competition proxied through high levels of mobile network deployment and low mobile prices, greater competition has a negative and significant impact of RF-EMF exposure limits.

Table 4. The whole dataset versus the 5G dataset:
Impact of competition and technology on RF-EMF exposure limits [+]

Hypotheses & variables	Variable names	The whole dataset		The 5G dataset	
		OLS	probit	OLS	probit
Hypothesis 3					
Mobile-broadband subscriptions	MBB_subs	+**	+**	-**ⁱ	-**ⁱ
Mobile-broadband subscriptions squared	MBB_subs_sq	-**	-**	NS	NS
Mobile-broadband subscriptions (CAGR)	MBB_subs_CAGR	NS	NS	+**	+*
Mobile-broadband prices (1.5 GB)	MBB_prices_data	-**	-**	NS	NS
Mobile-broadband prices squared (1.5 GB)	$MBB\_prices\_data\_sq$	+*	NS	NS	NS
Mobile-broadband prices (low consumption)	MBB_prices_low	-**	NS	NS	NS
Mobile-broadband prices squared (low con.)	$MBB\_prices\_low\_sq$	+**	NS	NS	NS
Mobile-broadband prices (high consumption)	MBB_prices_high	-***	-***	NS	NS
Mobile-broadband prices squared (high con.)	$MBB\_prices\_high\_sq$	+**	+*	NS	NS
Hypothesis 4					
5G technology (dummy)	$tech\_5G$	-*ᵞ	-*ᵞ	NA	NA
5G technology (high frequency)	$tech\_highfreq$	NS	NS	NS	NS
5G technology (intensity)	$tech\_intensity$	NS	NS	NS	NS

[+] NS stands for non-significant; NA stands for non-applicable, +/– indicates that the impact of federalism or decentralization proxy on RF-EMF exposure limits is positively/negatively significant, and */ **/*** stands for significance at the 10%/5%/1% level. ⁱ Data reported from Tables A.11-A.18, and A.30. ᵞ Data reported from Tables A.21-A.23 when the regression is run with the $EMF\_Chiaraviglio$ dependent variable. Otherwise, Table 4 reports values from Tables A.19-A.26 (hypothesis 3) and from Tables A.27-A.30 (hypothesis 4).

In contrast with these results for the whole dataset, the 5G dataset demonstrated negative and significant relationship between competition and RF-EMF exposure limits is only observed. This relationship is reflected through the mobile-broadband subscriptions (MBB_subs) explanatory variable, mobile-broadband prices variables are non-significant. In addition, the CAGR in mobile-broadband subscriptions impacts positively and significantly RF-EMF exposure limits in the 5G dataset. That is, the higher the levels of network deployment, the more relaxed RF-EMF exposure limits in countries in the 5G dataset, these countries being characterized by high levels of deployment and low prices (see the previous section with the preliminary empirical analysis). Higher growth rates in the network (and hence low initial deployment) shall favour more restrictive limits. Overall, these results seem to be consistent with those obtained for the whole dataset.

Hypothesis 4 that says that the onset of 5G technology will tend to relax RF-EMF exposure limits. The binary variable accounting for the presence of 5G technology ($tech\_5G$) has a negative and significant impact on RF-EMF exposure limits in the whole dataset, but only when the dependent variable is the $EMF\_Chiaraviglio$ indicator (Table 4). In addition, the variables that proxy the use of high frequency bands associated with 5G ($tech\_highfreq$) and the number of frequency bands allocated to 5G ($tech\_intensity$) do not have significant statistical impact on RF-EMF exposure limits. The impact of 5G technology is better captured through the regressions applied to the 5G dataset than when including discrete variables in regressions with the whole dataset.

To summarize, the analysis showed that RF-EMF exposure limits are influenced by decentralization, competition, and technological factors. When comparing the whole dataset with the 5G dataset, political and fiscal decentralization variables have a positive impact on RF-EMF exposure limits in the whole data set, the impact is instead negative in the 5G dataset. The smaller the area covered by the local government and, more importantly, the fewer the population living in that area, the higher the RF-EMF exposure limits, but this statement only applied to the whole dataset. Federalism has no significant impact on RF-EMF exposure limits, independently of the dataset analysed. Finally, low levels of competition, have a positive and significant impact of RF-EMF exposure limits. However, when there is a high degree of competition which is common in countries in the 5G dataset, it has a negative and significant impact of RF-EMF exposure limits.

5. Conclusion

This article finds that RF-EMF exposure limits are influenced by decentralization, competition, and technological factors through the first empirical analysis on the topic across a worldwide cross-sectional dataset. In contrast with Borraz et al. (2005) qualitative analysis for five European countries, the degree of decentralization is a relevant determinant of RF-EMF exposure legislation, while federalism plays no role. That is, policy choices concerning decentralization determine RF-EMF exposure legislation, and not constitutional decisions. This finding is consistent with previous research on the economic impact of policy choices versus constitutional decisions (Voigt and Blume, 2009). It is worth noting that the past decades have witnessed a clear trend towards decentralization around the world and, therefore, the role of this factor should remain relevant (Allain-Dupré, 2018).

The results for the whole dataset show that higher levels of decentralization, smaller local government population and area, and mobile network competition (with low levels of deployment) are all correlated with more restrictive RF-EMF exposure limits. This setting fits the framework described by Borraz et al. (2005) well and subsequently Salomon and Borraz (2005) in the 2000s. At that time, social unrest originated from the local level. While This disquiet was never really resolved given that local authorities often had no mandate to halt deployment, however, regions in more decentralised countries had a greater influence on national legislation.[40]

The findings for the 5G dataset are remarkably different compared to those obtained for the whole dataset: higher levels of decentralization and mobile network competition (with high levels of deployment) are both correlated with *less* restrictive RF-EMF exposure limits. While there have been a relatively high number of countries where there were protests against 5G technology and physical damage to the mobile network stations, the permission process for the installation of mobile network stations has continued to evolve since the 2000s. According to a recent ITU survey in Europe, in 18 countries out of 27 the approval process for mobile network stations must be validated by multiple authorities, and in 12 countries this process takes over two months (ITU, 2021d). This can contribute to explain why decentralization does not lead to more restrictive EMF exposure limits with 5G.

At the same time, unlike initial mobile network deployments in the 2000s, mobile data traffic demands may be constrained in countries and regions with restrictive RF-EMF exposure limits, particularly those countries with high levels of network deployment (ITU, 2018; ITU, 2019; Lewicki, 2020). For instance, in 2020 both Poland and Lithuania changed their legislation based on restrictive RF-EMF exposure limits to adopt the RF-EMF limits defined the ICNIRP guidelines. The RF-EMF exposure limits were posing challenges for the deployment of 5G technology (ITU, 2018).

Even though the role of the presence of allocation of millimetric frequencies typically associated with 5G, such as the 26 gigahertz band, is controlled by including a variable in the regressions, there is no significant impact on the choice of RF-EMF exposure limits. Millimetric frequencies are in the range between 30 to 300 gigahertz, and hence these frequencies are higher than those typically allocated for 2G, 3G, and 4G technologies. With respect to these millimetric frequencies, the current data is not sufficient to conclude on the existence or on the absence of effects to health related to mobile services emissions on those bands (ANSES, 2022).[41]

It is worth noting that the World Radiocommunications Conference (WRC) 2019 has already identified the frequency bands 37-43.5 gigahertz and 66-71 gigahertz for the deployment of 5G networks. The 40.5-43.5 gigahertz band is currently being harmonized at the European level for 5G services and the 66-71 gigahertz band is already available for 5G deployment in Europe (EC, 2020b). The WRC 2023 is considering the identification of the 6.425-7.125 gigahertz frequency band for mobile services. While

[40] At the European scale, groups in more highly decentralized regions are involved in the domestic EU policy-shaping process to a greater extent than those which do not (Tatham, 2011; López and Tatham, 2018).

[41] The ANSES calls for more scientific studies on the effects of exposure to humans and animals, particularly on millimetric frequency bands and on the effects of signal intermittency associated with 5G technology. See Russell (2018) for a recent review of 5G technology and public health.

these choices may cause some public contest, deployment in these high frequency bands is forecast to be relatively modest in the short-term compared to lower bands where technology is mature.

As compared to millimetric frequency bands, research in lower frequency bands, which have been commonly used for mobile services for over twenty years, is not sufficient to conclude on the existence or on the absence of effects to health related to mobile services emissions on those bands below the regulatory limit values (ANSES, 2022). Children, however, may be more exposed than adults due to their morphological and anatomical specificities and, hence, a moderate use prioritizing hand-free kits is recommended (ANSES, 2016).

The results in this article on the determinants of RF-EMF exposure limits associated with 5G technology should be useful for policymakers in central administrations and mobile operators alike to craft their decisions. The findings should contribute to policymakers' efforts to anticipate legislation outcomes in countries which have not as yet introduced 5G technology. They should also be useful to help review policies and strategies in the advent of the 6G technology in frequency bands that will be increasingly higher (above 6 gigahertz and up to terahertz for very local usage), and hence where the effects on humans are less well studied.

As the number of countries with RF-EMF exposure is small, future research work could consider time series data to proxy changes in RF-EMF exposure limits. It could also take into account the procedures for the calculation and monitoring of RF-EMF emissions since they also contribute to the non-alignment of RF-EMF exposure frameworks between countries. In addition, updated data on a wide variety of decentralization factors across a large number of countries (>150) would enable the robustness of the results to be tested. The results from the two datasets on decentralization (Ivanyna and Shah, 2012; Hooghe et al., 2016 and Shair-Rosenfield et al., 2021) are, for the whole dataset, similar and, for the 5G dataset, complementary.

The article analyses the determinants of RF-EMF exposure limits associated with mobile network stations. Indeed, legislation varies from one country to the other on this topic, and the public is particularly concerned with these installations (GSMA, 2022). In comparison, the legislation is fairly homogeneous for mobile handsets across the world, and the population typically attributes higher risk levels to mobile network stations than to mobile phone handsets (Siegrist et al., 2005; EC, 2007). Nevertheless, for active users, the exposure from mobile phones can be ten times higher than the exposure from mobile network stations (Deruyck et al., 2021). Moreover, exposure levels for people passing nearby can be as high as those experienced by the mobile phone user (Bonato et al., 2022).

It is important, therefore, to include track for the constant evolution in mobile phones themselves with the proliferation of innovative applications, and in particular, the way they are used (phone held against the ear, hands-free, Bluetooth versus wired headphones, body devises, etc), and when they are used (outdoor, indoor, daytime, night-time, etc) to estimate RF-EMF exposure adequately and explore potential medium- and long-term risks (Tavner, 2020).[42] There are initiatives to estimate real RF-EMF exposure of the population considering, for instance, the period (night, day), the network (macro-cells, microcells, etc), the technology, the environment (indoor, outdoor, in public transport), the profile (non-user, low-, medium-, high-user), the position of the user, the duration, the user typology (child, young adult, adult, senior), and the user professional category being analysed. All these factors influence the exposure of the individual to RF-EMF emissions and place part of the responsibility of exposure with the users (Tesanovic et al., 2014; Lô, 2017; Chiaramello et al., 2019; Regrain et al., 2020).

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Appendix

Data description, sources, and descriptive statistics

Sample of countries

The data set constructed for this article contains observations of a sample of 134 worldwide countries that apply the international mobile station exposure limits (ICNIRP, 1998 or ICNIRP, 2020) or the US national mobile network limits (FCC, 1996), and another sample of 30 countries worldwide that apply restrictive mobile station exposure limits, for which there is sufficient data on the determinants of interest (see Table 1 in the main text). Table A.1 below lists the 164 countries selected for the article according to the type of EMF legislation (standard exposure limits, restrictive exposure limits) and following the World Bank regional classification. This data is based on authors' elaborations building on ITU (2021d) surveys, GSMA (2022) and Chiaraviglio et al. (2022) datasets. Table A.2 below lists the 61 countries which have 5G amongst those countries in the whole dataset in Table A.1. Within this 5G dataset, there are 46 countries with standard exposure limits and 15 countries with restrictive exposure limits.

Table A.1 The whole dataset

Standard exposure limits	Restrictive exposure limits
East Asia and Pacific	
American Samoa, Australia, Brunei Darussalam, Cambodia, Guam, Hong Kong, Japan, Korean Republic, Malaysia, Micronesia, Mongolia, Myanmar, New Zealand, Northern Mariana Islands, Palau, Papua New Guinea, Philippines, Singapore, Thailand, Timor-Leste, Vanuatu, Vietnam	China, Indonesia
Europe and Central Asia	
Albania, Andorra, Austria, Cyprus, Czech Republic, Denmark, Estonia, Faroe Islands, Finland, France, Germany, Greenland, Hungary, Iceland, Ireland, Kosovo, Latvia, Lithuania, Malta, Netherlands, North Macedonia, Norway, Poland, Portugal, Romania, Slovak Republic, Spain, Sweden, United Kingdom	Armenia, Azerbaijan, Belarus, Belgium, Bosnia and Herzegovina, Bulgaria, Croatia, Georgia, Greece, Italy, Kazakhstan, Kyrgyz Republic, Luxembourg, Moldova, Monaco, Montenegro, Russian Federation, Serbia, Slovenia, Switzerland, Tajikistan, Ukraine, Uzbekistan
Latin America and Caribbean	
Antigua and Bermuda, Argentina, Bolivia, Brazil, British Virgin Islands, Colombia, Costa Rica, Dominican Republic, Ecuador, El Salvador, Guatemala, Guyana, Haiti, Honduras, Jamaica, Mexico, Nicaragua, Panama, Paraguay, Peru, Puerto Rico, Surinam, Trinidad and Tobago, Uruguay, Venezuela, Virgin Islands (U.S.)	Chile
Middle East and North Africa	
Algeria, Bahrain, Egypt, Iran, Jordan, Lebanon, Morocco, Oman, Qatar, Saudi Arabia, Syrian Arab Republic, Tunisia, United Arab Emirates, West Bank and Gaza, Yemen	Israel, Kuwait, Turkey
North America	
Unites States	Canada
South Asia	
Afghanistan, Bangladesh, Bhutan, Maldives, Nepal, Pakistan, Sri Lanka	India
Sub-Saharan Africa	
Benin, Botswana, Cabo Verde, Cameroon, Central African Republic, Côte d'Ivoire, Democratic Republic of Congo, Equatorial Guinea, Eswantini, Ghana, Guinea, Guinea-Bisseau, Kenya, Lesotho, Liberia, Madagascar, Mali, Mauritania, Mauritius, Mozambique, Namibia, Niger, Nigeria, Rwanda, Senegal, Seychelles, South Africa, South Sudan, Sudan, Tanzania, Uganda, Zambia, Zimbabwe	

Table A.2 The 5G dataset

Standard exposure limits	Restrictive exposure limits
East Asia and Pacific	
Australia, Brunei Darussalam, Cambodia, Hong Kong, Japan, Korean Republic, Malaysia, Myanmar, New Zealand, Philippines, Thailand, Vietnam	China
Europe and Central Asia	
Austria, Czech Republic, Denmark, Estonia, Finland, France, Germany, Hungary, Iceland, Ireland, Latvia, Lithuania, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovak Republic, Spain, Sweden, United Kingdom	Belgium, Bulgaria, Croatia, Greece, Italy, Luxembourg, Monaco, Slovenia, Switzerland, Ukraine
Latin America and Caribbean	
Argentina, Brazil, Mexico, Uruguay	Chile
Middle East and North Africa	
Bahrain, Oman, Qatar, Saudi Arabia, United Arab Emirates	Israel
North America	
Unites States	Canada
South Asia	
Bhutan	India
Sub-Saharan Africa	
Ghana	

Data content and sources

For the proxies of the determinants of EMF legislation, data was collected according to the three hypotheses considered in this article, namely, decentralization and federalism, technology, and competition hypotheses (see Table 1 in the main text), and some control variables regrouped under the label Others (controls) and some instruments were added. Table A.2 below gives the data content and the sources.

Table A.3 Data content and sources

Designation	**Variable name**	**Content and data source**
EMF legislation applicable to mobile network antennas		
Radiofrequency exposure limits (GSMA)	EMF_GSMA	Time-invariant binary variable that takes the value 0 if the country applies the international exposure limits (ICNIRP, 1998 or ICNIRP, 2020) or the US national exposure limits (FCC, 1996), and the value 1 if the country applies more restrictive exposure limits. Source: GSMA (2022), last update on the 23rd March 2021.
Radiofrequency exposure limits (Chiaraviglio)	$EMF\_Chiaraviglio$	Time-invariant binary variable that takes the value 0 if the country applies the international exposure limits (ICNIRP, 1998 or ICNIRP, 2020) or the US national exposure limits (FCC, 1996), and the value 1 if the country applies more restrictive exposure limits. Source: Chiaraviglio et al. (2022) based on data retrieved in June 2020.
Radiofrequency exposure limits	EMF	Time-invariant binary variable that takes the value 0 if the country applies the international exposure limits (ICNIRP, 1998 or ICNIRP, 2020) or the US national exposure limits (FCC, 1996), and the value 1 if the country applies more restrictive exposure limits. Source: authors' elaboration based on ITU (2021d) surveys, GSMA (2022) and Chiaraviglio et al. (2022).
Radiofrequency exposure limits (5G)	EMF_5G	Time-invariant binary variable where 0 indicates that the country applies the international exposure limits (ICNIRP, 1998 or ICNIRP, 2020) or the US national exposure limits (FCC, 1996), and 1 indicates that the country applies more restrictive exposure limits, for a country with 5G technology. Source: authors' elaboration based on Chiaraviglio et al. (2022).
Federalism and decentralization		
Federalism	$federal$	Time-invariant binary variable that takes the value 0 if the country is unitary and the value 1 if the country is federal. Source: Democracy Cross-national Data, Release 4.0 Fall 2015 (https://www.pippanorris.com/data) based on Norris (2008).

Administrative decentralization	$admin$	Time-invariant continuous variable that measures the ability of local governments to hire and fire and set terms of employment of local employees (lg_hr_policy) and the share of local government employment in general government employment (lg_employment). It is constructed as follows: 1/2(lg_hr_policy+ lg_employment). Source: Ivanyna and Shah (2012) mainly based on 2005 data.
Fiscal decentralization	$fiscal$	Time-invariant continuous variable that measures at the local government level the fiscal gap between expenditure needs and revenues (lg_gap), the taxation autonomy (lg_taxaut), the unconditional transfers (lon_transf), the expenditure autonomy (lg_expaut) and the borrowing freedom (lg_borrow). It is constructed as follows: lg_expaut * (δ+(1-δ)/2*(lg_taxaut +lg_borrow), where lg_expaut=1-lg_gap*((1-δ)-(1-2δ)*lg_transf)) where δ is a smoothing parameter. Source: Idem.
Political decentralization	$political$	Time-invariant continuous variable that measures local government legislative and executive elections (appointed or elected directly or indirectly) (lg_legel, lg_exel) and direct democracy provisions for different forms of citizen participation at the local level (lg_dirdem). It is constructed as follows: 1/3(lg_legel+lg_exel+lg_dirdem). Source: Idem.
Local government security of existence	$LG\_existence$	Time-invariant discrete variable that takes the value 1 if there are legislative safeguards against dismissal of the local government council by the central government, the value 0.5 if the local government can be dismissed under certain circumstances (prescribed by law or constitution), the value 0 if the local government can be dismissed in an arbitrary situation and the values 0.25 or 0.75 if the local government is treated asymmetrically. Source: Idem.
Relative importance of local government	$LG\_expenditures$	Time-invariant continuous variable that measures local government expenditures as a percentage of general government expenditures. Source: Idem.
Decentralization index	$decentr$	Time-invariant continuous index that incorporates the relative importance of local government (measured by lg_expdec), the security of existence of LG (measured by lg_indep), and fiscal, political and administrative indexes (fdi, pdi, and adi, respectively). It is constructed as follows: lg_expdec*(δ +(1-δ)*lg_indep)*fdi*(δ+(1- δ)*pdi)*(δ +(1- δ)*adi) where δ is a smoothing parameter. Source: Idem.
Local government population	$LG\_population$	Time-invariant continuous variable measuring the local government average population in thousands. Source: Idem.
Local government area	LG_area	Time-invariant continuous variable measuring the local government average area in thousands sq.km. Source: Idem.
Institutional depth	$inst\_depth$	Time-invariant discrete variable that measures in the year 2018 the extent to which a regional government is autonomous rather than deconcentrated. It takes the value 0: no functioning general-purpose administration at regional level; the value 1: deconcentrated, general-purpose, administration; the value 2: non-deconcentrated, general-purpose, administration subject to central government veto; and the value 3: non-deconcentrated, general–purpose, administration *not* subject to central government veto. Source: Hooghe et al. (2016) and Shair-Rosenfield et al. (2021).
Policy autonomy	$policy\_autonomy$	Time-invariant discrete variable that measures in the year 2018 the range of policies for which a regional government is responsible. It takes the value 0: very weak authoritative competence in a), b), c), d) whereby a) economic policy, b) cultural-educational policy, c) welfare policy, d) one of the following: residual powers, police, own institutional set-up, local government; the value 1: authoritative competencies in one of a), b), c) or d); the value 2: authoritative competencies in at least two of a), b), c), or d); the value 3: authoritative competencies in d) and at least two of a), b), or c); and the value 4: criteria for 3 plus authority over immigration or citizenship. Source: Idem.
Fiscal autonomy	$fiscal\_autonomy$	Time-invariant discrete variable that measures in the year 2018 the extent to which a regional government can independently tax its population. It takes the value 0: central government sets base and rate of all regional taxes; the value 1: regional government sets the rate of minor taxes; the value 2: regional government sets base and rate of minor taxes; the value 3: regional government sets the rate of at least one major tax: personal income, corporate, value added, or sales tax; and the value 4: regional government sets base and rate of at least one major tax. Source: Idem.
Borrow autonomy	$borrow\_autonomy$	Time-invariant discrete variable that measures in the year 2018 the extent to which a regional government can borrow. It takes that value 0: the regional government does not borrow (e.g. centrally imposed rules prohibit borrowing); the value 1: the regional government may borrow under prior authorization (ex-ante) by the central government and with one or more of the following centrally imposed restrictions: a. golden rule (e.g. no borrowing to cover current account deficits); b. no foreign borrowing or borrowing from the central bank; c. no borrowing above a ceiling; d. borrowing is limited to specific purposes; 2: the regional government may borrow without prior authorization (ex post) and under one or more of a), b), c), d); and the value 3: the regional government may borrow without centrally imposed restrictions.

Representation	$representation$	Time-invariant discrete variable that measures in the year 2018 the extent to which a region has an independent legislature and executive, which is the sum of $assembly$ and $executive$, where $assembly$ takes the value 0: no regional assembly; the value 1: indirectly elected regional assembly; and the value 2: directly elected assembly, and $executive$ takes the value 0: no regional executive or appointed by central government; the value 1: dual executive appointed by central government and regional assembly; and the value 2: regional executive appointed by a regional assembly or is directly elected. Source: Idem.
Law-making	law_making	Time-invariant discrete variable that measures in the year 2018 the extent to which regional representatives co-determine national legislation, which is the sum of law_making_a to law_making_f (see below for breakdown). Source: Idem.
Law-making (a)	law_making_a	Time-invariant binary variable that measures in the year 2018 that takes the value 0: a region or regional tier is *not* the unit of representation in a national legislature; and the value 0.5: a region or regional tier is the unit of representation in a national legislature. Source: Idem.
Law-making (b)	law_making_b	Time-invariant binary variable that measures in the year 2018 that takes the value 0: a region or regional tier does *not* designate representatives in a national legislature; and the value 0.5: a region or regional tier designates representatives in a national legislature. Source: Idem.
Law-making (c)	law_making_c	Time-invariant binary variable that measures in the year 2018 that takes the value 0: regions do *not* have majority representation in a national legislature; and the value 0.5: regions have majority representation in a national legislature. Source: Idem.
Law-making (d)	law_making_d	Time-invariant binary variable that measures in the year 2018 that takes the value 0: the legislature based on regional representation does *not* have extensive legislative authority and the value 0.5: the legislature based on regional representation has extensive legislative authority. Source: Idem.
Law-making (e)	law_making_e	Time-invariant binary variable that measures in the year 2018 that takes the value 0: the regional government or its regional representatives in a national legislature are *not* consulted on national legislation affecting the region; and the value 0.5: the regional government or its regional representatives in a national legislature are consulted on national legislation affecting the region. Source: Idem.
Law-making (f)	law_making_f	Time-invariant binary variable that measures in the year 2018 that takes the value 0: the regional government or its regional representatives in a legislature do *not* have veto power over national legislation affecting the region; and the value 0.5: the regional government or its regional representatives in a legislature have veto power over national legislation affecting the region. Source: Idem.
Executive control	$exec\_control$	Time-invariant discrete variable that measures in the year 2018 the extent to which a regional government co–determines national policy in intergovernmental meetings. It takes the value 0: no routine meetings between central and regional governments; the value 1: routine meetings between central and regional governments without legally binding authority; and the value 2: routine meetings between central and regional governments with legally binding authority. Source: Idem.
Fiscal control	$fiscal\_control$	Time-invariant discrete variable that measures in the year 2018 the extent to which regional representatives co-determine the distribution of national tax revenues. It takes the value 0: neither the regional governments nor their representatives in a national legislature are consulted over the distribution of national tax revenues; the value 1: regional governments or their representatives in a national legislature negotiate over the distribution of tax revenues, but do not have a veto; and the value 2: regional governments or their representatives in a national legislature have a veto over the distribution of tax revenues. Source: Idem.
Borrow control	$borrow\_control$	Time-invariant discrete variable that measures in the year 2018 the extent to which a regional government co–determines subnational and national borrowing constraints. It takes the value 0: regional governments are not routinely consulted over borrowing constraints; the value 1: regional governments negotiate routinely over borrowing constraints but do not have a veto; and the value 2: regional governments negotiate routinely over borrowing constraints. Source: Idem.
Constitutional	$constitutional$	Time-invariant discrete variable that measures in the year 2018 the extent to which regional representatives co-determine constitutional change. It takes the value 0: the central government or national electorate can unilaterally reform the constitution; the value 1: a national legislature based on regional representation can propose or postpone constitutional reform, raise the decision hurdle in the other chamber, require a second vote in the other chamber, or require a popular referendum; the value 2: regional governments or their representatives in a national legislature propose or postpone constitutional reform, raise the decision hurdle in the other chamber, require a second vote in the other chamber, or require a popular referendum; the value 3: a legislature based on regional representation can veto constitutional change; or constitutional change requires a referendum based on the principle of equal regional representation; and the value 4: regional governments or

		their representatives in a national legislature can veto constitutional change. Source: Idem.
Self-rule	$self\_rule$	Time-invariant discrete variable that measures in the year 2018 the authority exercised by a regional government over those who live in the region, which is the sum of $inst\_depth$, $policy\_autonomy$, $fiscal\_autonomy$, $borrow\_autonomy$, and $representation$. Source: Idem.
Shared rule	$shared\_rule$	Time-invariant discrete variable that measures in the year 2018 the authority exercised by a regional government or its representatives in the country as a whole, which is the sum of law_making, $exec\_control$, $fiscal\_control$, $borrow\_control$ and $constitutional$. Source: Idem.
Regulatory authority index	RAI	Time invariant continuous variable that measures in the year 2018 the regional authority index, which is the sum of $self\_rule$ and $shared\_rule$. Source: Idem.
Competition		
Mobile-broadband subscriptions	MBB_subs	Continuous variable that measures mobile-broadband subscriptions per 100 inhabitants in the year 2020. Source: ITU (2022).
Mobile-broadband subscriptions (squared)	MBB_subs_sq	The square of the variable mobile-broadband subscriptions. Source: Idem.
Mobile-broadband subscriptions (CAGR)	MBB_subs_CAGR	Continuous variable that measures the Compound Annual Growth Rate (CAGR) in mobile-broadband subscriptions per 100 inhabitants between the year 2015 and the year 2020. Source: Idem.
Mobile-broadband prices (1.5 GB)	MBB_prices_data	Continuous variable that measures data-only mobile-broadband prices for 1.5 GB in the year 2020 (US $, purchasing power parity as a percentage of Gross national income per capita). Source: Idem.
Mobile-broadband prices (1.5 GB) (squared)	$MBB\_prices\_data\_sq$	The square of the variable mobile-broadband prices (1.5 GB). Source: Idem.
Mobile-broadband prices (low consumption)	MBB_prices_low	Continuous variable that measures mobile data and voice low-consumption basket in the year 2020 (140 min, 70 SMS, 1.5 GB) (US $, purchasing power parity as a percentage of Gross national income per capita). Source: Idem.
Mobile-broadband prices (low consumption) (squared)	$MBB\_prices\_low\_sq$	The square of the variable mobile-broadband prices (low consumption). Source: Idem.
Mobile-broadband prices (high consumption)	MBB_prices_high	Continuous variable that measures mobile data and voice high-consumption basket in the year 2020 (70 min, 20 SMS, 500 MB) (US $, purchasing power parity as a percentage of Gross national income per capita). Source: Idem.
Mobile-broadband prices (high consumption) (squared)	$MBB\_prices\_high\_sq$	The square of the variable mobile-broadband prices (high consumption). Source: Idem.
Technology		
5G technology (dummy)	$tech\_5G$	Time-invariant binary variable where the value 0 indicates no 5G and the value 1 indicates that 5G is present. Source: Chiaraviglio et al. (2022) based on data retrieved in June 2020.
5G technology (high frequency)	$tech\_highfreq$	Time-invariant binary variable where the value 0 indicates no 5G in frequencies > 6 GHz and the value 1 indicates that 5G is present > 6 GHz. Source: Idem.
5G technology (intensity)	$tech\_intensity$	Time-invariant discrete variable where the value 0 indicates no 5G, the value 1 indicates that 5G is present in one frequency range (5G < 1GHz or 1 GHz < 5G < 6 GHz or 5G > 6 GHz), the value 2 indicates that 5G is present in two frequency ranges (5G < 1GHz and 1 GHz < 5G < 6 GHz or 5G < 1 GHz and 5G > 6 GHz or 1 GHz < 5G < 6 GHz and 5G > 6 GHz) and the value 3 indicates that 5G is present across three frequency ranges (5G < 1GHz and 1GHz < 5G < 6 GHz and 5G > 6 GHz). Source: Idem.
Others (controls)		
GDP per capita	gdp	Continuous variable that measures the gross domestic product per capita in the year 2020 (purchasing power parity, constant 2017 international $). Source: World Bank Indicators data.
Population density	$population$	Continuous variable that measures people per sq. km of land area in the year 2020. Source: Idem.
Rural population	$rural$	Continuous variable that measures the rural population as a share of the total population in the year 2020. Source: Idem.
Instruments		
Corruption	$corruption$	Continuous variable that captures perceptions of the extent to which public power is exercised for private gain, including both petty and grand forms of corruption, as

		well as "capture" of the state by elites and private interests in the year 2013. Source: World Bank Indicators data.
Stability	$stability$	Continuous variable that measures perceptions of the likelihood of political instability and/or politically motivated violence, including terrorism in the year 2013. Source: Idem.
Democracy	$democracy$	Continuous variable that measures liberal democracy in a standardized scale of 100 points in the year 2014. Source: Freedom House.

Summary statistics

Table A.4 Summary statistics: The whole dataset

Designation	Variable name	Obs.	Median	Mean	Std dev.	Min.	Max.
EMF legislation applicable to mobile network antennas							
Radiofrequency exposure limits (GSMA)	EMF_GSMA	153	0.00	0.16	0.37	0.00	1.00
Radiofrequency exposure limits (Chiaraviglio)	$EMF\_Chiaraviglio$	139	0.00	0.20	0.40	0.00	1.00
Radiofrequency exposure limits	EMF	164	0.00	0.18	0.38	0.00	1.00
Radiofrequency exposure limits (5G)	EMF_5G	61	0.00	0.24	0.43	0.00	1.00
Federalism and decentralization							
Federalism	$federal$	165	0.00	0.36	0.48	0.00	1.00
Administrative decentralization	$admin$	149	0.34	0.35	0.27	0.00	0.90
Fiscal decentralization	$fiscal$	149	0.34	0.37	0.25	0.06	1.00
Political decentralization	$political$	149	0.50	0.49	0.23	0.00	1.00
Local government security of existence	$LG\_existence$	149	0.25	0.29	0.29	0.00	1.00
Relative importance of local government	$LG\_expenditures$	145	0.10	0.15	0.14	0.00	0.59
Decentralization index	$decentr$	149	0.44	2.73	5.65	0.00	36.87
Local government population	$LG\_population$	145	0.06	0.10	0.11	0.00	0.78
Local government area	LG_area	147	41.40	113.17	364.85	0.00	4,270
Institutional depth	$inst\_depth$	89	2.00	2.22	1.59	0.00	6.72
Policy autonomy	$policy\_autonomy$	89	1.51	1.72	1.56	0.00	5.98
Fiscal autonomy	$fiscal\_autonomy$	89	0.12	1.04	1.52	0.00	5.92
Borrow autonomy	$borrow\_autonomy$	89	0.86	1.01	1.21	0.00	4.61
Representation	$representation$	89	3.11	3.11	2.43	0.00	8.91
Law-making	law_making	88	0.00	0.39	0.65	0.00	2.00
Law-making (a)	law_making_a	88	0.00	0.12	0.21	0.00	0.50
Law-making (b)	law_making_b	88	0.00	0.06	0.16	0.00	0.50
Law-making (c)	law_making_c	88	0.00	0.12	0.21	0.00	0.50
Law-making (d)	law_making_d	88	0.00	0.08	0.18	0.00	0.50
Law-making (e)	law_making_e	88	0.00	0.00	0.02	0.00	0.14
Law-making (f)	law_making_f	88	0.00	0.00	0.00	0.00	0.08
Executive control	$exec\_control$	88	0.00	0.31	0.62	0.00	2.00
Fiscal control	$fiscal\_control$	89	0.00	0.26	0.59	0.00	2.00
Borrow control	$borrow\_control$	89	0.00	0.18	0.55	0.00	2.00
Constitutional	$constitutional$	89	0.00	0.89	1.59	0.00	6.3,1
Self-rule	$self\_rule$	89	8.61	9.24	7.56	0.00	27.97

Shared rule	$shared\_rule$	88	0.00	2.07	3.51	0.00	12.95
Regulatory authority index	RAI	88	0.00	11.31	10.21	0.00	37.67
<u>Competition</u>							
Mobile-broadband subscriptions	MBB_subs	156	80.91	80.66	45.65	0.57	344.55
Mobile-broadband subscriptions (squared)	MBB_subs_sq	156	6,657.95	8,629.89	11,647.57	0.32	118,719.80
Mobile-broadband subscriptions (CAGR)	MBB_subs_CAGR	152	8.24	14.15	23.66	-22.70	181.97
Mobile-broadband prices (1.5 GB)	MBB_prices_data	149	1.23	2.78	4.47	0.18	32.31
Mobile-broadband prices (1.5 GB) (squared)	$MBB\_prices\_data\_sq$	149	1.51	27.62	113.32	0.03	1043.93
Mobile-broadband prices (low consumption)	MBB_prices_low	148	1.61	3.80	6.42	0.09	43.58
Mobile-broadband prices (low consumption) (squared)	$MBB\_prices\_low\_sq$	148	2.60	55.41	222.63	0.01	1899.21
Mobile-broadband prices (high consumption)	MBB_prices_high	149	1.96	5.67	9.72	0.18	69.46
Mobile-broadband prices (high consumption) (squared)	$MBB\_prices\_high\_sq$	149	3.84	126.12	510.51	0.03	4824.69
<u>Technology</u>							
5G technology (dummy)	$tech\_5G$	162	0.00	0.38	0.48	0.00	1.00
5G technology (high frequency)	$tech\_highfreq$	162	0.00	0.11	0.31	0.00	1.00
5G technology (intensity)	$tech\_intensity$	162	0.00	0.70	1.00	0.00	3.00
<u>Others (controls)</u>							
GDP per capita	gdp	152	14,292.44	21,945.12	20,968.33	937.85	112,557.30
Population density	$population$	164	85.33	376.55	1,721.42	0.13	19,360.63
Rural population	$rural$	164	36.09	37.00	22.42	0.00	86.65
<u>Instruments</u>							
Corruption	$corruption$	151	-0.34	-0.01	1.01	-1.61	2.41
Stability	$stability$	152	-0.03	-0.09	0.98	-2.68	1.45
Democracy	$democracy$	152	71.40	68.44	27.41	14.28	99.96

Table A.5 Summary statistics: The whole dataset - standard RF-EMF limits versus restrictive RF-EMF limits

Designation	Variable name	Standard RF-EMF limits			Restrictive RF-EMF limits		
		Obs.	Mean	Std. dev	Obs.	Mean	Std. dev
<u>EMF legislation applicable to mobile network antennas</u>							
Radiofrequency exposure limits (GSMA)	EMF_GSMA	128	0.00	0.00	25	1.00	0.00
Radiofrequency exposure limits (Chiaraviglio)	$EMF\_Chiaraviglio$	109	0.00	0.00	30	0.96	0.18
Radiofrequency exposure limits	EMF	134	0.00	0.00	30	1.00	0.00
Radiofrequency exposure limits (5G)	EMF_5G	46	0.00	0.00	15	1.00	0.00
<u>Federalism and decentralization</u>							
Federalism	$federal$	135	0.35	0.48	30	0.40	0.49

Administrative decentralization	$admin$	119	0.31	0.26	30	0.51	0.25
Fiscal decentralization	$fiscal$	119	0.35	0.24	30	0.47	0.25
Political decentralization	$political$	119	0.47	0.23	30	0.59	0.21
Local government security of existence	$LG\_existence$	119	0.26	0.28	30	0.43	0.27
Relative importance of local government	$LG\_expenditures$	115	0.14	0.14	30	0.21	0.14
Decentralization index	$decentr$	119	2.44	5.15	30	3.88	7.30
Local government population	$LG\_population$	116	0.11	0.11	29	0.05	0.04
Local government area	LG_area	118	134.20	404.54	29	27.64	29.16
Institutional depth	$inst\_depth$	70	2.02	1.45	19	2.99	1.87
Policy autonomy	$policy\_autonomy$	70	1.62	1.46	19	2.11	1.86
Fiscal autonomy	$fiscal\_autonomy$	70	0.89	1.29	19	1.59	2.13
Borrow autonomy	$borrow\_autonomy$	70	0.93	1.13	19	1.33	1.44
Representation	$representation$	70	2.97	2.39	19	3.63	2.57
Law-making	law_making	69	0.37	0.61	19	0.48	0.76
Law-making (a)	law_making_a	69	0.12	0.21	19	0.13	0.22
Law-making (b)	law_making_b	69	0.04	0.13	19	0.13	0.22
Law-making (c)	law_making_c	69	0.12	0.21	19	0.13	0.22
Law-making (d)	law_making_d	69	0.08	0.18	19	0.07	0.18
Law-making (e)	law_making_e	69	0.00	0.01	19	0.00	0.03
Law-making (f)	law_making_f	69	0.00	0.00	19	0.00	0.00
Executive control	$exec\_control$	70	0.28	0.60	19	0.42	0.69
Fiscal control	$fiscal\_control$	70	0.20	0.52	19	0.48	0.76
Borrow control	$borrow\_control$	70	0.17	0.53	19	0.21	0.63
Constitutional	$constitutional$	70	0.76	1.52	19	1.37	1.80
Self-rule	$self\_rule$	69	8.57	6.99	19	11.67	9.15
Shared rule	$shared\_rule$	69	1.82	3.32	19	2.97	4.11
Regulatory authority index	RAI	69	10.39	9.29	19	14.65	12.75
Competition							
Mobile-broadband subscriptions	MBB_subs	126	78.87	49.50	30	88.20	22.45
Mobile-broadband subscriptions (squared)	MBB_subs_sq	126	8,716.92	12,856.05	30	8,267.26	3,682.22
Mobile-broadband subscriptions (CAGR)	MBB_subs_CAGR	122	14.93	25.61	30	10.98	12.87
Mobile-broadband prices (1.5 GB)	MBB_prices_data	120	3.18	4.86	29	1.16	1.35
Mobile-broadband prices (1.5 GB) (squared)	$MBB\_prices\_data\_sq$	120	33.55	125.56	29	3.11	10.22
Mobile-broadband prices (low consumption)	MBB_prices_low	119	4.42	7.01	29	1.23	0.81
Mobile-broadband prices (low consumption) (squared)	$MBB\_prices\_low\_sq$	119	68.39	246.73	29	2.71	2.92
Mobile-broadband prices (high consumption)	MBB_prices_high	120	6.66	10.58	29	1.56	1.40
Mobile-broadband prices (high consumption) (squared)	$MBB\_prices\_high\_sq$	120	155.54	565.35	29	4.37	10.90

Technology							
5G technology (dummy)	$tech\_5G$	132	0.36	0.48	30	0.50	0.50
5G technology (high frequency)	$tech\_highfreq$	132	0.11	0.31	30	0.10	0.30
5G technology (intensity)	$tech\_intensity$	132	0.65	0.99	30	0.9	1.06
Others (controls)							
GDP per capita	gdp	123	20,699.44	20,528.28	29	27,230.22	22,342.48
Population density	$population$	134	288.92	947.37	30	767.98	3,513.62
Rural population	$rural$	134	38.04	22.98	30	32.39	19.43
Instruments							
Corruption	$corruption$	122	-0.01	1.01	29	0.00	1.00
Stability	$stability$	122	-0.11	1.01	30	-0.03	0.76
Democracy	$democracy$	122	68.47	27.08	30	68.30	29.21

Table A.6 Summary statistics: the 5G dataset - standard RF-EMF limits versus restrictive RF-EMF limits

Designation	Variable name	Standard RF-EMF limits			Restrictive RF-EMF limits		
		Obs.	Mean	Std. dev	Obs.	Mean	Std. dev
EMF legislation applicable to mobile network antennas							
Radiofrequency exposure limits (GSMA)	EMF_GSMA	43	0.00	0.00	11	1.00	0.00
Radiofrequency exposure limits (Chiaraviglio)	$EMF\_Chiaraviglio$	46	0.00	0.00	15	1.00	0.00
Radiofrequency exposure limits	EMF	46	0.00	0.00	15	1.00	0.00
Radiofrequency exposure limits (5G)	EMF_5G	46	0.00	0.00	15	1.00	0.00
Federalism and decentralization							
Federalism	$federal$	46	0.39	0.49	15	0.46	0.51
Administrative decentralization	$admin$	46	0.46	0.27	15	0.55	0.24
Fiscal decentralization	$fiscal$	46	0.49	0.26	15	0.57	0.25
Political decentralization	$political$	46	0.57	0.22	15	0.70	0.19
Local government security of existence	$LG\_existence$	46	0.42	0.32	15	0.56	0.24
Relative importance of local government	$LG\_expenditures$	45	0.20	0.15	15	0.19	0.14
Decentralization index	$decentr$	46	4.94	6.96	15	6.31	9.78
Local government population	$LG\_population$	45	0.09	0.10	14	0.05	0.05
Local government area	LG_area	45	82.41	142.31	14	28.95	33.72
Institutional depth	$inst\_depth$	38	2.33	1.36	13	2.99	1.97
Policy autonomy	$policy\_autonomy$	38	1.89	1.33	13	2.04	1.95
Fiscal autonomy	$fiscal\_autonomy$	38	1.26	1.43	13	1.26	1.88
Borrow autonomy	$borrow\_autonomy$	38	1.25	1.21	13	1.22	1.43
Representation	$representation$	38	3.48	2.02	13	3.57	2.66
Law-making	law_making	38	0.44	0.66	13	0.27	0.55
Law-making (a)	law_making_a	38	0.13	0.22	13	0.08	0.18
Law-making (b)	law_making_b	38	0.06	0.16	13	0.07	0.18
Law-making (c)	law_making_c	38	0.14	0.22	13	0.07	0.18

Law-making (d)	law_making_d	38	0.09	0.19	13	0.03	0.13
Law-making (e)	law_making_e	38	0.00	0.02	13	0.00	0.00
Law-making (f)	law_making_f	38	0.00	0.01	13	0.00	0.00
Executive control	$exec\_control$	38	0.37	0.70	13	0.38	0.65
Fiscal control	$fiscal\_control$	38	0.34	0.66	13	0.32	0.62
Borrow control	$borrow\_control$	38	0.28	0.69	13	0.00	0.00
Constitutional	$constitutional$	38	1.12	1.80	13	1.00	1.63
Self-rule	$self\_rule$	38	10.25	6.64	13	11.09	9.10
Shared rule	$shared\_rule$	38	2.57	4.08	13	1.98	3.22
Regulatory authority index	RAI	38	12.82	9.72	13	13.09	11.91
Competition							
Mobile-broadband subscriptions	MBB_subs	46	112.43	37.12	15	93.83	17.11
Mobile-broadband subscriptions (squared)	MBB_subs_sq	46	14,274.65	9,486.69	15	9,077.87	3,063.95
Mobile-broadband subscriptions (CAGR)	MBB_subs_CAGR	46	7.06	6.61	15	13.30	16.26
Mobile-broadband prices (1.5 GB)	MBB_prices_data	44	0.75	0.43	14	0.79	0.49
Mobile-broadband prices (1.5 GB) (squared)	$MBB\_prices\_data\_sq$	44	0.74	0.83	14	0.85	0.97
Mobile-broadband prices (low consumption)	MBB_prices_low	44	1.03	1.01	14	0.95	0.57
Mobile-broadband prices (low consumption) (squared)	$MBB\_prices\_low\_sq$	44	2.06	5.28	14	1.21	1.16
Mobile-broadband prices (high consumption)	MBB_prices_high	44	1.55	2.03	14	1.11	0.59
Mobile-broadband prices (high consumption) (squared)	$MBB\_prices\_high\_sq$	44	6.32	21.30	14	1.56	1.41
Technology							
5G technology (high frequency)	$tech\_highfreq$	46	0.26	0.44	15	0.20	0.41
5G technology (intensity)	$tech\_intensity$	46	1.73	0.85	15	1.8	0.77
Others (controls)							
GDP per capita	gdp	45	37,972.78	20,009.20	14	37,569.05	27,067.71
Population density	$population$	46	344.10	1,092.53	15	1,458.38	4,954.62
Rural population	$rural$	46	25.75	18.53	15	24.64	17.92
Instruments							
Corruption	$corruption$	44	0.79	0.96	14	0.60	1.08
Stability	$stability$	44	0.49	0.75	15	0.29	0.86
Democracy	$democracy$	44	80.32	28.27	15	88.06	20.49

Table A.7 Correlations between dependent and explanatory variables[+]

Dependent variables / Explanatory variables	EMF_GSMA	EMF_Chiaraviglio	EMF	EMF_5G
Federalism and decentralization				
$federalism$	0.06	0.06	0.06	0.06

administrative	-0.11	-0.11	-0.11	-0.11
fiscal	-0.15	-0.15	-0.15	-0.15
political	0.06	0.06	0.06	0.06
LG_existence	-0.08	-0.08	-0.08	-0.08
LG_expenditures	-0.11	-0.11	-0.11	-0.11
decentr	-0.13	-0.13	-0.13	-0.13
LG_population	-0.21	-0.21	-0.21	-0.21
LG_area	-0.11	-0.11	-0.11	-0.11
inst_depth	0.15	0.15	0.15	0.15
policy_autonomy	-0.04	-0.04	-0.04	-0.04
fiscal_autonomy	-0.10	-0.10	-0.10	-0.10
borrow_autonomy	-0.12	-0.12	-0.12	-0.12
representation	-0.06	-0.06	-0.06	-0.06
law_making	-0.09	-0.09	-0.09	-0.09
law_making_a	-0.08	-0.08	-0.08	-0.08
law_making_b	0.04	0.04	0.04	0.04
law_making_c	-0.10	-0.10	-0.10	-0.10
law_making_d	-0.12	-0.12	-0.12	-0.12
law_making_e	-0.09	-0.09	-0.09	-0.09
law_making_f	-0.06	-0.06	-0.06	-0.06
exec_control	-0.03	-0.03	-0.03	-0.03
fiscal_control	-0.04	-0.04	-0.04	-0.04
borrow_control	-0.21	-0.21	-0.21	-0.21
constitutional	-0.08	-0.08	-0.08	-0.08
self_rule	-0.04	-0.04	-0.04	-0.04
shared_rule	-0.10	-0.10	-0.10	-0.10
RAI	-0.06	-0.06	-0.06	-0.06
Competition				
MBB_subs	-0.24	-0.24	-0.24	-0.24
MBB_subs_sq	-0.23	-0.23	-0.23	-0.23
MBB_subs_CAGR	0.38	0.38	0.38	0.38
MBB_prices_data	0.06	0.06	0.06	0.06
MBB_prices_data_sq	0.03	-0.01	0.03	0.03
MBB_prices_low	-0.08	-0.08	-0.08	-0.08
MBB_prices_low_sq	-0.08	-0.09	-0.08	-0.08
MBB_prices_high	-0.10	-0.10	-0.10	-0.10
MBB_prices_high_sq	-0.10	-0.10	-0.10	-0.10
Technology				
tech_highfreq	-0.07	-0.07	-0.07	-0.07
tech_intensity	0.01	0.01	0.01	0.01
Others (controls)				
gdp	-0.04	-0.04	-0.04	-0.04
population	0.26	0.26	0.26	0.26
rural	0.07	0.07	0.07	0.07
Instruments				
corruption	-0.15	-0.11	-0.15	-0.15

stability	-0.21	-0.20	-0.21	-0.21
democracy	0.04	0.04	0.04	0.04

⁺ The matrix of correlations with the complete set of variables is available from the authors upon request.

Table A.8 Correlations between decentralization and federalism variables ⁺
Sources: Democracy Cross-national Data, Release 4.0 Fall 2015 and Ivanyna, M. and Shah, A. (2012)

	federalism	*administrative*	*fiscal*	*political*	*LG_existence*	*LG_expenditures*	*decentr*	*LG_population*	*LG_area*
Democracy Cross-national Data									
federalism	1.00	0.24	0.34	0.36	0.32	0.18	0.17	0.00	0.14
Ivanyna, M. and Shah, A. (2012)									
administrative		1.00	0.66	0.46	**0.80**	0.48	0.61	-0.20	-0.11
fiscal			1.00	0.49	**0.78**	0.36	0.68	-0.13	0.02
political				1.00	0.56	0.28	0.39	-0.24	-0.19
LG_existence					1.00	0.45	**0.71**	-0.20	-0.09
LG_expenditures						1.00	0.58	-0.18	0.11
decentr							1.00	-0.13	0.07
LG_population								1.00	0.45
LG_area									1.00

⁺ Values of correlation greater than or equal to 0.60 are considered as significant and indicated in bold.

Table A.9 Correlations between decentralization and federalism variables ⁺
Sources: Democracy Cross-national Data, Release 4.0 Fall 2015, Hooghe et al. (2016) and Shair-Rosenfield et al. (2021)

	federalism	*inst_depth*	*policy_autonomy*	*fiscal_autonomy*	*borrow_autonomy*	*representation*	*law_making*	*law_making_a*	*law_making_b*	*law_making_c*	*law_making_d*	*law_making_e*	*law_making_f*	*exec_control*	*fiscal_control*	*borrow_control*	*constitutional*	*self_rule*	*shared_rule*	*RAI*
Democracy Cross-national Data																				
federalism	1.00	0.38	0.42	0.50	0.38	0.35	0.48	0.43	0.41	0.41	0.30	0.22	0.18	0.36	0.41	0.33	0.55	0.44	0.53	0.51
Hooghe et al. (2016) and Shair-Rosenfield et al. (2021)																				
inst_depth		1.00	**0.87**	**0.64**	**0.70**	**0.90**	0.49	0.43	0.54	0.44	0.23	0.01	0.01	0.49	0.41	0.40	0.56	**0.92**	0.57	**0.88**
policy_autonomy			1.00	**0.74**	**0.80**	**0.90**	0.52	0.47	0.45	0.49	0.32	- 0.01	0.03	**0.63**	0.51	0.46	0.59	**0.96**	**0.64**	**0.93**
fiscal_autonomy				1.00	**0.77**	**0.61**	0.56	0.52	0.51	0.50	0.34	-0.03	0.03	0.59	0.53	0.50	**0.69**	**0.81**	**0.70**	**0.84**
borrow_autonomy					1.00	**0.74**	0.42	0.33	0.41	0.36	0.31	-0.05	0.00	0.57	0.49	0.39	0.51	**0.87**	0.56	**0.84**
representation						1.00	0.44	0.42	0.43	0.41	0.19	0.01	0.03	0.49	0.37	0.35	0.49	**0.94**	0.51	**0.87**
law_making							1.00	**0.91**	**0.61**	**0.95**	**0.80**	-0.05	0.00	0.58	**0.64**	0.56	**0.82**	0.54	**0.86**	0.69
law_making_a								1.00	0.40	**0.87**	**0.68**	-0.07	0.00	0.55	0.50	0.46	**0.71**	0.48	**0.75**	0.62
law_making_b									1.00	0.49	0.21	-0.05	0.00	0.40	0.59	**0.61**	**0.66**	0.51	**0.68**	0.61
law_making_c										1.00	**0.75**	-0.09	0.04	0.54	0.58	0.51	**0.77**	0.49	**0.81**	0.64
law_making_d											1.00	-0.08	0.06	0.42	0.48	0.30	0.58	0.30	**0.62**	0.44
law_making_e												1.00	**0.71**	0.06	0.07	0.05	0.01	0.01	0.04	0.02
law_making_f													1.00	0.01	0.04	0.03	0.00	0.02	0.01	0.01
exec_control														1.00	**0.67**	**0.62**	**0.64**	**0.60**	**0.79**	**0.72**
fiscal_control															1.00	**0.72**	**0.70**	0.49	**0.84**	0.66
borrow_control																1.00	**0.62**	0.45	**0.78**	0.60
constitutional																	1.00	**0.62**	**0.94**	**0.78**
self_rule																		1.00	**0.65**	**0.96**
shared_rule																			1.00	**0.82**
RAI																				1.00

⁺ Values of correlation greater than or equal to 0.60 are considered as significant and indicated in bold.

Table A.10 Correlations between decentralization variables (selected) +
Sources: Ivanyna, M. and Shah, A. (2012) and Hooghe et al. (2016) and Shair-Rosenfield et al. (2021)

Hooghe et al. (2016) and Shair-Rosenfield et al. (2021) (selected)	inst_depth	policy_autonomy	fiscal_autonomy	borrow_autonomy	representation	law_making	exec_control	fiscal_control	borrow_control	constitutional	self_rule	shared_rule	RAI
Ivanyna, M. and Shah, A. (2012)													
administrative	0.29	0.32	0.30	0.41	0.34	0.04	0.20	0.21	0.14	0.11	0.36	0.15	0.32
fiscal	0.41	0.45	0.48	0.51	0.47	0.17	0.35	0.30	0.25	0.27	0.51	0.31	0.49
political	0.16	0.28	0.29	0.34	0.28	0.11	0.28	0.16	0.02	0.13	0.30	0.16	0.28
LG_existence	0.30	0.38	0.43	0.42	0.36	0.17	0.30	0.27	0.20	0.22	0.41	0.26	0.39
LG_expenditures	0.08	0.07	0.06	0.11	0.17	-0.10	-0.05	-0.06	-0.18	-0.15	0.11	-0.13	0.03
decentr	0.12	0.18	0.27	0.24	0.19	0.00	0.13	0.07	-0.06	0.03	0.22	0.04	0.17
LG_population	-0.05	0.05	0.05	0.01	0.02	0.06	0.18	0.15	0.08	-0.01	0.02	0.07	0.04
LG_area	0.04	0.09	0.00	-0.01	0.12	0.00	-0.07	-0.02	-0.09	-0.12	0.06	-0.09	0.01

+ Values of correlation greater than or equal to 0.60 are considered as significant and indicated in bold.

Table A.11 OLS and probit regression parameter estimates (the whole dataset and the 5G dataset): Federalism and decentralization (decentralization and regional authority index)+

	OLS		probit		OLS		probit	
Dependent variable	EMF	EMF_5G	EMF	EMF_5G	EMF	EMF_5G	EMF	EMF_5G
feder	0.078	0.047	0.271	0.022	0.096	0.116	0.350	0.294
decentr	0.003	0.006	0.010	0.025				
RAI					0.003	-0.006	0.010	-0.019
MMB_subs	0.000	-0.004**	0.001	-0.020**	-0.001	-0.003*	-0.003	-0.016*
tech_5G	-0.003		-0.021		0.084		0.070	
tech_intensity		-0.005				0.031		
rural	-0.001	-0.001	-0.005		-0.001	-0.001	-0.005	
constant	0.203	0.701**	-0.864	1.226	-0.246	0.679	-0.669	1.101
Obs.	146	61	146	61	87	52	87	52
F	0.70	1.21			0.82	0.74		
LR(chi2)			3.61	7.32*			3.79	4.43

+ */**/*** indicate the significance at the 10%/5%/1% level, respectively.

Table A.12 OLS and probit regression parameter estimates (the whole dataset and the 5G dataset): Federalism and decentralization (self-rule and shared rule)+

	OLS		probit		OLS		probit	
Dependent variable	EMF	EMF_5G	EMF	EMF_5G	EMF	EMF_5G	EMF	EMF_5G
feder	0.099	0.046	0.346	0.121	0.119	0.217	0.408	0.566
self_rule	0.005	-0.002	0.016	-0.010				
share_rule					0.004	-0.034	0.014	-0.102
MMB_subs	-0.001	-0.003*	-0.004	-0.015*	-0.001	-0.004*	-0.004	-0.015*
tech_5G	0.008		0.300		0.093		0.337	
tech_intensity		0.014				0.022		
rural	-0.001	-0.001	-0.005		-0.001	-0.001	-0.005	
constant	0.243	0.652*	-0.676	0.980	-0.264	0.697**	-0.602	0.901
Obs.	87	52	87	52	87	52	87	52
F	0.84	0.64			0.74	1.09		
LR(chi2)			4.33	4.02			3.89	5.69

+ */**/*** indicate the significance at the 10%/5%/1% level, respectively.

Table A.13 OLS and probit regression parameter estimates (the whole dataset and the 5G dataset): Federalism and decentralization (administrative and fiscal decentralization)+

	OLS		probit		OLS		probit	
Dependent variable	EMF	EMF_5G	EMF	EMF_5G	EMF	EMF_5G	EMF	EMF_5G
feder	0.054	0.035	0.162	-0.020	0.050	0.024	0.167	0.021
admin	0.437***	0.219	1.598***	0.809				
fiscal					0.258	0.181	0.87	0.209
MMB_subs	-0.001	-0.004**	-0.000	-0.018**	0.000	-0.004**	0.001	-0.003**
tech_5G	-0.051		-0.214		-0.027		-0.111	
tech_intensity		-0.009				-0.008		

rural	-0.001	-0.002	-0.005		0.000	-0.001	-0.002	
constant	0.126	0.638**	-1.208**	0.814	0.121	0.629**	-1.166**	0.547**
Obs.	146	61	146	61	146	61	146	61
F	2.91**	1.29			1.15	1.19		
LR(chi2)			14.14**	7.45			5.71	1.99

[+] */**/*** indicate the significance at the 10%/5%/1% level, respectively.

Table A.14 OLS and probit regression parameter estimates (the whole dataset and the 5G dataset): Federalism and decentralization (political decentralization and local government security of existence) [+]

	OLS		probit		OLS		probit	
Dependent variable	*EMF*	*EMF_5G*	*EMF*	*EMF_5G*	*EMF*	*EMF_5G*	*EMF*	*EMF_5G*
feder	0.042	0.030	0.131	0.008	0.038	0.026	0.127	-0.078
political	0.301*	0.261	1.215*	1.490				
LG_existence					0.325**	0.249	1.170**	0.957
MMB_subs	0.000	-0.003**	0.001	-0.015*	0.000	-0.003**	0.001	-0.018**
tech_5G	-0.033		-0.177		-0.055		-0.248	
tech_intensity		-0.018				-0.025		
rural	-0.001	-0.001	-0.003		0.000	-0.001	-0.003	
constant	0.066	0.454	-1.477**	-0.048	0.143	0.633**	-1.129**	0.799
Obs.	146	61	146	61	146	61	146	61
F	1.35**	1.48			1.78	1.43		
LR(chi2)			7.25	8.57			8.88	8.36**

[+] */**/*** indicate the significance at the 10%/5%/1% level, respectively.

Table A.15 OLS and probit regression parameter estimates (the whole dataset and the 5G dataset): Federalism and decentralization (relative importance of central government and local government population)[+]

	OLS		probit		OLS		probit	
Dependent variable	*EMF*	*EMF_5G*	*EMF*	*EMF_5G*	*EMF*	*EMF_5G*	*EMF*	*EMF_5G*
feder	0.071	0.024	0.242	0.022	0.100	0.077	0.400	0.163
LG_expenditures	0.592**	0.230	1.957**	0.767				
LG_population					-0.916***	-0.705	-7.197***	-3.523
MMB_subs	0.000	-0.004**	-0.003	-0.019**	0.000	-0.003*	0.004	-0.014*
tech_5G	0.009		0.039		-0.068		-0.297	
tech_intensity		0.001				-0.001		
rural	-0.001	-0.002	-0.006		-0.001	-0.001	-0.006	
constant	0.226	0.724	-0.754	-1.142	0.268	0.661**	-0.397	0.996
Obs.	142	60	142	60	143	59	143	59
F	1.62	1.12			2.55	1.17		
LR(chi2)			7.95	6.47			18.32***	7.26*

[+] */**/*** indicate the significance at the 10%/5%/1% level, respectively.

Table A.16 OLS and probit regression parameter estimates (the whole dataset and the 5G dataset): Federalism and decentralization (local government area and institutional depth)[+]

	OLS		probit		OLS		probit	
Dependent variable	*EMF*	*EMF_5G*	*EMF*	*EMF_5G*	*EMF*	*EMF_5G*	*EMF*	*EMF_5G*
feder	0.097	0.105	0.563	0.249	0.063	-0.058	0.223	-0.189
LG_area	-0.001*	-0.000	-0.010***	-0.004				
inst_depth					0.056*	0.056	1.88*	-0.137
MMB_subs	0.001	-0.002	0.006	-0.012	-0.001	-0.003	-0.002	-0.013
tech_5G	-0.044		-0.435		0.058		0.208	
tech_intensity		0.002				-0.029		
rural	-0.001	-0.001	-0.005		-0.002	-0.001	-0.008	
constant	0.159	0.574*	-0.601	-0.680	0.196	0.576*	-0.876	0.416
Obs.	144	59	144	59	88	52	88	52
F	1.22	1.16			1.40	0.87		
LR(chi2)			24.12***	7.68*			6.83	4.70

[+] */**/*** indicate the significance at the 10%/5%/1% level, respectively.

Table A.17 OLS and probit regression parameter estimates (the whole dataset and the 5G dataset): Federalism and decentralization (law-making and law-making (c))+

	OLS		probit		OLS		probit	
Dependent variable	*EMF*	*EMF_5G*	*EMF*	*EMF_5G*	*EMF*	*EMF_5G*	*EMF*	*EMF_5G*
feder	0.147	0.241	0.491	0.631	0.163	0.189	0.546	0.512
law_making	-0.014	-0.244*	-0.039	-0.725				
law_making_c					-0.138	-0.605*	-0.429	-1.987
MMB_subs	-0.001	-0.004*	-0.004	-0.015*	-0.001	-0.003*	-0.004	-0.015*
tech_5G	0.095		0.342		0.094		0.340	
tech_intensity		0.036				0.025		
rural	-0.001	-0.001	-0.005		-0.001	-0.001	-0.005	
constant	0.276	0.653**	-0.561	0.930	0.279	0.641*	-0.551	0.964
Obs.	87	52	187	52	87	52	87	52
F	0.73	1.32			0.80	1.26		
LR(chi2)			3.84	6.60*			4.11	6.72*

+ */**/*** indicate the significance at the 10%/5%/1% level, respectively.

Table A.18 OLS and probit regression parameter estimates (the whole dataset and the 5G dataset): Federalism and decentralization (borrow control)+

	OLS		probit	
Dependent variable	*EMF*	*EMF_5G*	*EMF*	*EMF_5G*
feder	0.141	0.148	0.468	0.464
borrow_control	-0.035	-0.236**	-0.070	-60.331
MMB_subs	-0.001	-0.004*	-0.004	-0.017*
tech_5G	0.103		0.356	
tech_intensity		-0.001		
rural	-0.001	-0.002	-0.006	
constant	0.279	0.748**	-0.557	1.117
Obs.	88	52	88	52
F	0.74	1.60		
LR(chi2)			3.78	11.18**

+ */**/*** indicate the significance at the 10%/5%/1% level, respectively.

Table A.19 OLS and probit regression parameter estimates (the whole dataset): Competition (mobile-broadband subscriptions)+

	OLS				probit			
Dependent variable	*EMF_GSMA*	*EMF_Chia.*	*EMF*	*EMF*	*EMF_GSMA*	*EMF_Chia.*	*EMF*	*EMF*
feder	0.060	0.073	0.057	0.116	0.178	0.206	0.158	0.291
LG_existence	0.177	0.247*	0.291**	0.533*	0.750	0.954*	1.132**	2.098**
MMB_subs	0.006**	0.007**	0.006**	0.008	0.049**	0.063***	0.060***	0.037
MMB_subs_sq	-0.001**	-0.001**	-0.001**	-0.000	-0.001**	-0.001**	-0.001**	0.000
tech_5G	-0.102	-0.091	-0.067	-0.934	-0.358	-0.347	-0.289	-2.893
rural	0.000	0.000	0.000	0.000	0.002	0.002	0.002	-0.002
constant	-0.141	-0.159	-0.128	-0.320	-3.213***	-3.740**	-3.666***	-2.863
Obs.	137	137	146	142	137	137	146	142
F	1.64	2.24**	2.65**	1.09				
LR(chi2)					13.07**	18.40***	20.78***	7.08
Hausman (chi2)				2.85				
Wald (chi2)								4.56
Instruments				*corruption stability democracy*				*corruption stability democracy*

+ */**/*** indicate the significance at the 10%/5%/1% level, respectively.

Table A.20 OLS and probit regression parameter estimates (the whole dataset): Competition (mobile-broadband subscriptions – CAGR)+

	OLS				probit			
Dependent variable	*EMF_GSMA*	*EMF_Chia.*	*EMF*	*EMF*	*EMF_GSMA*	*EMF_Chia.*	*EMF*	*EMF*
feder	0.038	0.052	0.037	0.074	0.128	0.166	0.119	0.294
LG_existence	0.223	0.287*	0.323**	0.449**	0.867	1.015*	1.157**	1.724**
MMB_subs_CAGR	0.000	0.000	-0.000	0.011	0.003	-0.001	-0.001	0.034
tech_5G	-0.072	-0.069	-0.053	-0.112	-0.298	-0.263	-0.220	-0.641
rural	-0.001	0.000	0.000	-0.004	-0.004	-0.003	-0.003	-0.016
constant	0.174	0.165	0.154	0.094	-0.937**	-0.970**	-1.012***	-1.108
Obs.	136	136	145	141	136	136	145	141
F	0.79	1.25	1.73	1.42				

LR(chi2)					4.20	6.29	8.64	
Hausman (chi2)				2..58				
Wald (chi2)								3.91
Instruments				*corruption stability*				*corruption stability*

+ */**/*** indicate the significance at the 10%/5%/1% level, respectively.

Table A.21 OLS and probit regression parameter estimates (the whole dataset): Competition (mobile-broadband prices – 1.5 GB)+

	OLS				Probit			
Dependent variable	*EMF_GSMA*	*EMF_Chia.*	*EMF*	*EMF*	*EMF_GSMA*	*EMF_Chia.*	*EMF*	*EMF*
feder	0.052	0.073	0.056	0.150	0.172	0.232	0.177	0.511
LG_existence	0.117	0.147	0.204	-0.320	0.349	0.421	0.654	0.901
MMB_prices_data	-0.059**	-0.065**	-0.055**	-0.722	-0.339**	-0.341**	-0.307**	-2.575
MMB_prices_data_sq	0.001*	0.001**	0.001*	0.023	0.008	0.008	0.007	0.084
tech_5G	-0.117	-0.147	-0.110	-1.057	-0.471	-0.534*	-0.435	-3.900
rural	0.001	0.001	0.001	0.020	0.006	0.006	0.005	0.068
constant	0.253	0.283	0.239	1.259	-0.519	-0.448**	-0.594	2.999
Obs.	132	130	140	137	132	130	140	137
F	1.72	1.91*	2.03*	0.33				
LR(chi2)					12.79**	13.77**	14.60**	3.15
Hausman (chi2)				0.83				
Wald (chi2)								6.07
Instruments				*corruption stability democracy*				*corruption stability democracy*

+ */**/*** indicate the significance at the 10%/5%/1% level, respectively.

Table A.22 OLS and probit regression parameter estimates (the whole dataset): Competition (mobile-broadband prices – low consumption)+

	OLS				Probit			
Dependent variable	*EMF_GSMA*	*EMF_Chia.*	*EMF*	*EMF*	*EMF_GSMA*	*EMF_Chia.*	*EMF*	*EMF*±
feder	0.037	0.063	0.044	0.030	0.162	0.249	0.160	0.343
LG_existence	0.128	0.166	0.211	0.193	0.347	0.402	0.633	-0.731
MMB_prices_low	-0.044***	-0.054***	-0.042**	-0.336	-0.089	-0.066	0.137	-0.084
MMB_prices_low_sq	0.001**	0.001**	0.001**	0.007	-0.077	-0.088	-0.121	-1.105
tech_5G	-0.118	-0.149*	-0.110	-1.216	-0.573	-0.628*	-0.493	-1.799
rural	0.001	0.001	0.001	0.009	0.008	0.009	0.006	0.044
constant	0.258**	0.278**	0.244**	1.162	-0.536	-0.503	-0.749	1.466
Obs.	132	130	140	137	132	130	140	137
F	2.02*	2.32**	2.36**	0.51				
LR(chi2)					20.56***	22.20***	22.97***	3.48
Hausman (chi2)				1.43				
Wald (chi2)								3.00
Instruments				*corruption stability democracy*				*stability democracy*

+ */**/*** indicate the significance at the 10%/5%/1% level, respectively. ± 5G technology (dummy) is not endogenized.

Table A.23 OLS and probit regression parameter estimates (the whole dataset): Competition (mobile-broadband prices – high consumption)+

	OLS				Probit			
Dependent variable	*EMF_GSMA*	*EMF_Chia.*	*EMF*	*EMF*	*EMF_GSMA*	*EMF_Chia.*	*EMF*	*EMF*±
feder	0.041	0.071	0.049	0.053	0.172	0.303	0.210	0.328
LG_existence	0.112	0.147	0.195	-0.437	0.257	0.266	0.527	-2.307
MMB_prices_high	-0.027***	-0.033***	-0.026***	-0.348	-0.321***	-0.364***	-0.306***	-1.446
MMB_prices_high_sq	0.001**	0.001**	0.001**	0.004	0.004*	0.004**	0.003*	0.022
tech_5G	-0.109	-0.138	-0.104	-1.214	-0.601*	-0.684**	-0.557	-2.303
rural	0.001	0.001	0.001	0.024	0.010	0.011	0.009	0.092
constant	0.241**	0.258**	0.232**	1.292	-0.341	-0.236	-0.405	2.122
Obs.	132	130	140	137	132	130	140	137
F	2.14*	2.46**	2.51**	0.22				
LR(chi2)					21.06***	23.42***	23.41***	3.35
Hausman (chi2)				0.57				
Wald (chi2)								3.26

Instruments				*corruption* *stability* *democracy*				*stability* *democracy*

+ */**/*** indicate the significance at the 10%/5%/1% level, respectively. ± 5G technology (dummy) is not endogenized.

Table A.24 OLS and probit regression parameter estimates (the 5G dataset):
Competition (mobile-broadband subscriptions and mobile-broadband subscriptions - CAGR)+

	OLS		probit		OLS		probit	
Dependent variable	EMF_5G	EMF_5G	EMF_5G	EMF_5G	EMF_5G	EMF_5G	EMF_5G	EMF_5G±
$feder$	0.012	0.022			-0.015	0.025	1.084	1.231
$LG\_existence$	0.247	0.025	0.993	1.108	0.253	-0.347		
MMB_subs	-0.007	-0.017	-0.072	0.157				
MBB_subs_sq	0.000	0.000	0.000	0.000				
MBB_subs_CAGR					0.015**	0.252	0.042*	0.831
$tech\_intensity$	-0.024	0.187			0.003	0.662	-0.023	0.029
$rural$	-0.001	-0.002			-0.003	-0.005		
$constant$	0.859	1.277	-3.599	-7.832	0.080	-0.909	-1.575	-2.082
Obs.	61	58	61	58	61	58	61	59
F	1.20	0.58			1.71	0.30		
LR(chi2)			10.47**	3.71			7.11*	3.66
Hausman (chi2)		1.15				0.42		
Wald (chi2)				0.98				0.77
Instruments		*corruption* *stability* *democracy*		*corruption* *stability*		*corruption* *stability*		*stability*

+ */**/*** indicate the significance at the 10%/5%/1% level, respectively. ± 5G technology (intensity) is not endogenized.

Table A.25 OLS and probit regression parameter estimates (the 5G dataset):
Competition (mobile-broadband prices - 1.5 GB and mobile-broadband prices - low consumption)+

	OLS		probit		OLS		probit	
Dependent variable	EMF_5G	EMF_5G	EMF_5G	EMF_5G	EMF_5G	EMF_5G	EMF_5G	EMF_5G
$feder$	0.054	0.050			0.056	-0.183		
$LG\_existence$	0.158	0.043	0.657	0.362	0.157	0.574	0.591	-0.428
MMB_prices_data	-0.180	-2.691	-0.565	-10.826				
$MBB\_prices\_data\_sq$	0.129	1.594	0.416	5.918				
MBB_prices_low					0.155	3.888	0.678	9.658
$MBB\_prices\_low\_sq$					-0.035	-1.032	-0.185	-2.590
$tech\_intensity$	0.017	0.068			-0.003	-1.016		
$rural$	0.000	-0.004			0.001	-0.002		
$constant$	0.137	1.017	-0.936	2.804	0.045	-0.071	-1.388	-5.590
Obs.	59	57	59	57	59	57	59	57
F	0.24	0.47			0.32	0.04		
LR(chi2)			1.37	1.88			2.23	0.33
Hausman (chi2)		2.00				0.14		
Wald (chi2)				2.07				2.63
Instruments		*corruption* *stability* *democracy*		*corruption* *stability*		*corruption* *stability*		*corruption* *stability*

+ */**/*** indicate the significance at the 10%/5%/1% level, respectively.

Table A.26 OLS and probit regression parameter estimates (the 5G dataset):

Competition (mobile-broadband prices - high consumption)+

	OLS		probit	
Dependent variable	EMF_5G	EMF_5G	EMF_5G	EMF_5G
$feder$	0.068	1.037		
$LG\_existence$	0.141	-1.766	0.550	-0.863
MBB_prices_high	-0.015	-3.734	0.835	3.902
$MBB\_prices\_high\_sq$	-0.001	0.591	-0.259	-0.863
$tech\_intensity$	-0.008	3.647		
$rural$	0.001	-0.030		
$constant$	0.136	-2.877	-1.457	-2.641
Obs.	59	57	59	57
F	0.28	0.01		

LR(chi2)		2.76	1.14
Hausman (chi2)	0.02		
Wald (chi2)			4.18
Instruments	*corruption stability democracy*		*stability democracy*

+ */**/*** indicate the significance at the 10%/5%/1% level, respectively.

Table A.27 OLS and probit regression parameter estimates (the whole dataset): Technology (5G technology – dummy)+

	OLS				probit			
Dependent variable	*EMF_GSMA*	*EMF_Chia.*	*EMF*	*EMF*	*EMF_GSMA*	*EMF_Chia.*	*EMF*	*EMF*
feder	0.039	0.053	0.038	0.117	0.137	0.174	0.127	0.394
LG_existence	0.211	0.289**	0.325**	0.526*	0.815	1.025**	1.170**	2.002**
MMB_subs	0.000	0.000	0.000	0.008	0.002	0.001	0.001	0.028
tech_5G	-0.099	-0.074	-0.055	-0.918	-0.382	-0.297	-0.248	-3.259
rural	0.000	0.000	0.000	0.000	-0.002	-0.002	-0.003	0.000
constant	0.120	0.146	0.143	-0.329	-1.170**	-1.101*	-1.129**	-2.564
Obs.	137	137	146	142	137	137	146	142
F	0.85	1.30	1.78	1.20				
LR(chi2)					4.49	6.57	8.88	
Hausman (chi2)				1.92				
Wald (chi2)								6.36
Instruments				*corruption stability*				*corruption stability*

+ */**/*** indicate the significance at the 10%/5%/1% level, respectively.

Table A.28 OLS and probit regression parameter estimates (the whole dataset): Technology (5G technology - high frequency)+

	OLS				probit			
Dependent variable	*EMF_GSMA*	*EMF_Chia.*	*EMF*	*EMF*	*EMF_GSMA*	*EMF_Chia.*	*EMF*	*EMF*
feder	0.042	0.056	0.042	0.089	0.149	0.185	0.146	0.309
LG_existence	0.194	0.292**	0.335**	0.558**	0.717	0.989**	1.171**	2.210**
MMB_subs	0.000	0.000	0.000	-0.001	0.001	0.000	0.000	-0.007
tech_highfreq	-0.091	-0.128	-0.142	-0.913	-0.333	-0.432	-0.501	-3.406
rural	0.000	0.000	0.000	-0.003	-0.001	-0.001	-0.002	-0.015
constant	0.126	0.145	0.140	0.346	-1.156**	-1.118**	-1.154**	-0.094
Obs.	137	137	146	142	137	137	146	142
F	0.77	1.43	2.06*	1.49				
LR(chi2)					3.95	6.91	9.90	
Hausman (chi2)				2..54				
Wald (chi2)								7.54
Instruments				*corruption stability*				*corruption stability*

+ */**/*** indicate the significance at the 10%/5%/1% level, respectively.

Table A.29 OLS and probit regression parameter estimates (the whole dataset): Technology (5G technology - intensity)+

	OLS				probit			
Dependent variable	*EMF_GSMA*	*EMF_Chia.*	*EMF*	*EMF*	*EMF_GSMA*	*EMF_Chia.*	*EMF*	*EMF*
feder	0.037	0.051	0.037	0.068	0.127	0.165	0.123	0.221
LG_existence	0.206	0.297**	0.343**	0.564*	0.780	1.028*	1.224**	2.140**
MMB_subs	0.000	0.000	0.000	0.002	0.001	0.000	0.000	0.006
tech_intensity	-0.030	-0.032	-0.035	-0.259	-0.113	-0.117	-0.136	-0.920
rural	0.000	0.000	0.000	-0.001	-0.001	-0.002	-0.002	-0.008
constant	0.124	0.145	0.140	0.089	-1.162**	-1.111*	-1.147**	-1.077
Obs.	137	137	146	142	137	137	146	142
F	0.73	1.29	1.87	1.70				
Wald (chi2)					3.83	6.40	9.19	
Hausman (chi2)				3.02				
Wald								8.44
Instruments				*corruption stability*				*corruption stability*

+ */**/*** indicate the significance at the 10%/5%/1% level, respectively.

Table A.30 OLS and probit regression parameter estimates (the 5G dataset): Technology+

	OLS		probit		OLS		probit	
Dependent variable	EMF_5G	EMF_5G	EMF_5G	EMF_5G	EMF_5G	EMF_5G	EMF_5G	EMF_5G
$feder$	0.038	0.017			0.026	0.058		
$LG\_existence$	0.264	0.067	1.061	0.283	0.249	0.057	0.972	0.115
MMB_subs	-0.003**	-0.006	-0.018**	-0.019	-0.003**	-0.007	-0.018**	-0.020
$tech\_highfreq$	-0.123	0.356	-0.457	1.708				
$tech\_intensity$					-0.025	0.142	-0.063	0.843
$rural$	-0.001	-0.002			-0.001	-0.002		
$constant$	0.606**	0.890	0.825	0.641	0.633**	0.833	0.822	-0.143
Obs.	61	58	61	58	61	58	61	58
F	1.62	0.51			1.43	0.56		
LR(chi2)			9.37**	2.54			8.39**	2.81
Hausman (chi2)		1.32				1.34		
Wald (chi2)				1.54				1.12
Instruments		$corruption$ $stability$		$corruption$ $stability$		$corruption$ $stability$		$corruption$ $stability$

+ */**/*** indicate the significance at the 10%/5%/1% level, respectively.

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