The impact of license duration on tangible investments of mobile operators *

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Abstract

Using data from the WCIS (World Cellular Information Service) and the Telecoms Market Matrix of Analysis Mason, we were able to build a database relating the level of investment per capita to license duration for 14 countries over a 10-year period. An empirical analysis of the data shows a positive correlation between the tangible investment per capita and the license duration (the average of all active licenses or the latest license). More precisely, we observe an increase of €1.5 in the average investment per capita per year for each additional year of license duration. We also find no significant negative impact of license duration on mobile market competition. The competition outcomes are measured using the Lerner index at the operator level. Some robustness checks are performed at the country level by using the HHI (Herfindahl-Hirschman index) and the number of active mobile operators as measures of the level of competition, and we obtain additional results indicating once more that the competition is not negatively impacted by license duration.

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1 Introduction

This paper analyzes the relationship between the duration of spectrum licenses of mobile operators, and the levels of operators' tangible investment in a sample representing 75% of European mobile subscribers. Econometric modeling of investment at the operator level reveals the positive effect of longer licenses on investment.

The question of whether mobile license duration should be globally extended to foster investment in new mobile infrastructure has been hotly debated during the period of legislative discussion of the future European Electronic Communications Code, that will regulate telecom markets in Europe after 2020. In summary, the debate involved two contrasting arguments:

- On the one hand, advocates of longer license duration insist that installation of tens of thousands of antennas along with the associated equipment and network upgrades implies that operators engaged in tens of billions in sunk investment costs that necessitated reduced uncertainty and enhanced security.

- On the other hand, opponents insist that a long license duration could hinder competition from new entrants and disruptive technologies that would foster investment.

These two contradictory arguments represent the well-known trade-off between static efficiency (competition) and dynamic efficiency (investment).

Given that both arguments could be true in principle, the question from an economic point of view is whether a quantitative analysis based on real data will identify the effect that is the strongest and that should be given priority for policy purposes. As this specific question has not yet been directly addressed in the literature, we have developed the present analysis to fill this gap in research using a simple ordinary least-squares regression on a sufficiently large dataset. Although the economic literature has extensively analyzed numerous aspects of mobile license allocation, such as whether licenses should be supplied to auctions or beauty contests, how auctions should be designed, how many licenses should be granted in a given market, and how license fees impact market outcomes, the specific question of the impact of license duration on investment has not previously been empirically analyzed.

The rest of this paper is organized as follows. Section 2 reviews the approaches to analysis used by three literature streams: the first on mobile license design, the second on patent lives that have some similarities with licenses, and the third on the impact of policies on investment and competition in the telecom industry. Section 3 describes the dataset and provides some descriptive statistics. Section 4 describes an econometric model of investment per capita as a function of license duration at the operator level. Section 5 proposes a similar econometric model of competition as a function of license duration. Section 6 derives policy implications of these outcomes and concludes.

2 Literature review

Although spectrum allocation plays a crucial role in the wireless industry, the impact of license duration, to our knowledge, has not been specifically studied. The economic literature on spectrum licenses has mainly considered the topics of spectrum concentration and auctions.

Competition and sectoral authorities have long suspected that spectrum concentration could harm competition and therefore proposed measures aimed at limiting spectrum concentration (e.g., the Radio Act of 1927 in the US). However, recent empirical studies have found little correlation between spectrum concentration and downstream concentration in wireless services, Israel & Katz (2013), or between spectrum concentration and consumer welfare Faulhaber *et al.* (2011).

The impact of license fees on competition is also well known: the higher the license fee is, the lower the number of operators sustained by the market (Gruber, 2001). Considering that greater spectrum allocation improves transmission capacity, the theoretical literature highlights that such greater allocation improves service quality as perceived by consumers and tends to reduce marginal costs. Loertscher & Marx (2014) found that a transfer of spectrum from a low-quality or inefficient operator to a high-quality or more efficient one increases consumer surplus. Lhost *et al.* (2015), considering the lack of spectrum as a capacity constraint, showed that a spectrum allocation in which the more efficient operators do not hold more spectrum than the least efficient operators was unsuitable and could hamper competition and increase prices.

For more information about spectrum concentration and its impact on the performance of the wireless industry, see Woroch (2018).

In the economic literature, investments in information technologies in general and in telecommunications in particular are assumed to provide major contributions to economic growth. Roller & Waverman (2001) found a causal link between telecommunication infrastructure and economic growth in OECD countries, and Waverman *et al.* (2005) extended this result to developing countries for the wireless network rollout. Furthermore, Jeanjean (2015) showed that investment in the wireless industry is mainly responsible for data traffic growth by means of installed capacity.

These considerations do not explicitly take the duration of licenses into account. However, considering that a license constitutes a right to install and use transmission capacities, it is natural to assume that the longer the duration is, the higher the value of the license. In this context, what is written for spectrum allocation in general remains valid for the duration of the licenses.

More generally, license duration gives rise to a trade-off between the visibility that fosters investment and the market power that hampers competition. This trade-off may be considered in the broader context of the trade-off between static and dynamic efficiency (cf. (Bouckaert *et al.* , 2010)]. In particular, there are similarities between license duration and patent lives. A license grants transmission capacities and a patent grants exclusivity on a certain technology. Both favor investment but may hinder competition. There are also some differences. The main difference is that patents provide monopoly power whereas licenses lead to oligopolistic competition. Indeed, a patent is only granted to the innovative firm, whereas licenses are granted to several operators together. Therefore, the negative impact of patents on competition should be much higher than that of licenses.

Nordhaus (1969) shows that an extended patent life increases both the pace of innovation and the market power of the patent holder, which gives rise to the well-known trade-off between static and dynamic efficiency. Budish *et al.* (2016) slightly modified the Nordhaus's model to calculate the optimal patent life. They showed that the optimal patent life increases with the elasticity of innovation with respect to patent term. In other words, all things being equal, the most innovative industries require longer patent terms.

However, the patent term is not necessarily the most relevant parameter, as subsequent innovations may make the technology protected by the patent obsolete before the patent term ends. O'donoghue *et al.* (1998) introduced the notion of effective patent life, which may be the statutory patent term or a lower duration if the protected technology becomes obsolete before the end of the statutory term. As a result, an increase in statutory patent life beyond the effective life should not significantly change innovation or competition outcomes.

Similarly, the technology granted by the license may be surpassed before the end of the statutory term. For instance, LTE licenses have generally been granted before the end of 3G licenses. However, despite the similarities between patent life and license duration, there are also some differences. As mentioned in the introduction, a patent is granted only to the innovative firm, whereas licenses are granted to several operators together, which should be less detrimental to competition.

Another difference is that patent terms impact mainly investment in R&D, whereas license duration impacts investment in wireless infrastructure. The network rollout for a given license based on a given technology takes several years and still requires investment even after the emergence of a new generation. It also takes time for consumers to become equipped with the new-generation terminals, while maintenance and even enhancement of the capacities of the networks from the previous generation are still required for several years. Thus, several generations of technology overlap, which makes the difference between statutory and effective duration less relevant for licenses.

To investigate the specificity of license duration and its impact on investment, we can examine the literature on investment and uncertainty. Investment in transmission capacity depends on a license granted for a fixed period. The longer the period is, the lower the uncertainty of the investment. Ingersoll Jr & Ross (1992), Dixit & Pindyck (1994) and Tselekounis & Varoutas (2013) clearly indicate that uncertainty tends to delay or reduce investment.

Regulatory uncertainty is a particular case of uncertainty which has also been pointed out in economic literature. Bittlingmayer (2000) showed empirically that uncertainty in antitrust policy in the United States during the twentieth century led to curtailed investment. One can assume that antitrust policy has strengthened competition, which once again highlights the

trade-off between static and dynamic efficiency. Similar results have been found in various industries, e.g., by Ishii & Yan (2004) for the electricity industry in the US and by Fabrizio (2012) for the renewable energy industry. Jaspers *et al.* (2007), examining the wireless market in the Netherlands, explained that it was challenging for the regulatory authority OPTA to define a clear regulatory policy for the entry of MVNOs because of the difficulty of resolving the trade-off between static and dynamic efficiency.

On the other hand, licenses can be viewed as entry barriers that could prevent more efficient entrants from entering the market. From this perspective, decreasing the duration of licenses may allow more new entries and should reduce the market power of incumbents, as noted by Leyton-Brown *et al.* (2017). There is thus a trade-off in the duration of licenses between allocating radio spectrum to the most efficient operators who will make better use of it and the resulting market power. This trade-off should be resolved empirically. This is the purpose of this paper.

3 Data

We combine four datasets for 14 European countries[1]. Summary statistics at the operator level are reported in Table 1, and statistics at the country level are reported in Table 2.

The first two datasets are from the WCIS (World Cellular Information Service), where sufficient data for both the license duration and the quarterly tangible investment are available. The first dataset contains the quarterly tangible investments[2] by mobile operators from Q2 2008 to Q3 2017. The second dataset contains mobile spectrum licenses granted in the 14 countries. For each mobile license, the dataset provides the mobile technology or frequency bands (2G, 3G, 900 MHz, 1800 MHz, 2.6 GHz, etc.), and the start and end dates, so we are able to calculate the number of active mobile licenses for each quarter and each operator.

Then, we calculate the duration of each license (equal to the difference between the end year and the start year). The average duration at the operator level is obtained by dividing the sum

[1] Austria, Belgium, Denmark, Finland, France, Germany, Italy, the Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, and the United Kingdom.

[2] Excluding license fees.

of the duration of all active licenses by the number of active licenses. The total population of the 14 countries is approximately 399 million, which represents more than 75% of the population of European Union. For some quarters, the CAPEX values of some countries are missing. In these cases, for a uniform comparison, only the active licenses and the population of countries for which we have CAPEX values are taken into account.

The third dataset is obtained from the Telecoms Market Matrix provided by Analysys Mason, using the 6 April 2018 version. It provides the number of active mobile operators who own wireless networks together with the corresponding years of incumbency, and the country-level market share of MVNO (Mobile Virtual Network Operator [3]).

The fourth dataset is obtained from Cullen international and contains MTR (Mobile Termination Rates) for the period from 2008Q2 to 2017Q3. Mobile termination rates are the wholesale rates charged for connecting calls between mobile networks. MTRs are regulated in all EU member states by national telecom regulators on the basis of the EU regulatory framework for electronic communications. MTRs vary over time and across countries. Sometimes, MTRs are even different among operators in the same country. The transitional asymmetry of mobile termination rates was commented on by Commissioner Reding: "Asymmetric mobile termination rates can be temporarily an effective instrument to promote competition and encourage investments by new market entrants, provided that there are objective cost-differences which are outside their control."

[3] A Mobile Virtual Network Operator does not own the wireless network infrastructure over which it provides services to its customers

Table 1: Summary statistics at the operator level

Variable	Obs	Mean	Std. Dev.	Min	Max
CAPEX per capita (€ per quarter)	1008	13.258	7.643	1.908	117.923
competition	717	.694	.107	.489	1.506
duration_mean (years)	1008	17.91194	2.649713	5	23
MTR (€cents/min)	1008	2.76	2.65	.06	30.17
incumbencyYear (years)	1008	16.41	4.84	0	22
license_nb	1008	3.138	1.449	1	7
operator's market share	1008	.280	.125	.044	.618
duration_lastlicense (year)	959	19.300	2.495	15	26
license fee per capita (€)*	543	27.313	24.965	.298	157.5
year_quarter	1008			2008Q2	2017Q3

*The license fee is available for a reduced number of observations: 543 instead of 1008.

Table 2: Summary statistics at the country level

Variable	Obs	Mean	Std. Dev.	Min	Max
HHI	416	0.3377	0.0535	0.2270	0.4821
nb_firms	416	3.896	0.723	3	5
MVNO_market share	416	.0973	.0583	.0098	.2377
GDP per capita (€ per year)	416	47011.91	15340.93	25912.05	104512.8
population	416	3.84e+07	2.73e+07	4817567	8.28e+07
density (inhabitants per km^2)	416	178.9073	120.914	14.859	409.853
year_quarter	416			2008Q2	2017Q3

4 Relationship between tangible investment of mobile operators and license duration

To estimate the relationship between a mobile operator's investment and license duration, we first calculate the average license duration. Since each operator owns several licenses, recall that the average license duration is calculated by dividing the sum of all active licenses' duration by the number of active licenses owned by each operator. All licenses correspond to all spectrum

resources. Investments in all frequencies are spread over the life of the licenses. Taking the average is the most representative and the least biased method. We performed robustness tests by repeating the same analysis for the duration of the latest awarded license.

We propose a linear model to understand the relationship between an operator's investment and the average duration of licenses:

$$CAPEX\_pc_{it} = \alpha\, duration\_mean_{it} + \beta\, X_{it} + \gamma\, Y_{ct} + T_t + M_i + \varepsilon_{it} \tag{1}$$

where $CAPEX\_pc_{it}$ is the quarterly investment per capita of operator i in quarter t, calculated by dividing the quarterly CAPEX by the number of the operator's subscribers (the product of population and operator's market share). $duration\_mean_{it}$ is the average license duration. The vector X_{it} corresponds to control variables, such as MTR and years of incumbency of the mobile operator, for operator i in quarter t. The vector Y_{ct} corresponds to control variables, such as GDP per capita, population density, the number of MNO, the market share of all MVNOs, for country c in quarter t. T_t is a quarterly time dummy that represents time-specific events common to all operators. M_i are operator dummies that account for time-invariant characteristics of an operator. ϵ_{it} is the error term.

Table 3: Positive correlation between the average license duration and the tangible investment at the operator level

VARIABLES	(1) CAPEX_pc	(2) CAPEX_pc	(3) CAPEX_pc	(4) CAPEX_pc	(5) CAPEX_pc	(6) CAPEX_pc
duration_mean	0.3986***	0.3856**	0.3844**	0.3721**	0.3697**	0.3728**
	(0.148)	(0.153)	(0.154)	(0.153)	(0.153)	(0.159)
GDP_pc		0.0002***	0.0002***	0.0002***	0.0002***	0.0002***
		(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
density		0.2545**	0.2575**	0.2828**	0.2873**	0.2624**
		(0.126)	(0.131)	(0.127)	(0.127)	(0.131)
MTR			0.0704	0.0591	0.0452	0.0504
			(0.339)	(0.340)	(0.339)	(0.343)
incumbencyYear			0.0222	0.0555	0.0440	0.0339
			(0.267)	(0.269)	(0.267)	(0.258)
nb_firms				-0.7311	-0.7314	
				(0.482)	(0.482)	
HHI						4.0370
						(10.889)
MVNO_ms					-4.9799	-5.7319
					(9.378)	(9.737)
operator dummies	Y	Y	Y	Y	Y	Y
quarter dummies	Y	Y	Y	Y	Y	Y
Constant	5.9621*	-29.3673**	-30.2941*	-30.4223*	-30.3053*	-31.9855**
	(3.480)	(13.286)	(16.903)	(16.918)	(16.908)	(14.596)
Observations	1,008	1,008	1,008	1,008	1,008	1,008
R-squared	0.366	0.375	0.375	0.376	0.376	0.375

Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Table 3 displays the estimation results obtained using ordinary least-squares regression. First, in column (1), we observe a positive and significant effect of the average license duration on CAPEX per capita. Then, columns (2)-(3) sequentially introduce the GDP per capita and population density. We observe that the results are rather stable. The GDP per capita has a positive effect on investment. This effect shows that a country's higher income is associated with larger investment. The positive impact of population density is not intuitive. In general, the deployment cost is decreasing with population density. Accordingly, a negative coefficient is expected for this control variable. The unexpected sign of density is related to the fact that national regulators take into account the population density in the spectrum assignment processes. We note that a longer license term is allocated to low-density countries so that operators can cover the entire territory with an appropriate license term. Therefore, the duration of the license partly takes into account the density effect. In columns (4)-(5), MTR, years of incumbency of the MNO (Mobile Network Operator), the number of MNO and MVNOs' market

share have expected sign, but are not statically significant. As robustness check, the number of MNO is replaced by HHI in columns (6). The coefficient of "duration_mean" remains unchanged.

All effects have the expected signs, and the model appears to predict reasonable outcomes. The sign of the impact of license duration on investment per capita is robust and independent of the list of control variables. Therefore, this result suggests that the longer the mobile license duration is, the more the operators invest. Instead of using the average license duration, we also perform the same regressions with the duration of the latest license awarded to each MNO. We assume that the investment effort is mainly focused on the latest license that corresponds to the most advanced technology. The results of regressions performed by using the average license duration and those performed by using the duration of the latest license are quite similar. Furthermore, table A-1 in Appendix 1 shows that the impact of the latest license duration on investment is equivalent across all technologies or frequency bands.

Table 4: Positive correlation between the latest license duration and tangible investment at the individual operator level

	(1)	(2)	(3)	(4)	(5)	(6)
VARIABLES	CAPEX_pc	CAPEX_pc	CAPEX_pc	CAPEX_pc	CAPEX_pc	CAPEX_pc
duration_lastLic	0.8662***	0.9232***	0.9235***	0.9800***	1.0557***	1.2507***
	(0.240)	(0.218)	(0.219)	(0.216)	(0.220)	(0.296)
GDP_pc	0.0002***	0.0002***	0.0002***	0.0002***	0.0002***	0.0001
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
density	0.2574*	0.2563*	0.2559*	0.2797**	0.2745**	0.2856*
	(0.134)	(0.135)	(0.136)	(0.133)	(0.134)	(0.163)
MTR		-0.1447	-0.1460	-0.1791	-0.1659	-0.4327
		(0.352)	(0.355)	(0.357)	(0.356)	(0.477)
incumbencyYear			-0.0349	0.0161	0.0380	-0.5705
			(0.249)	(0.252)	(0.259)	(0.439)
nb_firms				-1.0793*	-1.0756*	
				(0.559)	(0.562)	
HHI						8.8364
						(10.800)
MVNO_ms					10.3705	2.6763
					(8.996)	(11.551)
Constant	-41.2242**	-41.6737***	-41.0135**	-41.8503**	-43.5789**	-47.7972***
	(16.012)	(15.450)	(17.564)	(17.468)	(17.367)	(15.409)
Observations	959	959	959	959	959	959
R-squared	0.390	0.391	0.391	0.392	0.393	0.392
Observations	1,008	1,008	1,008	1,008	1,008	1,008
R-squared	0.366	0.375	0.375	0.376	0.376	0.375

Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Table 4 displays results similar to those in Table 3. The coefficient of "duration_lastLic"

remains positive and significant for all specifications from column (1) to column (6). We note that the number of MNO has a negative and weakly significant impact on investment. This result again suggests the positive impact of license duration on investment.

5 Relationship between mobile market competition and license duration

In section 4, we have only estimated the impact of license duration on investment. In this section, we focus on the impact of license duration on mobile market competition. The objective of regulation is to guarantee a satisfactory level of competition while encouraging investment with licensing. To this end, we measure the level of competition with three variables. The first variable "competition" is the competition index at the operator level, determined on the basis of the Lerner index as (1-EBITDA/Revenue). The second and third variables, at the country level, are the number of active MNOs in the market, denoted by "nb_firms" and "HHI".

We run the regressions following Equation 1 by replacing "CAPEX_pc" with "competition", "nb_firms" or "HHI". These regressions include the same set of explanatory variables as those in Table 3.

Table 5: No negative correlation between the average license duration and competition measured by the Lerner index at the operator level

VARIABLES	(1) competition	(2) competition	(3) competition	(4) competition	(5) competition
duration_mean	0.0016	0.0019	0.0027*	0.0025*	0.0026
	(0.001)	(0.001)	(0.001)	(0.001)	(0.002)
MTR		-0.0063***	-0.0049**	-0.0059**	-0.0071***
		(0.002)	(0.002)	(0.002)	(0.003)
MVNO_ms			0.3203**	0.3107**	0.2787*
			(0.140)	(0.140)	(0.145)
incumbencyYear				-0.0173***	-0.0198***
				(0.005)	(0.006)
GDP_pc					-0.0000
					(0.000)
density					-0.0027**
					(0.001)
license_nb					0.0032
					(0.004)
operator dummies	Y	Y	Y	Y	Y
quarter dummies	Y	Y	Y	Y	Y
Constant	0.5997***	0.6305***	0.6121***	0.9309***	1.2890***
	(0.026)	(0.030)	(0.030)	(0.109)	(0.185)
Observations	717	717	717	717	717
R-squared	0.699	0.701	0.704	0.706	0.709

Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Table 5 displays the estimation results obtained using equation 1. First, in column (1), we observe that the average license duration does not have a significant impact on competition outcome at the operator level. Then, columns (2)-(5) sequentially introduce the controls. The coefficient of "duration_mean" is either not significant (columns (1), (2) and (5)) or weakly positive (columns (3) and (4)). MTR, the number of years of incumbency and the population density have negative effects on competition. An MVNO's market share tends to have a positive impact on competition. GDP per capita and the number of active licenses do not have significant effects on competition. As explained in the introduction, the impact of licenses on competition is expected to be lower than that of patents. Indeed, the result suggests that a long license duration does not have a negative impact on competition.

To perform robustness checks of the absence of negative impact of license duration on competition, we run the same regressions with our second and third measures of competition outcomes at the country level, "nb_firms" and "HHI". To homogenize all variables at the country level, we transform operatorlevel variables, such as average license duration, MTR, years of incumbency and the number of licenses, to countrylevel variables by computing the average value of each operatorlevel variable.

Table 6: No correlation between the average license duration and competition measured by the number of active operators (MNO) in a country

	(1)	(2)	(3)	(4)	(5)
VARIABLES	nb_firms	nb_firms	nb_firms	nb_firms	nb_firms
duration_mean	-0.0271*	-0.0262	-0.0154	0.0050	0.0100
	(0.016)	(0.016)	(0.018)	(0.019)	(0.024)
MTR		-0.0265**	-0.0213*	-0.0251**	0.0040
		(0.013)	(0.012)	(0.013)	(0.015)
MVNO_ms			2.3471**	2.2627**	1.4789*
			(0.960)	(0.946)	(0.770)
incumbencyYear				-0.1143***	-0.1140***
				(0.021)	(0.021)
GDP_pc					0.0000***
					(0.000)
density					0.0217***
					(0.006)
license_nb					0.2119***
					(0.036)
country dummies	Y	Y	Y	Y	Y
quarter dummies	Y	Y	Y	Y	Y
Constant	4.1142***	4.2739***	4.0825***	5.9116***	2.1368**
	(0.325)	(0.341)	(0.363)	(0.425)	(0.853)
Observations	416	416	416	416	416
R-squared	0.681	0.684	0.688	0.710	0.767

Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Table 6 displays the estimation results obtained using equation 1. Columns (1) shows that the license duration seems to have a small negative effect on the number of active MNOs in a country. Then, columns (2)-(5) sequentially introduce the controls, and the small negative effect of column (1) disappears. We observe that the results are rather stable across the additional

specifications. Therefore, this result further suggests that a long license duration does not have a negative impact on competition.

This finding is unsurprising. As explained above, the effect of license duration is not identical to that of patent life. For instance, the first 2G licenses were awarded to the first three mobile operators in France. At the time of entry of the fourth operator, Free Mobile, it was directly awarded a 3G license without using a 2G license. Hence, the 2G license duration of existing operators did not have a direct impact on the fourth operator's entry.

Table 7: No correlation between the average license duration and competition measured by HHI

	(1)	(2)	(3)	(4)	(5)
VARIABLES	HHI	HHI	HHI	HHI	HHI
duration_mean	0.0005	0.0005	0.0011	-0.0009	-0.0003
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
MTR		0.0000	0.0003	0.0007	0.0010
		(0.001)	(0.001)	(0.001)	(0.001)
MVNO_ms			0.1296**	0.1380***	0.0939*
			(0.054)	(0.051)	(0.053)
incumbencyYear				0.0114***	0.0119***
				(0.001)	(0.001)
GDP_pc					-0.0000***
					(0.000)
density					0.0005
					(0.000)
license_nb					-0.0036***
					(0.001)
country dummies	Y	Y	Y	Y	Y
quarter dummies	Y	Y	Y	Y	Y
Constant	0.3383***	0.3381***	0.3275***	0.1450***	0.1733***
	(0.018)	(0.018)	(0.019)	(0.023)	(0.048)
Observations	416	416	416	416	416
R-squared	0.815	0.815	0.817	0.857	0.870 height

Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Table 7 shows the regression results of equation 1 where HHI is used as the country-level competition index. Note that the coefficient of license duration is not significant across all columns from (1) to (5). We observe that the results are rather stable across the additional

specifications. Therefore, this result suggests again that a long license duration does not have a negative impact on competition.

In the same way, we also perform the same regressions by using three competition variables, "competition", "nb_firms" and "HHI", with the duration of the latest license awarded to each MNO. The regression results are reported in Table A-2 for the dependent variable "competition", in Table A-3 for the dependent variable "nb_firms", and in Table A-4 for the dependent variable "HHI". The comparisons between Table 5 and Table A-2, between Table 6 and Table A-3, and between Table 7 and Table A-4 show that the results obtained using the average license duration and those obtained using the latest license duration are similar.

The results between the impact of the license duration on the investment in section 4 and the level of competition in section 5 are consistent. In section 4, we find that the license duration positively affects CAPEX. The competition measures, added as additional control variables, are not really significant. In addition, these control variables do not affect the sign and the value of the coefficient of license duration. This result suggests that the license duration is not correlated with the level of competition. Otherwise, the coefficient of the license duration would be disturbed and therefore modified. This non-correlation is demonstrated in three tables of section 5.

6 Conclusions: Empirical analysis and policy implications

Using data from the WCIS (World Cellular Information Service) on the tangible investments of mobile operators and mobile spectrum licenses, we were able to build a database relating the level of per capita investment to license duration for 14 countries (representing more than 75% of the number of mobile subscribers of the EEA) over 10 years.

An econometric analysis at the operator level shows that license duration has a significant positive impact on a mobile operator's investment. We also found no significant negative impact of license duration on mobile market competition measured by the Lerner index at the operator level or HHI and the number of active mobile operators at the country level. The results are robust to using the average license duration or the latest license duration. These two findings are

consistent since the investigation on the determinants of competition supports the first finding.

The results of the empirical analysis presented in this paper provide an answer to the policy question posed in the introduction. Currently, for mobile markets in the European Union, a longer license duration corresponds to higher levels of investment while not affecting the level of competition. It would therefore be appropriate to extend the average duration of individual licenses of mobile operators if increased investment is considered a relevant policy objective. Further research is, however, required to understand the mechanisms underlying this outcome. Moreover, we cannot be sure that the same rule would apply everywhere and under all circumstances.

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Appendix

■ Appendix 1: The impact of the latest license duration on investment according to mobile technology or frequency bands

Table A-1: The coefficient of "duration" is approximately the same within the confidence interval for all technologies or frequency bands

VARIABLES	CAPEX_pc
duration_lastlic 1800MHz	1.2289***
	(0.375)
duration_lastlic 2.6GHz	0.9163***
	(0.222)
duration_lastlic 3G	0.9690***
	(0.211)
duration_lastlic 800MHz	0.8720***
	(0.215)
duration_lastlic 900MHZ	0.8802***
	(0.241)
duration_lastlic LTE-700	0.9734***
	(0.219)
duration_lastlic Neutral	0.8516***
	(0.230)
duration_lastlic W-CDMA	1.0322***
	(0.275)
MTR	-0.1848
	(0.363)
MVNO_ms	12.5289
	(9.545)
incumbencyYear	-0.0553
	(0.267)
GDP_pc	0.0002***
	(0.000)
density	0.2553*
	(0.139)
operator dummies	Y
quarter dummies	Y
Constant	-41.2681**
	(18.133)
Observations	959
R-squared	0.399
Robust standard errors in parentheses	*** p<0.01, ** p<0.05, * p<0.1

■ **Appendix 2: The impact of the latest license duration (used instead of the average license duration) on competition outcomes measured by the Lerner index, the number of active operators, and HHI**

Table A-2: No negative correlation between the latest license duration and competition measured by the Lerner index

	(1)	(2)	(3)	(4)	(5)
VARIABLES	competition	competition	competition	competition	competition
duration_lastlic	-0.0021	-0.0023	0.0009	0.0154	0.0245**
	(0.008)	(0.008)	(0.008)	(0.011)	(0.012)
MTR	-0.0039	-0.0047	-0.0077	-0.0118**	-0.0117**
	(0.004)	(0.005)	(0.005)	(0.005)	(0.005)
MVNO_ms		-0.1468	-0.1672	-0.1715	-0.1554
		(0.312)	(0.312)	(0.276)	(0.272)
incumbencyYear			-0.0198***	-0.0217**	-0.0218**
			(0.007)	(0.009)	(0.009)
GDP_pc				0.0000**	0.0000**
				(0.000)	(0.000)
density				0.0043	0.0048
				(0.005)	(0.005)
licfee_pc					-0.0007
					(0.001)
operator dummies	Y	Y	Y	Y	Y
quarter dummies	Y	Y	Y	Y	Y
Constant	0.6926***	0.7020***	1.0129***	-0.1689	-0.3854
	(0.141)	(0.142)	(0.170)	(0.708)	(0.668)
Observations	345	345	345	345	345
R-squared	0.665	0.665	0.670	0.676	0.680

Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Table A-3: No negative correlation between the latest license duration and competition measured by the number of active operators

VARIABLES	(1) nb_firms	(2) nb_firms	(3) nb_firms	(4) nb_firms	(5) nb_firms
duration_lastlic	0.0207	0.0438**	0.0610***	0.0674***	0.0061
	(0.015)	(0.020)	(0.017)	(0.017)	(0.019)
MTR	-0.0145	-0.0160	-0.0256***	-0.0178	-0.0367***
	(0.010)	(0.010)	(0.009)	(0.012)	(0.013)
MVNO_ms		2.9636**	3.1811***	2.9477***	-0.1304
		(1.234)	(1.157)	(1.114)	(0.932)
incumbencyYear			-0.1562***	-0.1723***	-0.1810***
			(0.017)	(0.018)	(0.024)
GDP_pc				0.0000***	-0.0000
				(0.000)	(0.000)
density				0.0248***	0.0059
				(0.006)	(0.008)
licfee_pc					0.0014
					(0.002)
country dummies	Y	Y	Y	Y	Y
quarter dummies	Y	Y	Y	Y	Y
Constant	3.3948***	3.0219***	5.7138***	2.5176***	6.3306***
	(0.299)	(0.365)	(0.426)	(0.768)	(1.163)
Observations	395	395	395	395	243
R-squared	0.751	0.756	0.797	0.811	0.929

Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Table A-4: No positive correlation between the latest license duration and competition measured by HHI

VARIABLES	(1) HHI	(2) HHI	(3) HHI	(4) HHI	(5) HHI
duration_lastlic	-0.0032***	-0.0022*	-0.0034***	-0.0030***	0.0002
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
MTR	0.0013*	0.0012	0.0019**	0.0020*	0.0020**
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
MVNO_ms		0.1363**	0.1212**	0.0993	0.1415**
		(0.069)	(0.061)	(0.065)	(0.062)
incumbencyYear			0.0108***	0.0119***	0.0112***
			(0.001)	(0.001)	(0.001)
GDP_pc				-0.0000***	0.0000
				(0.000)	(0.000)
density				-0.0001	0.0013**
				(0.000)	(0.001)
licfee_pc					-0.0001
					(0.000)
country dummies	Y	Y	Y	Y	Y
quarter dummies	Y	Y	Y	Y	Y
Constant	0.3911***	0.3740***	0.1878***	0.2644***	0.0003
	(0.019)	(0.022)	(0.025)	(0.049)	(0.077)
Observations	395	395	395	395	243
R-squared	0.828	0.830	0.866	0.878	0.903

Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1