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The impact of regulation on innovation capacity in the telecommunication sector

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Declaration of Authorship

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Prague, May 12, 2013

Lenka Šperková

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Abstract

This paper provides an analysis of efficiency and innovation capacity of regulatory measures in two major areas of telecommunication sector: voice telephony and broadband market. In the first part we introduce basic concepts connected with development and performance of voice telephony along with recent European regulatory measures connected to mobile termination rates (MTR) and possible externalities. Impact of introduction LRIC approach on prices of local calls is provided by econometric panel data model covering 17 countries from 2004 till 2011. We have found no significant impact. In the second part we study broadband market segmentation and performance in connection with application "ladder of investments" and "local loop unbundling" approaches. This model is tested on panel dataset of 23 countries in 2004-2010 period of time. Our findings include presence of positive relationship between all three forms of unbundled accesses with different magnitudes of effects. Following test of access payments impact on facility-based competition has detected that: high (average monthly) payments per fully unbundled access do not tend to have positive impact on number of entrants' lines. Despite this result consolidation of our findings supports "ladder of investments" and "local loop unbundling" theory in application on Western European countries.

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Abstrakt

Cílem této práce je analýza efektivity regulace a jejího dopadu na inovační schopnost ve dvou hlavních telekomunikačních odvětvích: trhu hlasových služeb a datového širokopásmového připojení (broadbandu). V první části jsou představeny hlavní koncepty spojené se strukturou v sektoru hlasových služeb spolu s regulačními opatřeními na Evropské úrovni v oblasti mobilních terminačních sazeb (MTR) a jejích vedlejších účinků. Dopad zavedení LRIC regulace na MTR a ceny hovorů je zkoumán na panelových datech 17 zemí a období 2004-2011. V následné analýze jsme neshledali výrazný vliv zavedení tohoto opatření. Druhá část studie je věnována oblasti „broadbandu“, kde vedle struktury a současného stavu zkoumáme dopad dvou teoretických konceptů: „local loop unbundling“ a „ladder of investments“. Model je postaven na panelových datech popisujících 23 Evropských zemí v období 2004 až 2010. Analýza potvrdila pozitivní dopad všech tří forem sdíleného přístupu na tvorbu síťové infrastruktury (nově příchozími operátory), avšak v různém rozsahu. Zároveň jsme testovali vliv průměrných měsíčních poplatků za plně sdílený přístup na tvorbu nových sítí a inovací. Výsledky ukázaly, že výše poplatků nevykazuje kladný dopad na tvorbu nové síťové infrastruktury. Nicméně konsolidace našich zjištění hovoří ve prospěch teorie „ladder of investments“ a „local loop unbundling“ aplikované zejména na státy západní Evropy

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Acronyms

ICT	Information and Communication Technologies
EC	European Commission
COCOM	Communications Committee
ETNO	European Telecommunications Network Operators' Association
ERG	European National Telecommunications Regulatory Authorities
NRA	National Telecommunications Regulatory Authorities
BEREC	Body of European Regulators for Electronic Communications
ITU	International Telecommunication Union
CPNP	Calling Party Network Pays
RPNP	Receiving Party Network Pays
BaK	Bill and Keep
CPP	Calling Party Pays
RPP	Receiving Party Pays
MTR	Mobile Termination Rate
F2M	Fixed to Mobile Interconnection
M2M	Mobile to Mobile Interconnection
MVNO	Mobile Virtual Network Operators
LRIC	Long Run Incremental Costs
NGN	Next Generation Networks
LLU	Local Loop Unbundling
LoI	Ladder of Investment theory
FE	Fixed Effect
RE	Random Effect
OLS	Ordinary Least Squares
FGLS	Feasible Generalizes Least Squares

1 Introduction

ICT sector has become, in recent decades, one of the most dynamically developed segments of national economies in the European region. Gradual penetration of ICT services not only to common lives, but also into production processes and administrative systems, has made them inseparable part of individual economies contributing to technological development and generally higher knowledgability. Positive impact on GDP growth, competitiveness and productivity has been reflected not only by reports on ICT development by also by various studies.

Growing importance and technological development of whole sector as well as telecommunication industry has been, since its deregulation in 1998, reflected in set of regulation measures, approved on both national and international levels. Historical characterization of whole segment revolves around highly saturated structure determined by high initial infrastructure cost requirements. Regulators endeavors in this area could be divided into two major branches of interest. Firstly, promotion of competition in telecommunication sector and price efficiency with respect to increase in customers' welfare and intensifying innovative potential with respect to new technologies adoption. On the European level we might observe additional superior aspect of regulation: trend towards regulation unification and convergence of national regulators measures to the singular scheme, reflecting national dissimilarities. An example of such regulation could be concept "Europe 2020" covering wide range of economy segments, where long term objectives are defined with respect to national specifications of members.

Objective of this paper is dedicated to two major segments of ICT industry: voice telephony and broadband. Despite recent convergence tendencies towards multiple data and voice services transmission there were observed two separate regulatory concepts. In our study we would like to concentrate on descriptions of these segments in the context of their recent developments on the European level. Further, we will provide a summary of major regulatory frameworks affecting this area including theoretical concepts which have been incorporated or significantly

affected their structure. Main part of this paper will be focusing on efficiency of application of those concepts in context of market structure, technological development and endeavors to promote investments into new technologies.

In the first part we will analyze major components of voice telephony market, especially current trend including shift from fixed to mobile technologies and general structure of transmission. Globally we may find several different types of interconnection arrangements which significantly influence pricing mechanisms used in various countries. Their structure has different impact of end-user price and subscribers welfare.

On the European level convergence tendencies are observed towards singular type of interconnection arrangement and payments charged for these services. Their transformation consists of various trends, especially transition from asymmetric to symmetric regulation and unique pricing scheme settlement. Application such measures brings possible externalities, in connection with interconnection arrangements existence of "waterbed effect". Therefore we will outline those concepts and discuss their efficiency and validity. Main part of this section is dedicated to actual implementation of regulation on mobile termination rates arrangements and their possible impact on prices of local calls. Analysis will consist of an econometric model covering 23 European countries in the period of 2004 - 2011. Obtained results will be studied and discussed in the context of recent developments and geographical specifications.

Broadband sector belongs to the most developing areas of ICT industry. This fact has been reflected in continuously changing structure reflecting technological progress and its application. Our aim is to define structure of broadband segment and describe recent European developments in this area. High penetration of "smart phone" technologies and personal computers has generated pressures on increase in broadband speeds. This target has been already implemented into EC strategy Europe 2020 along with promotion of "next generation networks" and competitive measures as predisposition for innovation efficiency.

Simultaneous task of achievement of price efficiency in the short run and innovation in the long rung described by static and dynamic efficiency concept

appears to be unsolvable problem for regulators. Therefore we will show possible solution to this trade-off by introduction of “ladder of investment” and “local loop unbundling” concepts. Validity of both approaches will be analyzed in econometric model constructed with number of new entrants’ lines as a dependent variable indicating infrastructure innovation. We will use panel data from 17 countries covering years 2004 – 2010. Results of our model will discuss impact of both approaches on innovation process with respect to static and dynamic efficiency of European broadband market. In the final section we will discuss possible regulatory challenges of voice telephony and broadband markets.

All models and approaches described in this paper are based on researches and papers published on this topic and selected in accordance with them. As a supporting literature we have used recommendations and reports of European Commission, BEREC, ERG and ETNO. Citation of such sources will as follows: 435/2008/EC as “number of document/year of approval/European Commission” or ERG(09)07 as European Regulatory Group (year) number of report.

2 The efficiency of regulation in voice telephony

Voice services belong to the oldest segments of telecommunication sector which, despite its long history, belongs to the most penetrated ICT areas[1]. To the main characteristics of whole sector belongs strong market share concentration caused by high initial infrastructure costs and long period need for customer base attainment. In order to promote competition pressures in this segment regulation measures were approved. To the most significant areas of interest belongs price regulation and development of schemes for voice transmission and interconnection.

2.1 Price structure and regulation of mobile voice services

Telecommunication market is not a homogenous environment consisted of single subject (although sometimes with partially monopolistic structure), which would provide telecommunication services to customers and supervise all calls made through networks. Because of complex structure of telecom market final retail mobile price charged for usage and interconnection through mobile network is influenced by number of factors varying in market structure, type of connection, regulation policy etc. Final retail mobile price is than consisted of various variables influencing both market and mobile operators

2.2 Main factors influencing pricing structure

Regulation regime determines not only position for incumbents and new entrants (asymmetric and symmetric regulation), but also level at which regulation is incurred – national and international (European Commission etc.) or eventually when: ex-ante vs. ex-post regulation. In more advanced stages we may speak about of regulation of wholesale mobile termination rates etc.

[1]EU average penetration rate is 128%

Payment structure is one of key factors for subscribers. Here we distinguish calling party pays system (CPP) applied in the most of European countries or receiving party pays (RPP) usually accompanied by bill and keep interconnection regime. Second type could be found in USA, Canada and some Asian countries (Hong Kong). In RPP higher traffic intensity and higher penetration than in CPP have also been observed, which was profoundly studied by T. Majer and M. Pistollato (2010)[2] or in Frontier analysis of European market (2012) [5]. One of the reasons[3] could be existence of very low or zero interconnection charges which generate pressure on marginal costs and could have effect on final price for subscribers. Nevertheless, background behind to his argumentation contains many restrictions and cannot be generally applied.

Market share and structure defines key environment factor affecting price. Despite historical tendency to monopolistic structure of telecommunication industry factors which can be partly overcomed by appropriate regulatory measures and technological development (Mobile Virtual Network Operators – MVNO), number of subscribers and market share still determine position of operator on the market and affect final price. Especially in the area of mobile networks number of new factors emerged: saturation of market and entrance of MVNO, existence of various pricing regimes on all levels (CPP/RPP or disparity between pre-paid and post-paid services), market penetration, spectrum allocation policy and situation and other technological factors.

In the case of providing interconnection between two subscribers we may speak about of mobile-to-mobile (M2M) or fixed-to mobile (F2M) calls. Accordingly, final price structure of both models revolves around type of network used and trends affecting them. In the most general way we may technologically distinguish two basic types of interconnection through networks: Fixed and mobile networks.

Fixed networks are historically connected with almost monopoly structure in which only small number of providers was operating on the market. Reasons behind this position may lay in high infrastructure and investment requirements. From the

[2] Majer,T; Pistollato, M (2010*): Calling vs. Receiving Party Pays: Market Penetration and the Importance of the Call Externality* .[online]. 2010. [cit. 2013-03-07]. Available at http://www.recercat.net/bitstream/handle /2072/152020/84510.pdf?sequence=1

[3] FRONTIER Ltd. (2008): The impact of recent cuts in mobile termination rates across Europe

cost perspective fixed networks suffers from relatively low "traffic cost" [2] generated by change (or growing) volume of calls made.

Opposed to fixed networks mobile networks' market structure is determined by spectrum allocation policy which enables creation of highly competitive environment. Increasing number of mobile calls on the other side makes traffic costs of mobile networks higher comparable to fixed networks. In recent years we might have observed general diversion from fixed networks towards mobile alternative in developed and developing world (Figure 2.1).

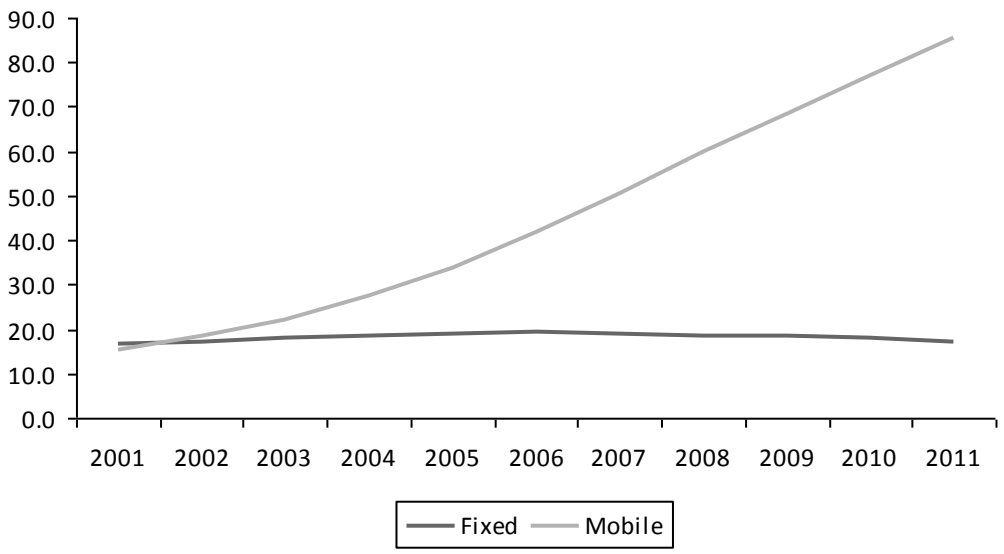

Figure 2.1: Number of subscriptions per 100 inhabitants development

Source: ITU Statistics (http://www.itu.int/ict/statistics)

However both networks' infrastructures are indistinguishable, technological development as well as customers' requirements for compatibility and accessibility caused their mutual convergence [4]. The visible trend can be seen even in telecommunication industry in penetration of smart phones and multi-usage technologies. Adoption of providing both F2M and M2M services incurred logical step for operators.

2.3 Mobile and fixed termination rates definition

In order to provide full telecommunication service interconnection between two subscribers (irrespective of type of connection) is required. If both of participants use mobile network of one operator we speak of on-net call. In reverse case (off-net call) usage of competitor's network is demanded in order to terminate call. Operator which enables other operator to use its network can impose a wholesale or retail charge for terminating the service - mobile termination rate (MTR) or as the case may be fixed termination rate (FTR).

2.4 Arrangements for interconnection

According to OECD and ITU we may observe set of basic types of regimes under which the mobile termination rate is charged. Magnitude and application differs according to applied system. From the wholesale perspective we define following systems [4]:

Calling party network pays (CPNP) belongs to the most dominant regimes. Provider representing calling party (originating service) pays a per-minute charge to provider, which terminates this call. Payment consists of using provider's network according to exchange traffic payment. This termination fee can differ according to the type of the termination service – FTR or MTR.

Receiving party network pays (RPNP) revolves around same pattern as CPNP but is inverted. Party receiving call pays a fee (per-minute charge) to provider which originates service. Presence of this regime is very limited and some sources acknowledge, there are no countries terminating services under this regime[4].

Under Bill and keep (BaK) or "sender keeps all" regimes there is an agreement between operators that traffic termination will not be charged by any fee, alternatively we speak of agreement on zero termination charges. The logic behind this decision lies in balanced traffic between network providers which are

[4] Lazauskaite, Vaiva (2009): *Costing and pricing of interconnection services today and tomorrow: impact of migration to NGN and ITU/BDT activitie*s [online] PPT presentation, 2009 [cit.2013-05-08] ITU Seminar on Tariff policies and interconnection. Available at ITU web: http://www.itu.int/ITU-D/finance/work-cost-tariffs/events/tariff-seminars/Ukraine-08/PDF/Vaiva_NGN _interconnection-Odessa.pdf

approximately equally distributed for both sides. We may find a fee billed to customers, but there is no connection of this fee and interconnection charges or obligation to transfer it to network's provider.

Mobile party network pays (MPNV) is specific regime introduced in Hong Kong after deregulation of termination charges in 2009. Burden of charge for interconnection is levied on mobile operator which pay per-minute fee for whole network traffic made irrespective of originating or terminating service.

We acknowledge existence of another regime – "peering and transit" similar to BaK regime with some differences in application on internet termination. (for more detailed specification see Developments in mobile termination, OECD, 2012)

Payments for interconnection significantly influence final costs of call. They are reflected in final consumer's bill as a retail charge for termination of demanded service (call). Two basic types of retail regimes exist (ITU):

Calling party pays (CPP) – Whole communication is paid by side initiating the call. Invoicing of call is based on either second or minute regime of charging. Amount of services paid by initiating side depends on combination of wholesale and retail regime, but the most common structure is combination of CPP and CPNP. Traffic terminations as well as all calls made are paid by side initiating voice connection. Nevertheless, dominance of this form does not exclude existence of other ones: BaK and CPP in Singapore or even usage of various systems for fixed and mobile interconnection (Sri Lanka until 2010).

Receiving party pays (RPP) – Major proportion or sometimes whole payment (including interconnection charges) for voice service is paid by receiver. The most logic combination with wholesale RPNP regimes is not widely used but there were evidences for RPP regimes in USA (Genakoss, Valetti (2009) [3]). There are several distinctions between RPP and US regime – sometimes referred as "bundle regime" or Both Parties Pays (BPP) regime (OECD (2011)). This specific type of bundle retail regime is based on system of bundles (packages) in which amount of incoming and outgoing minutes for domestic and international calls is defined (sometimes even unlimited packages) and from which final payment is extracted. However this system

shows low level of transparency. Despite that in US very high levels of voice traffic have been experienced compared to other regimes, Frontier (2012) [5].

In recent years we observe convergence of telecommunication services towards mobile technologies in which borders between different technologies and infrastructure systems used for providing those services has been vanishing. An example might be increasing proportion of providers using wireless infrastructure for voice interconnection.

As an alternative, which strives to reflect general shift and convergence in telecommunication technologies and cover more platform of communication interconnection is Capacity Based Interconnection (CBI). Opposed to already mentioned systems based on per-minute charge, CBI reflects cost of used network capacity. This pattern initially discussed in 1991 in broadband context has been implemented in either shared of single form in Spain and Colombia.

2.4.1 Waterbed effect

In telecom industry MTR has adopted noticeable position in mobile operator revenues (under CPP regime). According to Ofcom report (2009) [2] 14% of total revenues in UK are generated by call termination. Necessity of mutual interconnection incurs pressures on mobile retail charges and strongly influences subscriber's decisions. One of those tends is "club effect" in which choice of mobile operator is strongly dependent on percentage of subscribers favoring this operator in order to reduce costs for MRT. Consequence of this effect is higher market saturation to the most dominant mobile operators and in long term perspective possible distortions of the market. Profitability of MTR is enlarged by monopolistic nature of mobile operators with respect to other subscribers. Regardless of a degree of competition on the market mobile operator holds monopoly over interconnection of calls to its customers. Consequently behavior results in setting high MTR and in effect known as monopoly or competitive "bottleneck". Those inconsiderable impacts and tendencies make MTR one of the key areas of regulation on both national and international levels. The most of efforts in regulation telecom sectors have been therefore concentrated on lowering MTR in order to maximize subscriber's welfare. Nevertheless, lowering rates does not have to necessarily result in lowering mobile

retail prices and could have antipodal outcome known as "waterbed effect". It represents a

"trade-off relationship between wholesale prices and retail prices in relation to two sided markets" (Schiff, 2008) [7]

Lowering of MTR stimulates mobile operators to compensate decreasing profit through new pricing strategy - by increasing other tariffs for purpose of profit preservation or at least minimizing its fall.

Contradicting views revolves around existence of "waterbed effect". First larger debate about regulation of MTR in UK in 1997 stated doubts about existence and size of effect appeared. Since then, discussion has been held about size and impact of this effect on subscribers and market structure. In 2009 Ch.Genakos and T.Valletti [3] analyzed its existence and magnitude in panel data study. Their findings contain evidence of absence of full "waterbed effect" on two-sided market and its magnitude in range between 2% and 15%. Other studies strived to explain existence of effect by profit maximizing behavior or theory of profit neutrality introduced in 1998 and tested by Andersson and Hansen in 2009[5]. This theory revolves around constant level of profit before and after introduction of regulation on MTR and its full recovery, therefore existence of full "waterbed effect". Reverse to confirming attitudes argumentation is underway that reduction of MTR could lead to surge in subscriber's welfare. Interesting fact is that one of reports denying existence of effect was published by ACCC[6] 2009 even thought in previous study from 2005[7] it was acknowledged. Despite of contradicting outcomes of studies focused on impacts of MTR regulation its awareness is usually taken into account by introduction of new regulatory measures in telecommunication sector.

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[5] Andersson Kjetil; Hansen, Bjørn (2009): Network competition: Empirical evidence on mobile termination rates and profitability, [online] April 2009, [cit. 2013-05-08]. 27p. Available at: http://home.bi.no/a0510011/Papers/Andersson_Hansen_MTRempirics_april_2009.pdf

[6] ACCC - The Australian Competition and Consumer Commission – authority responsible for economic regulation in the Australian telecommunication sector

[7] ACCC reports on Domestic Mobile Terminating Access Service Pricing Principles Determination and indicative prices for periods till 2009 and 2011

2.4.2 Asymmetric regulation and waterbed effect

Even without taking into account for existence of waterbed effect, there is need to provide competitive environment on the market, especially if there is suspicion for irregular distribution of market shares, number of incumbents/new entrants, rates of on-net/off-net call rates ect. Purpose of regulatory measures in this case could be compensation of those irregularities in order to create appropriate conditions for innovations and to maximize subscribers welfare. One of attitudes thriving to accomplish those targets is usage of symmetric or asymmetric regulation (sometimes just various rates of asymmetric regulation) especially in connection with mobile termination rates. Nevertheless, their introduction does not have to necessarily mean total outperforming of waterbed effect.

Not fully-saturated mobile markets are usually consisted of various companies occurring in different phase of pervasion on the market and with various market shares. The most common mobile operator market structure comprises few major incumbents with strong monopolistic position, very market saturation and potentially abusing position, which cumber entrance of new provider. Such entrants are facing difficult position competing mobile termination rates for off-net call with operators with strong market power and facing very low subscriber's rate. In order to narrow measures and shift monopolistic position towards competitive environment for all mobile operators introduction of asymmetric mobile termination rates is imposed. Such asymmetry is defined as different attitudes to regulation of new entrants and incumbents or general difference in MTRs across operators within the same country, due to differences in regulation, Lee (2010) [8].

Performance of asymmetric regulation revolves around MTR adjustment towards new operators by allowing for higher interconnection charges that decreases gap in per unite costs. It narrows their unequal market position. Rate of such asymmetric treatment diverges across different market and country specifications. In short term perspective it facilitates entrance for companies, which would not be able to achieve it without specific measures. Incurred operators structure then may in short term perspective promote competitive environment and increase in subscriber's welfare and entrant's profit. Such policy can also promote subscribers flexibility in highly penetrated market with low subscriber's elasticity.

Benefits resulting from advantageous position might make entrant's market adaptation faster and approach it akin to incumbents. After attaining such position supporting regulatory measures start to generate abusing pressures. Increasing profits for entrant's operator does not motivate them for adjustment in MTR and may result in increasing retail prices. Reaction of incumbents would exacerbate "bottleneck effect" and rise in off-net calls. Generally such asymmetric (one-sided) profit elevation supported by regulation policy impediments investment into innovation. Recommended duration of such policy application without undesirable consequences varies, but is estimated to 4 years period of time (BEREC report, [9]).

Untenability of usage of asymmetric MTR regulation for long term period without negative externalities has been accompanied by diversion to more symmetric form observed in number of countries BEREC (see Appendix A: Table A.1)

2.5 European MTR regulation framework – LRIC

Attention paid to studies focusing on impacts of MTR lowering and presence of waterbed effect did not have only theoretical ambitions. In last 13 years majority of European countries decided to leave asymmetric attitude in MTR or stated mandatory date until which the change will be applied.

In 2009 EC approved new regulatory concept 396/2009/EC [10] for lowering MTR according to new system called LRIC (Long Run Incremental Costs). The method has become successor of FAC ("Fully Allocated Costs") or HC FDC ("Fully Distributed Historical Costs") pattern, where operators could reflect all cost spent on the network's maintenance and construction into MTR. Main negatives of it were seen in inefficiency of allocation especially with connection to customers' welfare and possible need to negotiate costs between operators. Despite existence of three types LRIC (top-down, bottom-up and benchmarks) and relatively sophisticated scheme, it is expected to contribute to increase in transparency and efficiency of price schemes. Since LRIC introduction we might have seen significant decrease in MTR in Europe. Cause of this effect is however questionable: was it caused by impact of regulation introduction or was it simple long run decreasing tendency.

Potential benefits of using LRIC persuaded regulator bodies to recommend this system for Universal service usage – calculations of net costs. Nevertheless, implementation process stated by EC has very gradual speed and not all EU members reflected this recommendation into national regulation frameworks. (Czech Republic announced in the end of 2012 final LRIC adoption (or finalization of implementation process n. CZ.1.04./4.1.00/48.00020). This is question whether this adoption will have expected effect, because MTR already have decreasing tendency (since 2005) and whether announced adoption would intensify this trend in the context of expected spectrum auction and roaming prices regulation.

3 Interaction between MTR and retail price

3.1 Research question and literature review

Interaction between MTR, asymmetric regulation and possible impacts on performance indicators in voice telephony has been challenging topic for various theoretical and empirical studies which in the long term period contributed to development of current European Regulatory Framework in this field. To the most current analysis belongs Frontier study from 2012 on determining impacts of lowering MTR in Europe. Study contains set of simple econometric and statistic models based on covering period 2007-2011. Results have shown no significant impact of MTR lowering neither on performance of smaller operators or on frequency of mobile phone usage. In a wider study from 2012 Jongyong Lee and Duk Hee Lee [8] provided broad analysis not only on MTR, asymmetric regulation and price interaction but also tested presence of possible externalities. A positive correlation between asymmetric MTR and prices of voice calls was observed same as presence of possible negative externalities.

On the other side Genakos and Valletti [3] have chosen very sophisticated approach to study existence of negative externalities generated by MTR lowering and known as “waterbed effect”. They confirmed presence of this effect on the dataset of 20 countries, nevertheless its magnitude was only partial, “waterbed effect” was not found full but strong. Reversing position on the existence of „waterbed effect” was not seen only among analyst but also among national and international institutions and was reflected in their reports. ACCC 2009 and 2005[8] posted two contradicting positions on the similar problem. Reverse to them EC acknowledged partial its presence in number of reports and recommendations.

[8] See section 2.4.1

In our study we would like to concentrate on determining nature of relationship between MTR lowering and prices of local calls in Europe. In the final discussion we would like co to cove eventual presence of "waterbed effect" based on our findings. Contribution of our research is not restricted to simple relationship determination, but also to inclusion of more (especially time, geographical and regulation) factors influencing final effect as well as analysis of number of control variables. For this proposes we have researched longest possible time period based on availability of datasets.

3.2 Data description

In our analysis we have decided to cover 23 European countries. With respect to research focusing on LRIC model adoption recommended in 2009 by EC, inclusion of non-European countries may cause outliers among observations. Distribution of countries covers various economical levels and new member states which would contribute to information capacity of a model. Selected time period consisting of 8 years from 2004 to 2011 includes sufficient panel data. Impact of financial crisis might be detected with respect to inclusion of years from 2009 but magnitude of effect should not be enormous, with respect to performance of whole sector.

Variables used in our model describe development of average mobile termination rate *(MTRi)* in observed period and prices of local call measured per minute *(p)*. Both variables have been purified from inflation impact. Collection of MTR was obtained from BEREC reports on mobile termination rate development being published every year. In addition to mentioned datasets we include set of controlling variables which should describe economical performance of countries: growth rate of GDP per capita *(GDPg)* and unemployment rate *(u)* (both taken from EUROSTAT databases). Market structure distribution is represented by leading operators market share *(ms)* and available on EUROSTAT database. Level of mobile technology adoption is represented by mobile penetration rate *(mob_pen)*. We have decided not to include fixed voice penetration rate especially because of general high market penetration and trend consisting of shift to mobile technologies and their general convergence (in the contexts of multiple services transmission). Used data

were taken from Frontier report of MTR lowering impacts on EU and supplemented (because of missing data) by EC reports. Tables 3.1 and 3.2 below show descriptive statistic of used variables including their statistical characteristics (correlation analysis: Apendix B, Table B.1).

Variable name	***Variable description***	***Source***
p	Price of local call per minute (in the prices of base year 2004)	EUROSTAT
MTRi	Average mobile termination rate in the prices of base year 2004	Analysis Mason
GDPpg	GDP per capita growth	EUROSTAT
mob_pen	Mobile penetration rate	Analysis Mason, EUROSTAT
MTRidum	MTRi*dummy variable for introduction of MTR regulation in 2009	
unempl	Unemployment rate	EUROSTAT
ms	Market share of leading operator	EUROSTAT

Table 3.1: Data description

Source: EUROSTAT[9], Analysis Mason[10], [6]

[9] ICT databases available at Eurostat web: http://epp.eurostat.ec.europa.eu/portal/page/portal/statistics/search_database

[10] Analysis Mason statistics Available at: http://results.analysysmason.com/search?w=mobile%20penetration

Variable	*N*	*Mean*	*Std. Dev*	*Min*	*Max*
time	184	2007.5	2.2975	2004	2011
geo	0				
MTRi	184	0.0856	0.041	0.01765	0.2065
geo_id	184	14.2609	8.1043	1	27
p	184	0.00039	0.00015	0.00012	0.00077
ms	184	0.4414	0.08814	0.21	0.7
mob_pen	184	1.1371	0.19212	0.789	1.6334
MTRidum	184	0.0181	0.02605	0	0.099003
GDPpg	184	0.9199	0.30706	0.34	1.47
unemp	184	0.0846	0.03652	0.031	0.217

Table 3.2: Summary statistics

Source: author's computations

3.3 Methodology

Main aim of our analysis is to study regulation impact of introduction LRIC on price development in the European countries. Collected dataset contains panel data of sufficiently long period for study of short and medium run impacts of regulation introduction. Firstly, we will run simple pooled OLS as a framework for model specification.

Stage 1: simple OLS regression

Stage 2: inclusion of FE and RE

Then we will gradually add selected variables in for purpose of reduction of over-specification in model. With respect to panel characteristic of our data we estimate fixed effect (FE) and random effect (RE) models. In order to obtain consistent estimators of FE and RE we will use Hausman test for consistency (Wooldrige, p. 453, 2002) [11]. As a part of final adjustment of model we will test

possible serial correlation of errors and in the case of positive outcome we will proceed to correcting procedure by using FGLS (Feasible Generalized Last Squares) correcting both heteroscedasticity and serial correlation.

3.4 Results

Initially we estimate simple model using simple pooled OLS including robustness. For purpose of regulation policy analysis we have created additional new variable *(MTRidum)* by multiplying MTR and dummy variable equaling 1 for years after 2009 (including). This contributes to decision about impact (sign) of introduction of MTR regulation (LRIC) (Table 3.3).

p	***(OLS) Coef..***	***Std.Err***
MTRi	-0.000584	(-0.00028)
GDPpg	0.00014***	(-0.00003)
mob_pen	-0.00024***	(-0.00005)
MTRidum	0.000617	(-0.00058)
unempl	0.000419	(-0.00036)
ms	-0.000128	(-0.00011)
_cons	0.000601***	(-0.0001)
Observations	184	
F(6, 177)	7.22	
Prob > F	0	
R-squared	0.1447	

*** P>|t| = 0.000

Table 3.3: OLS estimation results

Source: author's computations.

We may observe separate insignificance among variables, nevertheless F- test and value of F- statistic shows joint significance of all variables. Information capacity represented by R-squared indicated very low value around 14,5%. Interesting sign is connected with MTR inclusion of inflation where according to regulators intention positive sign could be expected. Magnitude of this effect is smoothened by control variable *MTRidum* including years after LRIC introduction, but is not sufficiently large to prevail it.

Panel data usage with connection to simple OLS may lead to omission of an unobserved effect. Neglecting its inclusion may generate irregularities within model and might lead to biased estimates originated by unobserved heterogeneity (Wooldrige, 2002) [11]. Avoidance of possible complications is facilitated by panel data estimation methods use. Therefore we accommodate our model for fixed and random effect procedures (Table 3.4)

	(FE)		*(RE)*	
p	***Coef..***	***Std.Err***	***Coef..***	***Std.Err***
MTRi	-0.00508	(-0.004)	-0.0006548	(-0.00034)
MTRidum	0.000463	(-0.00055)	0.000458	(-0.00051)
GDPpg	0.000141	(-0.0003)	0.0001511	(-0.00003)
unempl	0.000152	(-0.00034)	0,0003568	(-0.00006)
mob_pen	-0.000234	(-0.00007)	-0.0002347	(-0.001)
_cons	0.00055	(-0.00011)	0.0005435	(-0.001)
Observations	184		184	
R-squared	0.1392		0.1356	
F(5, 141)	4.45			
Prob > F	0.0007			
Wald $\chi^2(5)$			29.1	
Prob > χ^2			0	
Corr (u_i, Xb)	0.0404		0 (assumed)	

*** P>|t| = 0.000

Table 3.4: Fixed and random effect models

Source: author's computations.

Demand of consistent estimator forces us to make decision on choice between these two models. Hausman test, constructed for this purpose, states under null hypothesis consistency of both models. Received results show value of χ^2 statistic 18.47 and p-value 0.0052 leads us to conclusion that we do **not reject** null hypothesis on the 10% level of significance and application of random effect method. Conclusion is supported by nature of dataset which include large number of countries deployed on the long period of time (8 years). In both models we can see similar signs of coefficients and difference in magnitudes between them is not critically large. Before final interpretation of results we have to test our model for presence of serial correlation of errors. We have decided to test presence of AR (1)

autocorrelation. High value of F test (18413.87) and low p-value indicates presence of autocorrelation in the model therefore rejection of H0 hypothesis that there is no serial correlation. In order to clear negative implication arising from its presence we proceed to FGLS (Feasible Generalized Least Squares)[11] procedure correcting both serial correlation of errors and eventual heteroscedasticity. (Table 3.5)

p	***(FGLS) Coef..***	***Std.Err***
MTRi	0.00003	(-0.00005)
GDPpg	0.00014	(-0.00002)
mob_pen	-0.00001	(-0.00001)
MTRidum	0.00001	(-0.00004)
unempl	-1.15 e^{-7}	(0.000052)
ms	-0.00002	(0.000039)
_cons	0.00041	(0.0003)
Observations	184	
Wald χ^2 (5)	5.61	
Prob > χ^2	0.3462	

Table 3.5: FGLS model

Source: author's computations.

As we may see, formalization of final model has certain limitations regarding information capability with respect values of χ^2, however the whole procedure produced and proceeding the final model is dealing with the most common problems occurring with panel data manipulation.

[11] for further procedure specification see http://personal.rhul.ac.uk/uhte/006/ec5040/estimation%20using%20Panel%20Data.pdf

Discussion about magnitudes and signs of coefficient reflects only partially signs expected by regulators bodies during LRIC approval. We begin with the most general variable indicating market characteristic: mobile penetration rate. Voice telephony market belongs to the category of highly penetrated segments which currently goes through transformation process represented by convergence tendencies among voice and data transmissions. Gradual liberalization (in the late 90s) and regulatory measures has intensified competition among operators and allowed price lowering in the long run horizon. Negative sign, observed in all models, indicates successful implementation of regulation with respect to market share. Extremely high mobile penetration (on the European level reaching over 128%)[12] tend to support service price lowering and need to further widened subscribers' base. Classification of such impact fulfills characteristic of price competition among operators.

Positive but very low coefficient of MTR impact indicates very low impact on local call prices. Despite fulfillment of our expectations regarding positive sign of coefficient of this relationship its size tends to have very limited effect. Researches studying MTR development in the European countries have shown (since 2005) gradually decreasing tendency. This fact is supported by statistical analysis of our datasets and their plotting on the time graph for each country (Figure 3.1)

Nevertheless, no significant impact was detected of introduction regulatory established in 2009. Control variable representing this effect has very low effect (0.0000191) on its final coefficient size. Taking into account previous models for fixed and random effects negative sign of MTR impact on prices of local calls has been strongly smoothened by this "regulation" coefficient and in the end limited impact close to 0. Interpretation of obtained results is therefore very complicated with respect to contradicting signs obtained in the different stages of contraction, but finalized model has shown us very limited impact of LRIC introduction. Partially it could be explained by nature of this "recommendation" which allows member countries time space regarding national application (Czech Republic has fully implemented LRIC in the beginning of 2013)[13] and insufficient time for

[12] GSMA (2011): European Mobile Industry Observatory 2011

[13] CTA (Czech telecommunication authority) – termination of LRIC implementation project number CZ.1.04./4.1.00/48 .00020) available at CTA web

demonstration of potential impacts. Controlling for possible interaction with asymmetric MTR regulation has also limited interpretation with respect to intentions to shift towards symmetric model and announcement of dated for entering it. Nonetheless, presence of positive relationship between base variables indicates either absence or limited presence of waterbed effect among studied countries. Results may differ with respect to Western and Central and Eastern Europe categorizations where voice telephony markets indicate higher level of monopolistic pressures and generally higher prices observed even in the Czech Republic. Market adjustment has in those cases already indicated some development especially on the field of unlimited voice packages and trend for price lowering, but for final result statement more time will be needed.

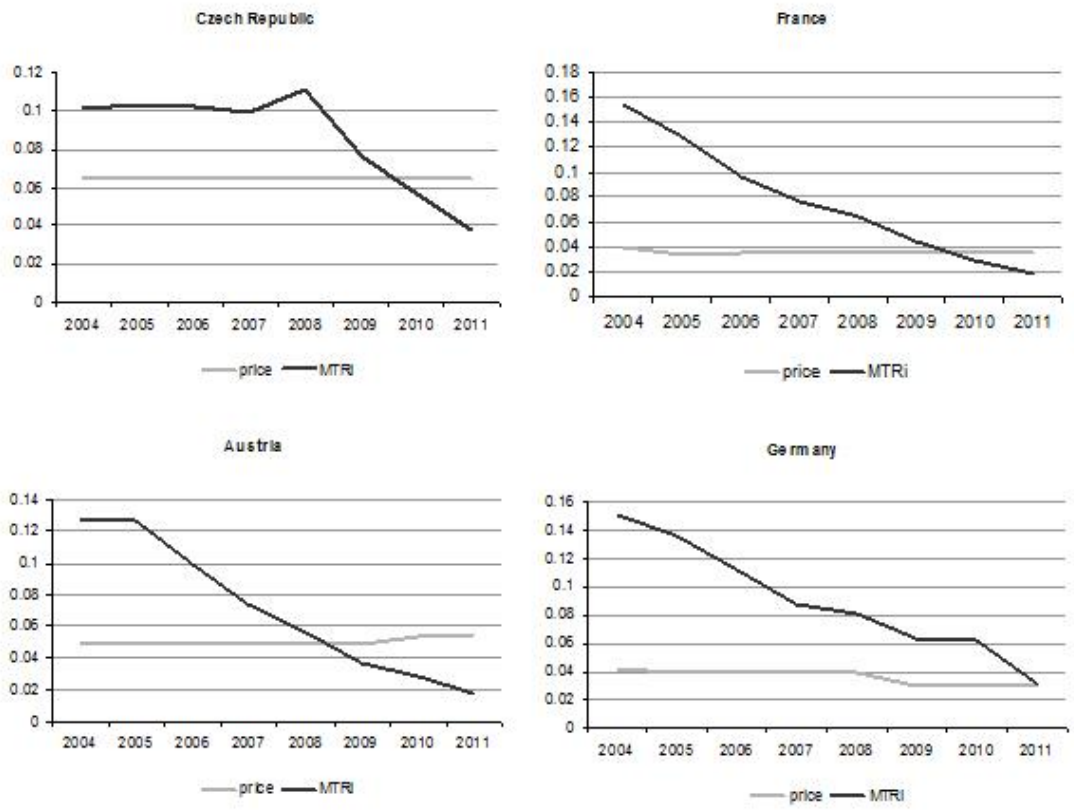

Figure 3.1: MTR and price of local calls development

Source: author's computations.

Final inclusion of all variables, their effect on the price of local calls and development in recent years tended to contribute to decreasing tendency of MTR, voice calls prices and market structure evolution which might increase subscribers'

welfare, nevertheless impacts of regulatory reforms approved in 2009 have very restricted interpretation.

For purposes of further research it would be challenging to study MTR and local price calls relationship on the national or at least regional level. This case may resulted in inclusion of company datasets from annual reports which might lead to confusing conclusion (question of credibility of annual reports statement with connection to recognition and marketing strategies). More regional attitude would in this case lead to more specific results without generalization on the international level.

3.5 Other regulatory measures

Regulation of MTR does not belong to isolated intentions on the European level. To the major trends in telecommunication sector (and especially in the voice telephony) belongs introduction of price competition and general regulation towards price reduction. In the year 2007 approval process has been initiated which culminated by authorization of regulation 531/2012/EC[14] known due to introduction of regulation of international voice services (sometimes called as "roaming"). Requirement of mandatory adoption of specific tariff in both voice and SMS service allowed lowering international tariffs (on the European level) even in the area of data transmission.

Number of European countries has already introduced regulatory measures as spectrum auction, in order to prepare for MVNO entrance and further promotion of competitive pressures. However is this step considered the key factor for reduction of operators market share, there are countries which has not yet realized it. Czech Republic belongs among them. In those separated case may questions arise: about background of such intentions revolving especially around regulatory bodies or about operators strategies. With respect to directive approved by EC in 2009 (114/2009/EC)[15] and its mandatory nature, there is perspective for uniformity in this

[14] EC directive on roaming on public mobile communications networks 531/2012/EC Available at EC web: http://eur-lex.europa.eu/LexUriServ/ LexUriServ.do?uri=OJ:L:2012:172:0010:0035:CS:PDF

[15] EC directive on the frequency bands 114/2009/EC Available at EC web: http://eur-lex.europa.eu/LexUriServ /LexUriServ.do?uri=OJ:L:2009:274:0025:0027:en:PDF

field which would, together with other mentioned intentions, contributes to price efficiency and subscriber welfare.

4 The impact of regulation on broadband sector

4.1 Broadband and its basic concepts

Along with technological development in telecommunication devices there was experienced increasing need for wider range of telecom services along with searching new methods of interconnection which would simplify and reduce costs of providing services. One of platforms, which allowed widening those possibilities, was broadband.

Opposed to other platforms broadband has been strongly predisposed to technological development and general demand for faster types of data interconnection. Acknowledging this fact it would appear to be very difficult to state single firm definition. Despite general understanding of this concept as a wide bandwidth transmission mechanism (usually connected to high-speed internet connection, which level refers to current technological development and general statement of minimal speed limit) facilitating transferring of wide range signal types simultaneously. ITU states current definition of broadband as

"transmission capacity that is faster than primary rate Integrated Services Digital Network (ISDN) at 1.5 or 2.0 Megabits per second"[16]

But it is possible to find less "technical" alternatives (Federal Communications Commision):

"...advanced communications systems capable of providing high-speed transmission of services such as data, voice, and video over the Internet and other networks. Transmission is provided by a wide range of technologies, including digital

[16]ITU definition (2013): Available at: http://www.itu.int/osg/spu/publications/birthofbroadband/faq.html

subscriber line and fiber optic cable, coaxial cable, wireless technology, and satellite."[17]

However even the most perfect definition cannot be valid for longer period, because of continual development of new platforms and especially increasing speed requirements (stated either by regulatory body or end-user demand).

4.2 Broadband typology

Opposed to highly penetrated telephone market (in Europe) which indicates relatively stable transmission structure, broadband sector has been still experiencing stage of development of new types of transmission (especially with broadband of "next generation") along with convergence trend demanded mostly by technological development of multi-usage devises requiring both voice telephony and internet services. According to transmission channels we may distinguish two major types of interconnection same as with voice telephony: Fixed or wired – requiring cable interconnection and mobile or wireless using signal as a transmission channel. In the first category we can find:

DSL or digital subscriber line represents one of current telecommunication trends: convergence of transmission technologies. Telephone lines already installed (cooper cables) facilitate high speed transmission in the range from Kb/s[18] to Mb/s (current range of downstream[19] speeds from 10Mb/s to 30Mb/s with special types of ADSL). Main advantage lays in lower infrastructure requirement, but potential connection of subscribers lean on this network coverage. With respect to download and upload speed requirements two sub-branches of DSL have been recently developed.

[17] FCC definition (2013): Available at: http://www.fcc.gov/encyclopedia/strategic-plan-fcc

[18] Kb/s - kilobits per second - one bit per second represents data transmission speed or how many bits will be transferred in one second. The most common unit used in connection with broadband is Mb/s or Mbps – megabits per second

[19] Downstream or download represents direction of data stream transposed into the end-user device (PC, mobile phone ect.). Opposite: upstream or upload connected with direction of data sent from end-user device.

Currently ADSL (Asymmetrical Digital Subscriber Line) constitutes currently the most used platform being offered by national operators. Asymmetry of transmission is deflected towards high downstream (download) opposed to lower upstream (upload). Separation of those streams does not affect telephone traffic thanks to splitter, installed at the end of both lines, which divides both channels to high speed data channel and lower speed voice channel (usually as ISDN).

Opposed to ADSL SDSL (Symmetrical Digital Subscriber Line) denotes balanced level of speeds on both streams which are advantageous at video transmission as video conference. Compared to ADSL, which enable simultaneous data and voice transmission, SDSL requires additional installation of separate line for voice stream. Therefore the main area of usage specializes on business corporations. Opposed to high speed availability the main disadvantage of DLS is its dependence on local telecommunication infrastructure coverage.

Cable modem reflects different type of convergence trend in fixed broadband connecting broadcasting, voice and data transmission through coaxial cable. Usually it is offered in a form of packages for households by local operators. Even though it offers similar speeds as DSL (30 Mb/s which is comparable to high speed types of ADSL) its dependence remains on local telecommunication infrastructure coverage.

Fiber optic cable belongs to fastest available broadband transmission channels on the market. Conversion of signal into light and its transmission through glass fibers facilitates usage speeds up to 100 Mb/s[20]. Recent trend in optic cable technology covers network architecture. In order to maximize speed potential of optic fiber are local metal loops are replaced by optic fibers. This transformation is known as FTTx (fiber to the x), where "x" stands for type of interconnection, for example FTTH (fiber to the home), and their structure varies according to distance which is replaced by optic cable.

Increasing demand for availability of internet, which would be independent of infrastructure coverage, enables development and wider application of non-cable, mobile or wireless transmission technologies. Introduction of non-cable technologies

[20] recent experiments of Google facilitated reaching speed of 1000Mb/s in connection with FTTx platforms

launched development of xG (x^{th} generation) networks. In 1980s first 1G network was introduced. Even though it was based on the analog cable basis with speeds around 9kb/s (ITU), launched development gradually facilitating higher data peak speeds and wider frequency bandwidth. Currently penetration of 2G networks attacks almost 100% opposed to its successors which penetration rate differs among continents (from 99% in Japan in 2012 to 6% in India according to WCIS)[21]. One of the greatest challenges is promotion and wider penetration of 4G networks.

Alternative to 3G networks is WLAN – Wireless Local Area Networks, or its long distance forms, facilitating data traffic on non-cable basis. Transmission is providing signal, requires installation of external antennas in required areas. Low infrastructure requirements and high availability provide an alternative for distant areas and increase overall broadband penetration. Also opposed to 3G technologies, requiring arrangements between subscriber and operators initiated possibility of charge-free internet connection on short distance basis (usually as an additional service in restaurants and cities) and started discussion about possibility of introduction of new form of universal service.

Recent trend in broadband (Figure 4.1) reflects technological developments of mobile devices, especially smart-phones increasing demand for portable internet connection technology with high downstream speed. Along with convergence tendency in voice telephony and broadband it has been reflected by continually increasing dominant proportion of mobile broadband especially among smaller devices with precipitously increasing penetration, which reached in 2012 35,1% compared to computers - 8,9%.[22] In the area of cable interconnection we may observe strong tendency towards concentration of services into multi-usage transmission technologies (concentrating voice, data and broadcasting services) and further gradual increase in high broadband subscription speeds [23] which generates high

[21] WCIS – World Cellular Information System

[22] EC report on broadband lines in the EU from 1st of July 2012.. Available at: https://ec.europa.eu/digital-agenda/en/news/report-broadband-lines-eu-1st-july-2012

[23] Continually changing trend of understanding high-speed connection with increasing end-user requirements of the fastest possible interconnection in both directions (upload and download)

infrastructure coverage requirements and its adequate technological development and investments.

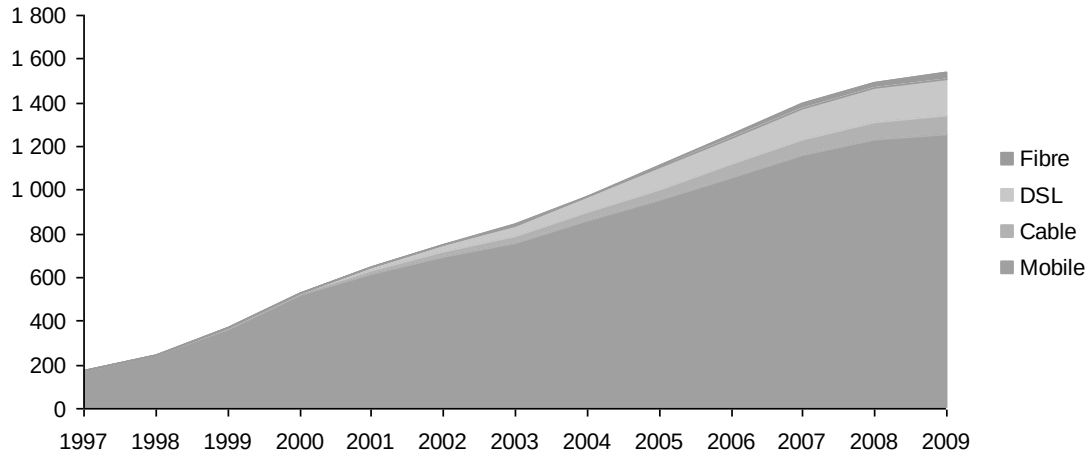

Figure 4.1: Broadband platforms development

Source: OECD Communication Outlook 2011

4.3 Broadband situation in the Europe

Despite the fact, that in recent years Europe telecommunication market has been (since 2007) experiencing temperate decline in revenues affecting both total sector and telecommunication branch (-1,5% in period 2010 – 2011) [1], we may observe transformation of market towards IT and data technologies which as the only one showed moderate increase in revenues[24]. Overall shift of interest towards data transmission follows current trend of smart-phone and multi-usage technologies demanding wider "package" of services than in the past. This shift in demand along with European technological development necessitate adequate regulatory framework on the international level. In the 2010 European Commission introduces intra-sector concept Europe 2020 setting major goals across different areas. Telecommunication sector was represented by regulatory framework Digital Agenda for Europe introducing main goals (across platforms and telecom sectors) achieved within this period. In the broadband sector three main targets have been stated:[25]

[24] 2,5% in period 2010 – 2011, ETNO annual report

[25] Digital Agenda for Europe targets. Available at: https://ec.europa.eu/digital-agenda/en/about-broadband

- achievement of overall availability of basic type broadband in Europe by 2013
- wider penetration of "next generation networks (NGN)" with minimum speed 30Mb/s by 2020
- achievement of at least 50% of households with high speed connection at least 100Mb/s

Also with respect to short time, expiring by the end of 2013, "standard broadband" adoption has noted highest level of fulfillment. Acknowledging of very wide definition of "standard broadband" performance of this platform is more than eloquently represented by DSL technology. Cable and satellite platform experienced highest level of coverage across Europe. Even though there is regional diversity (especially between Western Europe and Central and Eastern Europe) overall penetration reaches highest levels among all platforms. Within cable broadband the most dominant position has DSL with market share over 74%. Despite high level of adoption in recent years we have been experiencing gradual decline. Nevertheless, broadband situation analysis should not be reduced only to one branch of platforms. In order to provide objective and complex reports about broadband development, set of indicators were introduced to facilitate policy efficiency evaluation as well as status (with respect to broadband adoption) of member states in this area. To the major indicators displaying broadband status (eventually differentiated for mobile and cable broadband) in Europe belong penetration, coverage and development of speeds (high-speed connection) and network structure with respect to available platforms on the market.

4.3.1 Penetration

Although average level of broadband penetration experienced 1% increase from 27% in 2011 to 28,2% in July 2012, which sets EU above OECD average (25,9%). Interpretation of relatively low level of average penetration shall be careful especially with respect to number of countries indicating very contradicting trends. Main factor influencing fixed (wired) broadband adoption can be geographical predispositions as well as economical factors. In Northern (especially Scandinavian) countries mobile

broadband belongs to the most popular or the most used one (penetration 102,6% in Sweden and 91,2% Denmark, EC broadband access report), but the level of fixed platforms also stays above EU average. On the opposite side of broadband penetration survey countries can be found with levels around 20% like Poland, Bulgaria, Romania and surprisingly Slovakia. Argumentation illuminating this fact could be later date of EU accession in the case of Bulgaria and Romania as well as short time for implementation innovative process supported by structural funds of EU. Both explanations on the other side contradict the presence of Slovakia and Poland.

In order to make penetration situation even more complicated there is number of countries with high proportion of households which do not have broadband access. Illusion of low level of penetration in those states (e.g. Poland) has been "doubted" by presence of Germany with one of the highest level of penetration and share of 20% households without access.

Although the situation in the field of broadband penetration in EU is very sophisticated problem vulnerable to problem of "averages", there are no doubts about adoption of "basic or standard broadband" availability for "all EU household" by the end of 2013.

4.3.2 NGN and high speed broadband adoption

High level of adoption of DSL technologies and their availability stays in strong contrast with "next generation networks (NGN)" situation. Very brief statement of ITU defines them as:

"packet-based network able to provide services including Telecommunication Services and able to make use of multiple broadband, Quality of Service -enabled transport technologies and in which service-related functions are independent from underlying transport-related technologies, ITU definitions"[26]

Importance of adoption of NGN revolves around this definition. Technological progress in telecommunication facilities and wider usage of internet have stated requirement of development of new platforms which would facilitate transmission of

[26] ITU definition. Available at: http://www.itu.int/osg/spu/publications/birthofbroadband/faq.html

multiple - services in “packages”. Irrespective of mobile or wired technologies this trend is sometimes called “convergence trend in telecommunication technologies” and can be compared to transmission used in internet interconnection (data packages).

EC legislation refers to those technologies mostly with respect to increase in speed and adoption of new high-speed platforms. This has been reflected in strategy Europe 2020 as a target stating speed at least 30 Mb/s. Broader understanding of this target could revolve around wider application of non-DSL platforms eventually mobile broadband. In the mobile area it is adoption of 4G networks especially LTE[27] and LTE-advanced platforms facilitating both downstream and upstream speed above 100 Mb/s (potential maximum 1000 MB/s). According to Strategy Analytics global study from 2012 LTE technologies belong to the fastest growing branches compared to its forerunners from 2G and 3G networks (GSM, CDMA,…). Nevertheless in Europe it still belongs to emerging technologies with coverage around 8% (EC report on broadband coverage 2011) [12]. In the area of wired high-speed broadband technologies it has imprinted especially FTTx, Docsis 3.0 and VDSL (Very high bit rate DSL) platforms.

Despite high infrastructure requirements they offer ultra-fast transmission of data reaching 2,5 Gb/s and enable speed 100 Mb/s irrespective of symmetrical or asymmetrical structure. VDSL has been widely offered by majority of national operators since 2008 or 2009 but we can find countries which have overtaken this date (Iceland in 2002 or Germany in 2006). Currently VDSL’s EU coverage reaches 20% but it is focused on urban areas. FTTx platform is represented by FTTP and FTTH types but its performance on EU coverage is far below VDSL and reaches only half of its values.

Importance of NGN adoption is accompanied by its positive influence on level of competitiveness and potential impact on GDP, where it is expected that “10% more households connected to high-speed broadband can generate up to 1.5% higher

[27] LTE - Long Term Evolution - high speed mobile internet connection formally on the basis of 3G networks, but with advanced modifications have already achieved status of 4G

GDP"[28]. Relationship between economic performance and NGN was also important area of interest for number of studies.

D.Strusani, D. Vincent, D. Kovo (2012) [29] have found out that "mobile data usage per 3G connection has a positive effect on the growth rate of GDP per capita" and further discussed linearity of this relationship. Studies weren't restricted only on GDP indicators Robert J. Shapiro, Kevin A. Hassett in 2012 studied employments effect of xG networks adoption on US market and have found out that adoption of 4G technology has positive effect on job creation which would allow for more than 230 thousand new jobs within a year (under specific conditions).

In order to intensify NGN implementation in Europe has EC recently introduced new strategy for supporting and financing infrastructure projects for period 2014 – 2020 Connecting Europe Facility (CEF). Budget around 9,2 billion EUR is considered for broadband infrastructure which would enable smoothest NGN adoption. Current status of NGN is only 16% of wired broadband accompanied by low coverage 50,1%.

4.3.3 Rural areas and broadband coverage

Acknowledging heterogeneity of national environments with respect to different stages of technological adoption, infrastructure coverage and economical development, we observe that majority of European countries have fulfilled availability of broadband "for all" in time by achievement of more than 80% coverage or higher. Despite existence of appropriate infrastructure coverage in the most of regional areas there can be seen gap between high population density and low density (rural) areas. This trend is the most visible within DSL coverage where gap reaches almost 17% (Figure 4.2). According to Study on broadband coverage issued by EC in 2012 the most of European countries have been able to accomplish 80% of "cable" coverage. But there are 8 countries which level lacks behind EU average

[28] Connecting Europe facilities (2012), EC report, Available at: https://ec.europa.eu/digital-agenda/sites/digital-agenda/files/cef.pdf

[29] *The Economic Impact of Next-Generation Mobile Services: How 3G Connections and the Use of Mobile Data Impact GDP Growth. Available at:* http://www3.weforum.org/docs/GITR/2013/GITR_Chapter1.6_2013.pdf

(78,4%). Partial explanation would be stated by later entrance of most post-communist countries into EU and therefore slower adoption accompanied by economical "catching up". The most interesting exception in this group is Germany with level below 60%. Nevertheless cable broadband coverage is more than compensated by high penetration of 4G (LTE) networks witch consequently contribute to higher level of adoption of NGN.

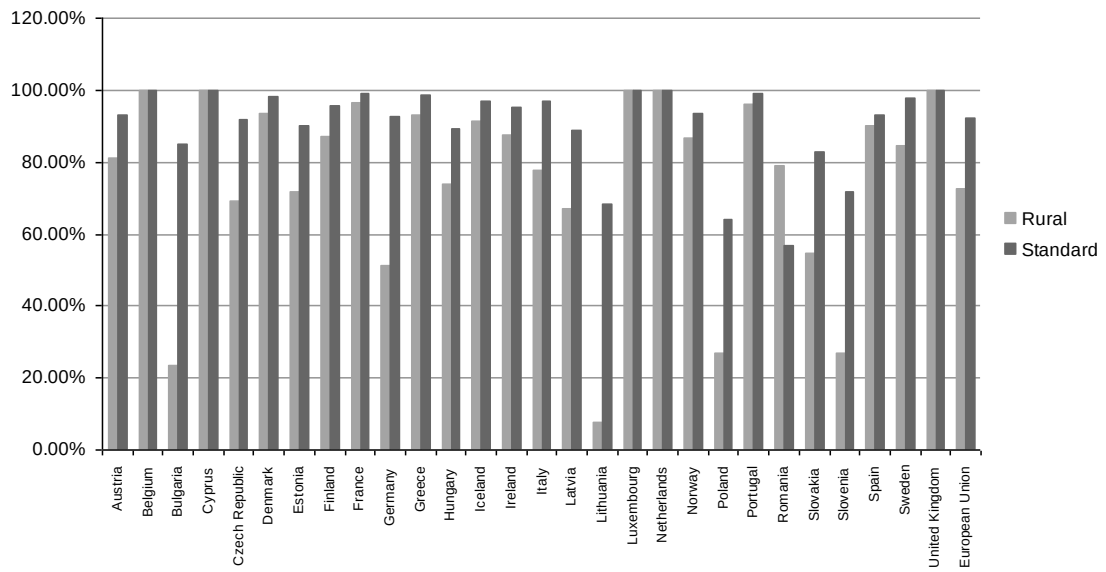

Figure 4.2: EU rural areas DSL coverage

Source: EC report on Broadband coverage in Europe in 2011 (2012)

4.3.4 Czech Republic

Market specification in the Czech Republic indicates slightly monopolistic structure with very low number if incumbent operators. In the year 2011 the market share of leading operator has reached 40%. This is reflected by strong effect on price creation and speed range being offered. In within the speed range 12 – 30 Mb/s Czech Republic belongs to the most expensive countries in category of bundles a service. Position in single-service category remains above average [30]. On the other

[30] for details see EC Report: Broadband lines in the EU: situation at 1 July 2012

side 65,6%[31] share of new entrants in fixed broadband lines shifts Czech Republic to the highest positions in EU.

Adoption of DSL technological reflects current EU trend. Major specification of market is characterized by large proportion of Wireless technologies (Wi-Fi connection) and their general popularity. It is supported by almost 50% penetration of mobile broadband. High Wi-Fi adoption is also reflected in 62% of non-DSL technologies. ADSL belong to the leading segment among wired platforms. Nevertheless, price competition in this case favors wireless technologies. Market is consisted of large number of very small (local) providers, offering high symmetrical speed for lower price.

Development of NGN is relatively slow and in the majority of cases remains in the project scheme. The most promising area in NGN appears to be implementation of LTE networks. In June 2012 first local project of LTE (of 4th generation) networks was launched by O2. Since this "pilot project" LTE coverage has not significantly increased. O2 announced further widening, but only in urban area (just Prague). Subsequent or broader installation of LTE is condition of spectrum auction announced on the beginning of 2013 but it was cancelled because of inadequate protraction.

4.4 Regulatory challenges

High DSL coverage accompanied by very low penetration of extra high speed broadband platforms and disparity between high and low population density areas makes warrant argument for proper regulatory improvement. There has been increasing need to invest into new infrastructures and promote development of new generation and platforms which would, along with intensification of inter- platform competition, increase end-user welfare and smoothen gaps among areas. One of the new platforms, which have already partly overbridged density gap, is mobile broadband technology. Lower infrastructure requirements and wider coverage after implementation have been compensated by faster high-speed broadband

[31] EC Report (2011): *Telecommunication Market and Regulatory Developments-Czech Republic* [online] 2011[cit.2013-05-03] Available at EC web: http://ec.europa.eu/digital-agenda/sites/digital-agenda/files/CZ_Country_Chapter_17th_Report_0.pdf

development. Evolution of 3G and 4G networks represents this trend. Nevertheless, necessity of network development generates cost-pressures and influences general distribution of operators on the market: are we able to achieve actually achieve competitive telecommunication market and simultaneous preservation of innovation?

Achievement of multiple targets indicating contradicting tendencies may mean unsolvable trade-off for EC and NRAs. Possible solution and study of this problem leads to theoretical concept merging maximizing of end-user welfare as well as incentives to infrastructure investments: Static and dynamic efficiency of sectors

4.5 Static and dynamic efficiency of sector

Precondition of high technological requirements in the area of network or infrastructure development determined monopolistic tendencies in telecommunication sector and its need to support competition through regulatory interventions. Nevertheless, the recent development along with gradual sector liberalization and "entrants" oriented regulation (asymmetrical regulation in voice telephony) allowed for shift towards competitive environment and increase in number of service providers. Achievement of reduction in monopolistic structure and shift towards price efficiency facilitated issuing of regulations creating suitable conditions for innovation. The main area of interest has became innovation and sustainability of current and new networks infrastructure which has intensified trade-off between static and dynamic regulations of sector and (in)compatibilities.

Static efficiency is connected with elimination of monopolistic structures and price efficiency attained by reduction of production cost and decrease of final price (which would in full model equals production costs). Dynamic efficiency should support incentives and create innovation oriented environment especially in the area of development of alternative networks.

Regulators trade-off dilemma revolves around mutual interconnection of both parts. Reduction of production costs have been determined by application economies of scale principle and existence of technologically appropriate networks with high coverage. Attainment of this target requires high infrastructure costs and innovation oriented expenditures (dynamic efficiency), which favors either monopole structure

or high end-user prices. Both results required for dynamic efficiency achievement are in strong opposition with static efficiency.

4.6 Ladder of investment

Trade-off arising from simultaneous effort to achieve both static and dynamic efficiency leaded endeavors to construct simple model which would be applicable in various countries and which would gradually enable surge of infrastructure and development investments. In recent years has this need has become more relevant with promotion of NGN and their penetration into EU countries. Main problem arising with application of appropriate regulation measures revolves around existence of two forms of competition and their attainability: service and facility based competition. "Service-based" competition usually connected to short-run period opposed "facility-based" competition accomplished in the long run. Time dimension dilemma is accompanied by conflicting nature of both forms. Trade- off between those two types denotes similarities with static and dynamic efficiency, but opposed to them gained in the telecommunication sector wide attention and leaded to origination of "ladder of investment" (LoI) approach. Although the name was initially introduced in 2006 by Cave [18] in the study "Encouraging infrastructure competition via ladder of investments", main thoughts could be noticed in the earlier works of Cave dated to 2001. Generally the concept can be described as follows:

"A regulatory approach on the one way access which ensures that service-based entry and facility-based entry are complements in promoting competition." (Bourreau, Dogan, Manant, 2009) [17]

In order to propose deepened insight into this concept we have to explain disposition of facility and service based competition. Service-based competition presumes competition on the horizontal level, where price pressures in the existence of multiple service providers occurs. In this stage we may meet with conflict between incumbents and new entrants, especially with respect to superior position of incumbents. On the other side facility based competition, as the name evoke, presume innovation process accompanied with infrastructure innovation (especially from the new entrants' side) and possible introduction of new technologies (recently installation of NGN). Potential problem with facility-based competition is determined

by extremely high cost connected with infrastructure contraction/innovation as well as with historically determined dominant incumbents' position (with large market share).

Ladder of investment approach presume solution of dilemma by setting appropriate regulation measures which would make service-based competition "stepping stone" for facility-based competition. Instrument used for this purpose could be access regulation focused in new entrants' position on the market. Dominant incumbents' position on the market and ownership of access infrastructure makes entrant impossible to gain simultaneously subscription base, market position and network access. Because of extremely high infrastructure costs which would reduce potential profits and, in the long run, avert product and service innovations, shared access to incumbents' infrastructure has been applied. By forming convenient conditions it is enabled to entrant benefit from shared network access. Entrant, placed into inferior position because of dominant incumbents market share, gradually builds customer base and during the time gains reputation by awareness of customers about entrant services and their qualities. Accumulation of profit, facilitated by this process, encourages entrant climb to the next step of ladder. By following stages (including mostly service based competition) gained is experience in the field and strengthening position on the market. Finally gradual saving from deferred infrastructure investment allows entrant to postpone innovation process into the level (final stage of ladder) where resources are accumulated (facility-based competition).

Crucial stage of whole process hides in setting measures which don't protract service-based phase and simultaneous neutralization of "replacement effect". Impact of this effect is supported by historically monopolistic nature of telecommunication sector, where incentives into innovation are drastically lowered compared to competitive company (holding other factors fixed). This process refers to replacing the competitive company through innovation. Shortening of service-based phase for entrant is key factor for additional incentive which lifts company to another stage. Excessive protraction may in the middle and long run discourage entrant to climb the ladder, because of benefit arising from low costs of accessing infrastructure and from advantageous position. Similar effect could be generated by asymmetric information distribution favoring entrants. In order to avoid possible externalities arising from this

implication Cave (2006) [18] suggests setting series of gradually increasing access charges or eventually establishing a "sunset clause" on a time basis after which would be access to level deregulated and position of entrant narrowed towards incumbent.

Contradicting effects of LoI application generated discussions about specification of number of steps in the "imaginary" ladder (Herrera-González, 2011)[32] or about validity of this approach globally or in connection with various geographical regions. Verada (2007)[33] studied problems of later entering the ladder, in the upper stages of service based or facility based competition. Selection of such regulatory measure, which would reflect network and equipment facilities among new entrant operator, belongs to the key challenges for successful application LoI theory. Reason is simple: should such operator "climb the ladder" from the initial stage or should be allowed joining upper stages without proceeding to the concept of "burning the lower rungs". One of possible solutions might be setting appropriate access charges. Burreau and Dogan (2005) [20] focused on this case in connection with investment incentives. Lowering (increasing) access process might have negative (positive) effect on investment creation. In the later work Burreau together with Dogan and Manant (2009) [17] wrote a comprehensive critique on the whole concept of ladder of investments.

Despite different views about validity and applicability of ladder of investment approach this concept has acquired strong influence at the international level in the U.S.A. as well as at the European level. First mention about acknowledgment of this approach is dated to 2003 (approved in 2004) by ERG as a position paper about "remedies in regulatory framework" where LoI recommended if

",there is sufficient certainty that efficient replication is possible, NRAs may signal in their reviews that they view some remedies as bridging a gap and/or consider

[32] Herrera-González, Fernando (2011) : *How many ladders of investment?,* Regulatory, economic and policy issue, 18 - 21 September, 201, Innovative ICT Applications – Emerging Regulatory, Available at: http://hdl.handle.net/10419/52148

[33] Verada J. (2007): *Access regulation under asymmetric information about demand*,. Lisboa, Novemtber 2007. Working paper series from University Nova de Lisboa. FEUNL Working Paper No. 525. Available at SSRN: http://ssrn.com/abstract=1079967

adopting dynamic access pricing rules in order to promote investments." (ERG (03) 30rev1[34]

In further studies focused on broadband market we may find various conclusions varying according to position of regulatory bodies and methods used (contradicting positions of ETNO and ECTA). Nevertheless, LoI concept has been implemented by majority of European NRAs and this concept influenced mainstream understanding of regulatory framework. Among instruments utilized to achieve top of the ladder (and implemented by the most of EU member states) has become implementation of access based competition and adoption of local loop unbundling on broadband services

Alternative way of understanding concept revolves around its application on product cycle theory (Figure 4.3). There is a function of penetration (in other concepts sales or volume) and time which can be divided into three parts: development stage, maturity and decline stage. Gradual life-cycle of new service then proceeds from innovation and development of this technology (product), connected to dynamic efficiency (Midttun and Gautesen 2006)[35]. Further there is an introduction on the market and static efficiency attainment along with increasing penetration and finally maturity stage followed by withdraw from this technology toward its successor.

[34] ERG (03) 30: ERG Common Position on the approach to Appropriate remedies in the new regulatory framework, 2004, page 13

[35]Midttun, A., Gautesen, K., Gjølberg, M. (2006): *The political economy of CSR in Western Europe*. [online] 2006 [cit 20313-04-23]. Corporate Governance - The International Journal of Business in Society, 6(4), 369–385

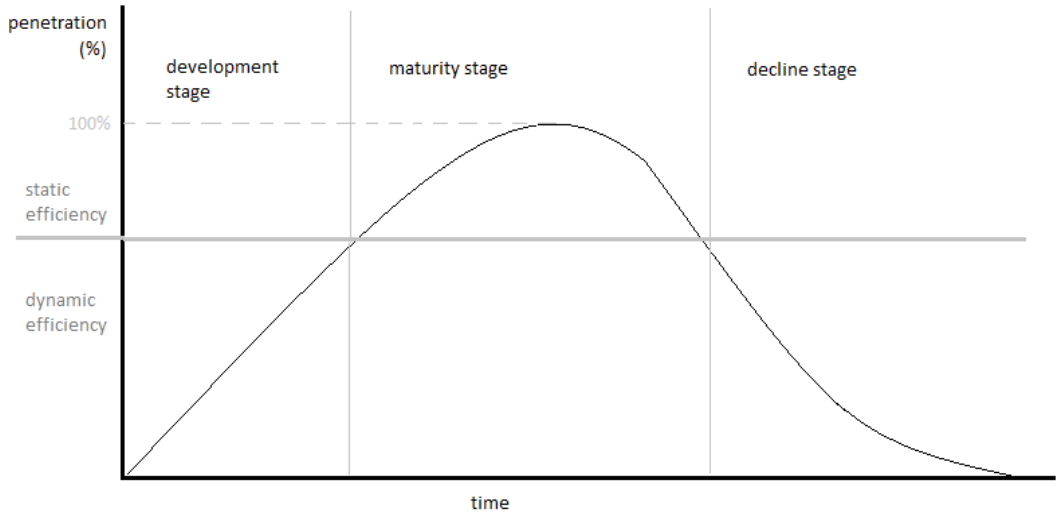

Figure 4.3: Adapted technology (product) life cycle graph

Source: author

Voice telephony has recently reached maturity stage represented by high penetration (120%, European mobile industry observatory 2011, 2012) and adoption of static efficiency regulation tendencies especially in the area of roaming and MTR regulation, experiencing decline in revenues which would proceed to 1,6 billion EUR in 2017, more than half of 2007 3,1 billion EUR (Analysis Mason, 2012)[36] indicates fulfilling of this stage. Gradual transformation is expected into development stage represented by convergence tendencies in the sector and accession of 4G and mobile broadband networks.

Theoretically static-dynamic efficiency concept can be applied to any sector in economy. Therefore we can find many studies oriented on structure of this concept and its possible solution. Distaso, Lupi and Manenti (2009) [15] describe contradiction tendencies of concept in European market along with application of ladder of investment and local loop unbundling approach as a possible solution (see ladder of investments in following section) or US market oriented analysis of short

[36]Analysis Mason statistic, 2012: Available at: http://www.analysysmason.com/About-Us/News/Insight/Mobile-operators-CEE-forecast-Nov2012/#.UYo5T6K-2So

and long term perspective (Bauer, Bohlin, 2008)[37]. Nevertheless, major national regulatory bodies (including Europe) acknowledge attainment of dynamic efficiency as major target and the most challenging areas (especially in the broadband sector).

4.7 Local loop unbundling

Among crucial objectives stated by Cave (2004) in the initial concept preceding LoI approach is determination of "replicability" of assets in the telecommunication market. Categorization corresponds to EC recommendation stating reduction non-transitory barriers to entry to minimum level. Accordingly its identification is more than helpful in future expectation about competition, development and cost demands. Also the identification of stages has the leading role, where European countries are located.

In compliance with those factors Cave distinguishes three major types of assets: easily replicable, non replicable and intermediate category located between them. In order to generate advantageous conditions for entrants' and lifts to help the "climb the ladder" regulator should put priority on strengthening and defining „replicability" of the most of assets used during this process. Telecommunication infrastructure pertains to the key assets. With respect to scarcity of this factor and extremely high initial infrastructure cost (especially for new entrant), network access belongs to the non-replicable access.

Promotion of infrastructure competition as effective objective necessary for LoI application was preceded by requirement of unbundling local loops. In 2000 EC approved access directive 2887/2000/EC on unbundling local loops in which it was acknowledged that:

"high cost of duplicating the local access infrastructure is ruling out new market entrants. This is affecting the level of competition, which the Regulation is intended to increase by offering unbundled access to the local loop, i.e. by enabling new competitors to offer high bit-rate data transmission services for continuous Internet

[37] Bauer, Johannes M.; Bohlin, Erik (2008): *From static to dynamic regulation: Recent developments in US telecommunications policy*, Intereconomics, ISSN 0020-5346, Vol. 43, Iss. 1, pp. 38-50,

access and for multimedia applications based on digital subscriber line technology as well as voice telephony services."[13]

Under current EC regulatory framework implemented in the national legislation bodies we can observe three forms of local loop unbundling: Bitstream access, shared access and full local loop unbundling.[38]

Bitstream access revolves (in recent years) around application of fiber connections, especially xDSL technologies (ADSL). Incumbent innovates his own network by adding new high speed technology (ADSL broadband) to already existing local access network in order to provide wider range of services beside voice telephony. After installation of equipment between local exchanger and final customer it is made available to the third party operators by guarantying access in distinct bandwidth. This access is enabled under a certain provision but incumbent holds full control over the line and remains the only authorized person entitled to add new platform or equipment into interconnection chain. Bitstream access has been recognized in recent years to be the key step for allowing new entrants to access local network with using incumbents' equipment (high speed modems etc.) and to intensify competition among broadband providers.

In the shared access framework incumbent controls whole cooper line, both parts of voice and broadband services. Entrant is entitled to install splitter to shared part of local loop and to lease part of spectrum bandwidth (high frequency spectrum for **non voice** services). Opposed to bitstream access entrant range of provided services is not designated to broadband and is allowed to add equipment into local chain (ADSL modems). Nevertheless, voice and broadband streams are divided by local splitter which allows incumbent to provide voice services to entrants customers indirectly, whereas entrants' transmission of broadband services proceed directly through entrants' network.

[38] Bitstream access has been acknowledged only in limited number of countries in EU

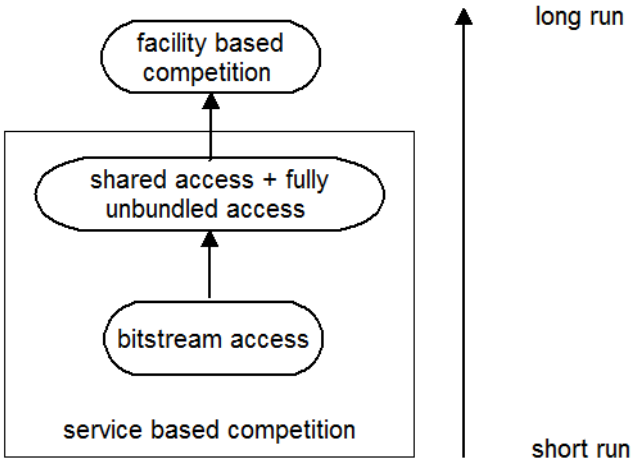

Figure 4.4: LoI application on LLU

Source: author and Serdajevic, Goran, (2012)

Finally fully unbundled access shift control of whole network from incumbent to entrant. It is attained by direct connection of entrants' equipments to the incumbents' local chain. This allows every competitor usage of all accesses without need to interconnection through incumbents' equipment. Both operators than obtain full control over the range of services provided whereas incumbent receive all payments from entrant for leased networks and spectrum bandwidth. Incumbent maintains the control over cooper pair by leasing them to entrant and entrant is allowed to provide voice and broadband services and control the cooper pair (same as incumbent). Technological requirements states restrictions to full unbundling to new technologies allowing multiple service usage (see section broadband typology).

Gradual adoption of facility and network infrastructure then facilitates attainment of recognition, market position and gradual infrastructure or innovation investment accumulation. With respect to rate at which are those factors rented and controlled it can be generated gradual "ladder" consisting of all three forms of LLU accesses. Time horizon in this concept might consist of selective attainment firstly service based and later facility based competition based on accesses characteristics described above. Overall synthesis of both concepts including this set of relationships might be described by simple diagram Figure 4.4.

Application of random form of local loop unbundling types generates high level of infrastructure coverage requirements to incumbent in order to provide sufficient range of accesses for new entrants. Therefore existence of "highly-infrastructured" operators prerequisites local loop unbundling implementation.

4.8 LLU and LoI synthesis consequences

Despite contradicting views about empirical validity of LoI hypothesis it might be acknowledged that LLU in all their forms tends to generate forces contributing to competitive environment creation by allowing new entrants to lower maintenance costs, gained recognition, widened customer basis and postponing investments into infrastructure into longer period of time.

Among problems connected to LoI and LLU application expected duration of each stage shall be mentioned. Lowering of initial network costs for longer period have shown discouraging forces to move up to the next stage and in the end contributed to operators' market share concentration. For this purpose it is suitable to either set gradually increasing charges for networks access (in the bitstream access) or provide date (eventually period) after which advantageous position is entitled by bitstream, shared or fully unbundled access abolished. On the other side this effect can be unpremeditatedly attained by increasing cost for LLU lines in the course of time. Nevertheless, disagreements about synthesis of LoI and LLU approaches are not restricted only to arguments about time dimension of each stage.

In spite of uncertainty about validity of all implication stated by LoI and LLU synthesis it was recognized by majority of NRAs and in the context of EC strategy Europe 2020. Eventual long term validation of approach on national or international levels may set future stages of ladder by demand of broadband development (NGN) and expansion of mobile platforms or eventual increase in speed (higher penetration of high speed broadband).

5 LOI and LLU synthesis: empirical evidence

5.1 Literature review and hypothesis statement

In economical literature we can find numerous works, reflecting contradicting views on ladder of investment theory or local loop unbundling. Their synthesis and disputes about empirical evidence of their validity has intensified intentions for finding supporting evidence. Cave, as the first author covering ladder of investment problems, belongs to the most productive economist focusing on this area. His works initiated in 2001 (in connection with LoI) contain whole description of implementation including "step" manual (2004) or connection to NGNs. To the broadest synthesis belongs study of Disato, Lupi and Manenti (2009) [15], where they connected three different approaches concept LoI, LLU and static and Dogan and Manant (2009) [17]. Their "Critical review of the ladder of investment approach" endeavors to highlight possible shortcoming arising from model application. To the other studies focusing on impact LLU interaction with broadband sector belong Bouckaert, Dijk and Verboven [21] who analyzed impact of inter-platform, facility and service based intra platform competition on broadband penetration rate. Among factors which were taken into consideration there was adoption of local loop unbundling forms. Results covering 27 European countries proved only partially positive relationship between them. On the other side, Sraer in 2008[39] studied LLU on penetration applied on the French datasets. Findings then included unbundling of at least one operator which led to increase in penetration rate by almost 4%. In more general inclusion of another works focused on this problem it appears that adoption of LLU concept leads to increase in competition pressures in the short run and evidenced supporting positive impact can be found on the facility based competition in the long run at least on the national or regional levels (Distato, Lupi, Manenti, 2009) [15].

[39] Sraer, David (2008): *Local Loop Unbundling and Broadband Penetration*.2008 [online] November 12 2008. [cit. 2013-04-24]. Available at Princeton web: http://www.princeton.edu/~dsraer/arcep_04.pdf

Fact that both concepts we incorporated into European regulatory frameworks gives us sufficient datasets for evaluation of both theories. Our study will focus on application of this approach on broadband segment. As major objects of interest we have stated number of unbundled lines (according to type) and their interaction with lines built by new entrants. Our hypothesis is that there will be positive relationship between shared and fully unbundled access. As a supporting model for validity of LoI theory we expect to find evidence about "burning lower stages" during "climbing the ladder". Finally we will test effect of prices for unbundled access on infrastructure investment (studied by Burreau and Dogan (2005), [20]), where we expect positive sign.

5.2 Data description

In our study we would like to focus on European broadband development in the context of LoI approach and implementation of LLU concept. For this purpose we have used panel data of 17 European states. Distribution of courtiers covers both economically strong and weaker regions. Regarding broadband sector factors there is sufficiently heterogeneous range of states including new member states which contribute to quality of model. Concerns about possible outliers leaded us to exclusion of Greece and Cyprus. Further restriction has to be made with respect of data shortage and non-existence of datasets because of later accession to EU. Our study covers period of 7 years from 2004 to 2010. Choice of time period may include impacts of financial crisis on economic variables, nevertheless for proposes of our study it would be convenient to include the largest period possible covering different economical stages and developments. Collected datasets include variables describing status of local loop unbundling in the selected countries and other, control, variables from describing economical status of each country.

Our variables can be divided into two groups. In the first group we study situation on the service-based entry, where entrants are partly or fully dependent on infrastructure and equipment owned by incumbent and by whom those services are (facilities) leased. Number of installed bitstream access lines *(ln_bitstream)* could (thanks usual usage and definition) fulfill this statement. We can found studies, which includes to this group resale access, nevertheless, for our purpose this was variable

insufficiently covered by available statistics. Second group consisting of second stage service based competition represents number of fully unbundled access lines *(ln_fullull)* and shared access lines *(shared)*, where we find larger proportion of entrants' contribution to the network either by adding an equipment (ADSL modems) or general control over the network. Regarding facility based competition as and superior stage to the previous one we have decided to use number on new entrants' lines *(ln_newentrline)* from which we have excluded "Wi-Fi" accesses. Reason lies in data availability for such variable. With respect to infrastructure investments being expected from entrant on the upper stage of "ladder" we expect this variable to be sufficiently representative. Among other variables, which we assume have impact on our model, there is a number of years since LLU introduction in each country *(LLU_years)*, which may positively contribute to the new infrastructure deployment. Finally we would like to include monthly average cost for fully unbundled access *(ln_fullull_p)* and study its possible impact on facility-based competition.

Additionally we have collected set of control variables which would increase quality of studied model. GDP per capita growth *(GDPg)* would reflect current economical situation of each country. Broadband penetration *(bb_pen)* describes deployment of studied technologies and their adoption. Covering urbanization rate has been substituted by proportion of population, population living in rural (sparsely populated) areas *(rur_den)*, where general lower broadband reception is expected. Percentage of people using internet daily *(i_daily)* would reflect level of internet integration into common life. In order to describe market structure of selected states we use market share *(ms)* of leading operator as a control variable. Following table delineates general distribution of all variables as well as sources used for this purpose. (Appendix B: Table B.2 correlation analysis and Table B.3 summary statistics)

Variable name	*Description*	*Source*
ln_newentline	Number of new entrants' lines	COCOM reports on Broadband access
ln_fullull	Number of fully unbundled lines	COCOM reports on Broadband access
ln_shared	Number of shared access lines	COCOM reports on Broadband access
ln_bitstrem	Number of bitstream lines	COCOM reports on Broadband access
GDPg	GDP growth rate	EUROSTAT
rur_den	Proportion of population living in rural (sparsely) populated areas	EUROSTAT
i_daily	Proportion of population using internet daily	EUROSTAT
ms	Market share of leading operator	EUROSTAT
bb_pen	Broadband penetration rate	OECD
ln_fullull_p	Monthly average price per fully unbundled access	COCOM reports on Broadband access
LLU_years	Years since LLU adoption	

Table 5.1: Dataset description

Source: author, Eurostat, OECD statistics and [23]

5.3 Methodology framework

Relationship between service and facility based competition has been widely analyzed by number on models mostly concentrated on panel data usage. With respect contradicting result of those analyses and uncertainty about validity and impacts of model we have decided to construct model describing short run effect of ladder of investment theory applied on broadband sector with simultaneous application of local loop unbundling concept. Both approaches have been mandatorily or optionally implemented into majority of NRAs strategies, which gives us sufficient space for discussion of results. Main theoretical concept of our model will come out from Garrone, Zaccagnino, Milanos' study from 2012 [16] focusing of

on similar problem, nevertheless we have modified variable selection. Contribution of our approach includes covering of longer period (2004 – 2010) which would help to describe LLU and LoI theory adoption. Both approaches (LLU and LoI) have been known since the beginning of millennium, nevertheless gradual implementation and recognition among national regulatory bodies might last longer time (sometimes till 2006)[40]. Further we will provide deeper regional analysis in order to cover eventual differences. Moreover modification of variables by inclusion of general broadband penetration and frequency of internet usage and price impact of fully unbundled access would lead to more explaining results.

Model 1: OLS regression

Model 2: Fixed and Random Effect estimation

Model 3: Adjustment of a model (tests for serial correlation ect.)

This intention is to be achieved by application of simple pooled OLS method covering robustness. In order to improve interpretation of constructed model we have used logarithmic forms of all variables connected to number of lines. Further, we will apply panel data methods (including fixed and random effect models) and decide for the most suitable form of model. After final adjustment we will test our model for possible presence of serial correlation of errors and in the case of their presence we will apply method of FGLS. In order to provide final analysis of magnitude within variables we discuss results by using meta-analysis based on national statistics.

[40] Slovak Republic and Switzerland officially adopted LLU approach in 2006

5.4 Model estimation and discussion

With respect to previous section and concept of ladder of investment theory we have constructed theoretical concept of estimated model revolving about major framework covering just base variables.

$$\ln newentrline = \beta_0 + \beta_1 . \ln fullull + \beta_2 . \ln shared + \beta_3 \ln bitstream + e$$

Application of OLS methods and addition of more controlling variables as well as price effects of cost of fully unbundled lines give us initial illustration about significance of variables and information capacity. Analysis of significance of selected variables in this stage resulted in reduction of number of variables used. We have decided to remove *LLU_years* (Table 5.2). Insignificance of singular variables is compensated by joint significance of whole model as well as sufficient R-squared 41,6%. Signs of majority of variables correspond (apart from *ln_fullull_p*) with our expectations, however construction of this model has only information purpose and its interpretation may lead to misleading results. With respect to panel data characteristics we have been aware of presence of unobserved effect (either fixed or random). Neglecting this fact might lead to "unobserved heterogeneity" and possible bias in estimates. Therefore we apply advanced panel data methods of fixed and random effect estimation (Table 5.3). In order to decide about nature of this unobserved effect we perform Hausman test for consistency of FE and RE models with null hypothesis: FE and RE estimators are consistent. Obtained results P- value of χ^2 distribution 41,91% and statistic equal to 9.20 speaks for rejection of null hypothesis. In this case only fixed effect model contains consistent estimators. Further we test presence of serial correlation of errors. F statistic equals to 243.34 and p- value 0.000 points to rejection of null hypothesis: no serial correlation on 1% level of significance. Solutions to this problem is performed by application of FGLS (feasible GLS) method for presence of AR (1) autocorrelation and heteroscedasticity. [11].

	(OLS)	
ln_newentline	***Coef..***	***Std.Err***
ln_fullull	0.0951	(0. 071)
ln_shared	0.0632	(-0.038)
ln_bitstrem	0.1852***	(-0.064)
GDPg	-2.597	(-7.457)
rur_den	0.6665	(-0.838)
i_daily	0.8111	(-1.063)
ms	-7.109***	(-1.861)
bb_pen	0.378	(-2.315)
ln_fullull_p	0.6504	(-0.891)
_cons	9.596***	(-2.866)
Observations	114	
F(9, 104)	15.36	
Prob > F	0	
R-squared	0.4161	

Table 5.2: OLS model estimation

Source: author's computations.

	(FE)		*(RE)*		*(FGLS)*	
ln_newentline	***Coef..***	***Std.Err***	***Coef..***	***Std.Err***	***Coef..***	***Std.Err***
ln_fullull	-.14356***	(-0.075)	-0.108	(-0.072)	0.06495***	(-0.026)
ln_shared	0.0259	(-0.049)	0.0362	(-0.047)	0.0916***	(-0.035)
ln_bitstrem	-0.0162	(-0.048)	0.0014	(-0.047)	0.1283***	(-0.034)
GDPg	0.5663	(-1.677)	0.4936	(-1.671)	2.6417***	(-0.942)
rur_den	0.4921	(-0.298)	0.4942	(-0.298)	0.0562	(-0.18)
i_daily	4.4183***	(-1.241)	3.7702***	(-1.177)	0.7248	(-0.747)
ms	-3.487	(-1.735)	-4.086***	(-1.694)	-6.040***	(-1.161)
bb_pen	2.2447	(-1.579)	2.1418	(-1.531)	1.798***	(-0.98)
ln_fullull_p	-1.2656	(-0.607)	-1.2248	(-0.585)	-0.348***	(-0.346)
_cons	16.167***	(-2.044)	15.917***	(-2.04)	12.41***	(-1.281)
Observations		114		114		114
R-squared		0.5978		0.5943		
F(9, 88)		14.59				
F(5, 141)						
Prob > F		0				
Wald χ^2				128.81		225.26
Prob > χ^2				0		0
Corr (u_i, Xb)		-0.3687		0 (assumed)		

*** P>|t| = 0.000

Table 5.3: Advanced panel data methods application

Source: author's computations.

Despite relatively high information capacity of our model we have decided to reduce shortcomings arising from high p-values connected with *rur_den* by removing this variable. Obtained results indicate singular and joint significance in all

fundamental variables. Formal construction of finalized model contains adjustments which prevent possible misleading interpretation caused by panel nature of dataset.

	(FGLS)	
ln_newentline	***Coef..***	***Std.Err***
ln_fullull	.0575783***	(-0.0198)
ln_shared	.1257268***	(-0.0374)
ln_bitstrem	.10910***	(-0.032)
GDPg	3.1402***	(-0.6762)
i_daily	0.561064	(-0.716)
ms	-5.2558***	(-1.1577)
bb_pen	1.9944***	(-0.9356)
ln_fullull_p	-0.2073***	(-0.2752)
_cons	11.733***	(-1.1015)
Observations		114
F(9, 104)		276.38
Prob > F		0

*** P>|t| = 0.000

Table 5.4: Final FGLS model

Source: author's computations.

In the final model we might see direct impact of number of fully unbundled lines on number new entrants' lines. Estimation, stated by this model, indicates that increase of fully unbundled lines by 1% generate increase in new entrants' lines by 5%. This relationship fully corresponds with ladder of investment theory or with the last stage of ladder, as the case may be. Fully unbundled lines, by their definition, require high proportion of entrants' participation in the area of ownership of facilities (ADSL modems) or control over local loop. Charges, generated by leasing this type of access, therefore should have impact on entrants' investment accumulation and

network infrastructure construction. To other motivations might belong efforts to provide different range of services or provide faster speeds than incumbent and therefore widened customers base. Therefore setting appropriate access payments acquires to be key factor influencing not only speed of this process but also fundamental realization. Existence of this statement was supported by researches of Burreau and Dogan (2005) [20]. It has been also analyzed by our model, where average monthly charges per fully unbundled loop tend have **negative** impact (20%) on new entrant line accrual. High access payments, hence, might in our case discourage entrants to move up on the "ladder" to more independent positions requiring larger proportion of services provided by them selves[41]. Final confirmation of general validity of this relationship would required further studies on the "lower stages of the ladder" especially along with shared and bitstream accesses. Realization of this analysis is limited by availability of sources on the European level.

Situation connected with shared access lines denotes similar effect as fully unbundled access. 12% increase in entrants' lines shows greater effect than fully unbundled access. Similar classification of shares access, close to the upper part of "ladder" implies convergence to the facility based competition, but on the lower level than fully unbundled access. Entrants could be in this stage less motivated to "skip" one stage because of higher dependence on incumbents' infrastructure and equipments. Supporting fact for final confirmation of our results would be inclusion of monthly average payments per shared access. This intention was defeated by insufficiency of available datasets. We leave in this area space for further research. Similar situation can be observed in the case of bitstream access, but its magnitude is not stronger than in preceding case (10,9%). Study of mutual relationship between each two LLU accesses mentioned above showed positive sign (Apendix B: Table B.4). Question is whether lower stages actually contribute to shift towards facility based competition and "burning lower stage" or whether it is simple substitution by new entrants placed on the lower stage. Both cases could speak in favor of "ladder of investment" theory nevertheless nature of this problem should be studied in further researches. Reason is that there might be possibility of widening each stage without "moving up" on the ladder.

[41] in connection with shared and fully unbundled accesses need to provide own facilities (ADSL modems ect.) and further control over network

Regarding controlling variables we have found negative relationship between magnitude of incumbents' market share and infrastructure investments. This is supported by hypothesis that large incumbents market share discourages innovation process and infrastructure investments (coefficient -5.256). Other control variables connected to the broadband adoption and economical performance: broadband penetration, proportion of people using internet daily and GDP per capita growth confirmed expected signs of effect. Economic growth tends to generate favorable conditions for infrastructure investments as well as general broadband adoption, which showed to have stimulation effect on number of entrants lines. Overall low level of p-values (among all independent variables) contributes to the information capacity of model.

In the deeper analysis, covering country specification, we have found increasing trend in number of entrants' line in studied period. Despite short term decline in 2009 there has been experienced fast recovery. There were no indications of divergence between Western, Central and Eastern European countries. Nevertheless, further time series analysis on the national levels (CEE countries) indicated very contradicting results with respect to relationship between the number of unbundled lines and new entrants lines.[42] Results vary on the on both country and LLU access levels. On the other side negative effect has been seen in connection with access payments for fully unbundled accesses which does not confirm (on this level) theory about motivators for "moving up" the ladder. Limitation of this interpretation is inclusion of only two countries belonging to this area and relatively short time series used. In the further research it would be challenging to analyze presence of different results between them (especially because of presence of new member states).

Importance of our findings and partial confirmation of validity of LoI and LLU theory and their mutual interaction might generate important precedent in the area of NGN implementation as a possible next stage of "ladder". Along with European

[42] Time series econometric analysis was provided on two countries from Central and Eastern Europe: Hungary and Czech Republic by application time series regression methods (Wooldrige, 2002, [11]) with dependent variable "number of new entrant lines" and independent variables describing forms of LLU and prices for fully unbundled access

regulatory framework which has stated NGN and increase in broadband speed among major targets in this area, application of LoI theory would, in connection with our results, increase subscribers' welfare by introduction of new and faster broadband platforms. Wider implementation of those platforms might further enable full utilization of current computer and mobile facilities.

6 Conclusion

Since deregulation of telecommunication sector in 1998 the market has indicated strongly saturated structure reflecting high infrastructure costs and long period required for recognition and customer base attainment. Among major objectives of regulatory concepts approved since this date belonged promotion of competitive pro-innovative market contributing to subscribers' welfare as well as technological development and their adoption. In our study we have analyzed concept of efficient regulation in two segments of ICT sector: voice telephony and broadband.

In the first model we have studied an effect of MTR lowering (as a result of LRIC introduction) on price of local call. Despite existence of number similar researches, contribution of our approach comes out from the use of longer time period, which would better reflect long run regulation adaptation, and inclusion of more control variables such as geographical characteristics (with respect to new member countries). Model consisting of panel data estimation resulted in very weak positive relationship between those two variables. Magnitude of this effect might be caused by already existing trend of lowering MTR in time. LRIC might therefore contribute to this process, but value of this effect was decreased by already existing tendency to lower MTR. We have also tested presence of "waterbed effect" in connection with asymmetric regulation. Nevertheless, recent broad adoption of symmetric regulation (or planned adoption) along with positive relationship between MTR and local price calls indicates non-existence of full, or very low value of, "waterbed effect" on our dataset. We are aware of limitation of our results with respect to data availability and absence of dynamic modeling scheme.

Nevertheless, there is question whether such relationship will exist among all countries or whether it is specific to western countries with longer time period of LRIC application. More than illustrative case could be example of the Czech Republic, where implementation of LRIC model finished in the beginning of 2013. At the same time the Czech Republic belongs to the countries with the highest prices of voice services. Adjustment is discharged only gradually and on very limited range.

To the major components contributing to competitive structure adoption belongs spectrum auction, which would facilitate enter of virtual operators and, in the longer run, intensified competitive pressures. Analysis of such implication has still limitations with respect to the absence or postponing of auction scheme to later date.

To the possible challenges of sector belongs convergence tendency of voice and data services and their consolidation. We might have already observed multiple transmission technologies and adoption of equipment which enable such interconnection (smart phones). Question is whether in the future the voice telephony segment will be replaced by simple broadband technologies. Limitations of such consideration are extremely high cost requirements for network coverage and demand of high mobility. However today voice telephony pertains to the most used connection channels enabling high level of mobility and probably (in the long run scheme) relatively low prices at the European level.

Second part of our study was dedicated to broadband market and impact of regulatory concepts on innovation capacity of segment. In our approach we have decided to test effect of LoI and LLU concept adoption on European broadband market. Basic framework of our model revolved around modified concept studied by Garrone, Zaccagnino, Milano (2012) [16]. Contribution of our approach is based on deeper focusing on facility based competition promotion and inclusion of wired technologies and analysis of specific access payments of infrastructure innovation. Further we have considered regional differences and their possible impact on final effect. Our results have shown positive relationship between all three forms of "local loop unbundling" access (bitstream, shared and fully unbundled access). Dimension of singular effects was following: 1% increase in number of fully unbundled lines generate 5% accrual of number of new entrants' lines. Shared access indicated higher effect (12%) and bitstream access 10,9% increase in number of entrants' lines. Despite expected signs of effects, dimension of "fully unbundled lines" does not fulfill theoretical expectations concerning the last stage of "ladder" as the level with highest motivation to infrastructure investment. However sequence of those effects could be explained by sooner adoption of facility based competition (in the stages of shared or bitstream accesses). Deeper analysis of interconnections between forms of unbundled accesses showed positive relationship. Cause of this effect might be

generated by gradual increase in each stage after "burning the preceding level", which would contribute to validity of LoI theory. Alternative reason might be overall growth of entrants, joining lower stages. In this case deeper analysis should be required in order to prove validity of this hypothesis. Challenging task for further researches would be determination of this effect by using more specific datasets, which are not currently available. As the last area of interest we have studied effect of average monthly payments on entrants' lines accrual. Our results showed negative relationship between monthly average payments per fully unbundled access and entrants' line accrual. Despite the size of this effect (20%) we would like to study the impact on the lower levels of "ladder" in order to obtain sufficient evidence for proving this statement.

With respect to national specifications on the European level we have focused on effects connected to Central and Eastern European countries. Analysis of time series datasets showed gradually increasing trend in number of entrants' lines accompanied by accrual in number of bitstream accesses. Reason for lower participation on shared and fully unbundled levels would be delay caused by later LLU adoption. Further econometric analysis on the national level showed limited positive relationship between the number of fully unbundled lines and entrants lines[43]. Reverse to this was negative effect of access payments in the upper steps of the "ladder"[44]. Generalization of those results is limited by low number of central and Eastern European countries covered in our analysis. Nevertheless, potential generated by LoI and LLU application would, in the long run period, contribute to EC strategies of NGN adoption and broadband speed increase. Further researches in this area would be limited by low NGN adoption rate and existence of time horizon for further adjustment[45].

We are aware of limitations of our results caused mainly by data availability and number of countries covered in the model. Our objective was to cover the largest

[43] Econometric analysis was provided by application of time series methods on selected countries especially in the Central and Eastern Europe

[44] Positive effect of monthly access payments was seen only in the case of Czech Republic

[45] Targets of strategy Europe 2020

sample and period possible, nevertheless for final confirmation of our result we suggest further enlargement of sample with respect to regional diversity.

In recent years broadband area and data transmission problems have not been limited to single theory. To the most developing areas of interest belongs question of security. Technological progress allowed development of mobile platforms and simplification of accesses to bank and government institutions. Facilitation of data transmission in the areas of “e-banking” and connection to governmental databases was enabled by wide adoption of smart phone and portable computers. Security of this type of interconnection has become one of the priorities accompanying European regulatory strategies. It is questioned whether it will generate additional technological and cost requirements on network constructions and development. Potential high security standards accompanied by demand of fast interconnection would produce additional access costs accompanied with facility-based competition attainment. However researches in this area and their application along with LoI theory remain one of the future challenges in telecommunication sector.

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Appendix A

Symmetry	Partial symmetry	Asymmetry
	Bulgaria*	
Austria	Croatia*	
Czech Republic	Denmark*	Belgium*
Estonia	France	Cyprus*
Finland	Germany	Netherlands
Greece	Ireland*	Poland*
Hungary	Italy*	Slovak Republic
Lithuania	Latvia	Switzerland
Malta	Norway	Turkey
Portugal	Romania*	
Sweden	Spain	
	UK	

Table A.1: Asymmetric MTR regulation in Europe

Source: BEREC (2010): BoR (10) 31, Available at: http://www.irg.eu/streaming/BoR%20(10)%2031%20Symmetry_final.pdf?contentId=546912&field=ATTACHED_FILE

* Announced date for symmtery adoption

Appendix B

	p	*MTRi*	*GDPpg*	*mob_pen*	*MTRidum*	*unempl*	*ms*
p	1.000						
MTRi	-0.117	1.000					
GDPpg	0.245	-0.097	1.000				
mob_pen	-0.114	-0.502	0.154	1.000			
MTRidum	0.084	-0.519	0.007	0.451	1.000		
unempl	0.043	-0.124	-0.322	0.021	0.302	1.000	
ms	-0.095	0.319	-0.288	-0.353	-0.0978	0.114	1.000

Table B.1: Correlation analysis

Source: author's computations

	ln_newentli.	*ln_fullull*	*ln_shared*	*ln_bitstrem*	*GDPg*	*rur_den*	*i_daily*	*ms*	*bb_pen*	*ln_full.*
ln_newentline	1.0000									
ln_fullull	0.4639	1.0000								
ln_shared	0.4511	0.5036	1.0000							
ln_bitstrem	0.4572	0.4098	0.4354	1.0000						
GDPg	-0.1982	-0.3409	-0.1252	-0.0868	1.0000					
rur_den	0.2767	0.3556	0.2551	0.1859	-0.2405	1.0000				
i_daily	0.1794	0.2961	0.279	-0.2111	-0.2436	0.3145	1.000			
ms	-0.5173	-0.4406	-0.424	-0.3962	0.1125	-0.1636	-0.198	1.000		
bb_pen	0.1342	0.3448	0.1006	-0.2596	-0.3757	0.3086	0.650	-0.147	1.000	
ln_fullull_p	-0.0665	-0.3244	-0.1786	-0.1919	0.1414	-0.1506	-0.204	-0.012	-0.079	1.0000

Table B.2: Correlation analysis

Source: author's computations

Vaviable	*N*	*Mean*	*Std. Dev.*	*Min*	*Max*
ln_newentline	119	12.69696	1.807841	7.376508	15.19023
ln_fullull	118	11.36726	2.536526	1.609438	15.99026
ln_shared	115	9.583108	3.453245	0	15.23851
ln_bitstrem	118	11.22317	2.485965	3.317805	14.60918
GDPg	119	0.010345	0.036309	-0.14	0.103
rur_den	119	0.542437	0.202083	0.07	0.91
i_daily	119	0.442269	0.167567	0.1	0.76
ms	119	0.423109	0.065996	0.21	0.58
bb_pen	119	0.195672	0.093086	0.007	0.384
ln_fullull_p	119	2.431595	0.219251	1.93586	2.933857
time	119	2007	2.008457	2004	2010
geo	0				

Table B.3: Summary statistics

Source: author's computations

			(FGLS)			
log_fullull	***Coef.***	***Std. Err.***	***Coef.***	***Std. Err.***	***Coef.***	***Std. Err.***
log_shared	0.487691***	(0.049242)			0.473983***	(0.045358)
log_bitstream	0.155821***	(0.053496)	0.27067***	(0.060266)		
_cons	4.028508***	(0.743787)	7.791028***	(0.650578)	5.949134***	(0.490693)
Observations		114		117		115
Wald chi2		121.03		20.17		109.2
Prob > chi2		0		0		0

*** P>|t| = 0.000

Table B.4: FGLS model of mutual LLU relationships

Source: author's computations