The Impact of Regulatory Frameworks on Competition and Penetration of Telecommunication Markets

Analysis of the European and Asian Broadband Markets

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***Abstract*—Based on the rising numbers of broadband Internet users and the resulting higher importance of broadband infrastructures, previous analyses often focused on the relation between competitive market behaviors and the development of customer broadband penetration rates. Additionally, some prognoses also consider the relation between the development of market concentration and customer prices. In both methods, researchers have started to implement some different regulatory variables, which measure the difference between the competition within an infrastructure and between different infrastructures. Here, there is either a simple binary variable (regulation implied: yes or no) or the variable expresses how many connection lines (in relation to the overall market) are affected by regulatory intervention. The target of this and further research will be to expand the current status of knowledge. Besides the analysis of the influence of regulatory frameworks as single (binary) variable on the development of market concentrations, penetration rates and customer prices, two further approaches will be discussed. In the first step, the regulatory variable is changed so that the duration of the implemented regulation is included in this variable. Then, in a second step, regression analyses will examine the relationship between (a) the market and regulatory variables and (b) the broadband connection speed development variables. Chiefly, this paper gives insights about the telecommunication market developments depending on the degree of regulation.**

***Keywords*—broadband development; market concentration; regulatory frameworks; Hirschmann-Herfindahl-Index; Linda-Index; broadband penetration rates.**

I. INTRODUCTION

Previous researches indicate the rising importance of the worldwide Internet and the increased usage of Internet services within broadband infrastructures in daily business and private life [1]. Here, especially the availability of Internet services like (a) cloud computing, (b) video on demand, (c) online telephony, (d) social media networks and (e) email services describes the importance of the Internet nowadays. The availability/implementation of broadband infrastructures and high broadband connection speeds are becoming increasingly important as location factors to guarantee the accessibility of Internet services [2]-[5]. The increased usage and rising importance of broadband infrastructures/connection speeds underline the significance of future communication/data transport for entertainment and work. Therefore, broadband access lines are one of the main indicators for economic growth [2].

In the world and particularly in the following considered European and Asian broadband markets, different standards for the provision of broadband infrastructures subsist [4], which are beside other factors responsible for the various broadband developments in the past years. On this account, in each regional/national telecommunication market different regulatory obligations and technical standards for broadband infrastructures can be observed, which result in different market situations and broadband penetrations [3]-[5]. These differences result by the following reasons: (a) customer broadband demand, (b) prices for broadband services, (c) quality and technologies providing broadband infrastructures (availability of wires and ducts), (d) implementation costs, (e) competition policy and regulatory obligations, (f) competition, and (g) demography and culture [3]-[6].

Most publications on this topic focus on the analysis of the relationship between: (a) regulatory and governmental frameworks, (b) competition, (c) broadband diffusion and adoption, (d) coverage and (e) penetration [7][8]. Furthermore, various papers deal with considerations regarding (a) the relations between implementation costs and customer prices, (b) operators and different broadband infrastructures, and (c) demand and supply of broadband Internet services [9]-[11]. Yet, the development of broadband does not only depend on the customer adoption and diffusion of broadband infrastructures. Broadband developments include all services and benefits, which are targeted to strengthen the following factors: (a) higher broadband coverage and penetration, (b) higher broadband connection speeds, (c) more services, (d) higher technical standard for infrastructures, and (e) measures to create acceptable prices for customers and to induce customer broadband demand. The following relations have been rarely considered in terms of their influence by the competition: (a) the influence of competition (market concentration) on the development of broadband access speeds, and (b) the influence of competition on the development of customer prices for broadband services. In addition, the extent to which the following regulatory provisions influence market factors will be examined: (a) the impact of regulatory obligations and regulatory frameworks on the market concentrations in broadband networks, (b) the impact of regulatory frameworks on the development of broadband penetration rates, and (c)

the influence of regulatory behavior on the customer prices are not considered in detail until the current point of time. As mentioned, the other impacts are not considered. In the past research approaches, regulatory obligations and frameworks are only estimated as binary variables or by number of regulatory used. It examined the influence of different types of competition on the development of broadband penetration rates.

This study will firstly examine the impact of market concentrations on the fixed-line broadband development to prove if the achieved data could present the past research. Next to the consideration of market concentrations, we have also measured the disparity in the broadband markets and have estimated this disparity in the relation to the named broadband developments. Based on this measurement, we have analyzed the different types of regulatory obligations for fixed-line broadband markets and their influence on competition. In the further steps, we have focused on the influences of the aforementioned factors with the focus being on the implementation of regulatory obligations. For the evaluation, we have collected secondary data of fixed-line broadband markets in Europe and Asia to conduct a combined cross-sectional and longitudinal panel data analysis with pooled ordinary least square regressions. The chosen time range of said data will include the years between 2004 and 2015 in order to reflect on the reasons for the different country-specific broadband developments, levels of competition/market concentration and regulatory behaviors over time. Apart from the different regression models, the intensity of competition will be – in a first step – measured through the usage of different economic concentration models. Following this approach, we will discuss how the regulatory frameworks can be examined. The major aim of this study is the analysis and the determination of the country specific different broadband developments.

The paper proceeds as follows: based on the introduction, Section II presents the literature review and the hypotheses. Section III includes the research methodology. Section IV gives the first results of the investigations regarding the development of competition and market penetration. In Section V, we discuss first insides of the regression analysis. After all, we conclude the paper in Section VI.

II. LITERATURE REVIEW

A. Influence of Competition on Market Developments

Due to the various influence factors described, the term of broadband development includes: the development of coverage and penetration of the existing broadband infrastructures, the expansion of new and upgrade of old infrastructures, the customer prices for broadband services and the quality of the broadband networks (broadband connection speeds).

Based on liberalizations of the fixed-line broadband markets in developed and emerging countries, various network operators and service providers compete in the provision of broadband Internet accesses and services. In order to get a quick return for their investments, operators often focus on broadband developments in regions with potentially large customer base and, high population densities and low implementation costs [10][12], which count as economic efficient areas [11]. This approach reduces significantly the incentives for investments, implementations and upgrades of the existing broadband infrastructures in rural regions with lower population density.

However, when competitors get access to the broadband infrastructure of the incumbent or when the competitors have their own broadband access infrastructure (cable or fiber), the customer prices for broadband services, the broadband diffusion and provision respectively are influenced. Especially in cases of providing access for new entrants and controlled prices, regulatory decisions and behaviors by the governmental authorities could strongly influence the existing market situations.

The opening of existing broadband infrastructures creates an intense price competition, which strengthens the broadband adoption by customers [7][8].

In case of competitive situations in broadband markets, the prices for broadband services decrease and the broadband diffusion and provision increase heavily [7][8]. The competition of different network operators and service providers exert a positive influence on customer adoption of broadband access networks and can be named as one of the key drivers to reach high broadband penetration rates [8]. Despite the fact that competition induces more broadband adoption, Gruber and Koutroumpis (2012) have figured out that competition within an infrastructure would be quite more effective for the customer broadband adoption than the competition between different broadband infrastructures [8]. Although the competition between different broadband infrastructures can stimulate stronger market behaviors because of the increased rivalry for market shares, the implementation of further broadband infrastructures is also quite more expensive than the wholesale of an existing broadband infrastructure.

To sum up the previous findings, the first hypothesis will examine the relationship between broadband diffusion and the development of market concentrations.

H1: A stronger competition (higher intensity of competition) leads to higher broadband penetration rates.

In consideration of the available data and the status of the work in progress, we focus on the further considerations of the influences between competition, regulatory frameworks and penetration rates. The estimations of customer broadband prices and broadband connection speeds will be addressed, but not finally concluded.

As mentioned with the first hypothesis, we assume that an existing competitive market structure in broadband markets could positively affect broadband penetration. As additionally addressed by Distaso et al. [7], Gruber and Koutroumpis [8], a higher intensity of competition leads to lower prices for the lease of an unbundled line and lower customer prices for broadband services in general. The

opening of the existing broadband infrastructures by regulatory obligations tackles directly the current market structure, the new market players have to encounter a price competition [9][10][13]. An increased competition with reduced prices could lead to a better acceptance of (broadband) accesses by the customers, because prices are most important driving indicators for the customers´ decision [9][10][13]. Following Distaso et al. and Gruber, there is a negative relationship between customer prices and the adoption of broadband accesses [7][14]. Moreover, Katz & Berry [10] also mention that a weak competition with high market concentrations would induce higher customer broadband prices.

On this account, the market entry is quite difficult for new market entrants, because a business on the boarder of price competition leads to lower sales on the base of constant costs for the use of the infrastructure of the incumbent [6]. Consequently, the incentives to get into the market, to compete with existing market players, and to get only low revenues are quite weak.

However, currently the prices are above the level of marginal costs and thus, new market entrants have the possibility to achieve revenues to stay successfully in the market. The main target is here: *Do customer prices have an impact on broadband developments in regional markets?*

Nonetheless, a former monopolist with an existing infrastructure has the advantage that he gains revenues and do not have the same investment costs like the entrants, because the network usually is already (mostly) depreciated. Therefore, the incumbent in the cases can (a) gain more usable resources, (b) react more flexible on market behavior and (c) longer survive in a price competition.

In competitive market situations, provider decrease their prices to reach a broader customer base [13]. Therefore, the broadband adoption can be positively influenced and will increase over time. The influence of competition on customer revenues may cause problems if the network operators have difficulty to provide the financial resources for new investments in broadband infrastructures. Furthermore, companies try: (a) to differentiate their products and (b) to invest in the broadband infrastructure to get into a better market position than competitors [10]. Generally, it can be ascertained that prices for broadband services and the adoption of accesses are negatively related [7][14]. However, the prices also depend on the customer's willingness to pay and the demand for broadband services. Since customers are price sensitive and their behavior is very price elastic, a declining price induces a higher willingness to adopt and use broadband access [15]. Based on the presented literature background, the following two hypotheses could be developed.

H2: A stronger competition leads to lower monthly customer prices for broadband access.

H3: Lower customer prices relates positively to higher broadband penetration rates.

The hypotheses H2 and H3 figure out how the behavior of the market players regarding the market shares and customer prices influence the broadband development and the adoption of broadband accesses.

However, previous studies do not consider the relationship between (a) competition, broadband and broadband penetration, and (b) available broadband connection speeds [9]. So far, researchers have often considered the relationships between competition and broadband penetration rates and between competition and customer prices. Additionally, some studies have focused on the influence of broadband prices on the development of penetration rates.

Normally, the assumption would be that more competition leads to faster broadband connection speeds, lower prices and higher penetration rates. If this expectation turns out to be true, it can be concluded that in broadband markets with higher concentrations usually strong monopolists and/or oligopolists try to hold and increase their market shares instead of investing into new infrastructures and push further broadband developments. Based on the missing pressure (potential market entry of a new competitor), the incumbent has no incentive to develop a new or better broadband infrastructure.

Only if the (former) monopolist fears a competitor's market entry or the incumbent is forced to grant the network access for new market entrants, it will have an incentive to upgrade the current infrastructure in order to improve the quality of its broadband networks and services [11][12]. Here, with a strong competition it can be assumed that on the one hand, the providers try to find new ways to win customers from competitors, and therefore, they have incentives to invest in new infrastructures [29][30]. On the other hand, if competition is not that strong, the (former) monopolist may (by owning the sole broadband infrastructure) be able to generate better margins and to invest in a better quality of his own infrastructure.

As mentioned before, the focus of this study will be the analysis of the relationships between regulatory behaviors and the market developments in specific countries. Nonetheless, some insides about the relations of broadband connection speeds will be given too.

Since the dependency between (a) market conditions and (b) customer pricing and broadband connection speeds has not been considered so far, it is considered that competition is a key driver for the development of broadband infrastructure and broadband services. It can be expected that a competitive broadband market structure leads to higher connection speeds, since competitors invest financial resources in new infrastructures and equipment in order to differentiate from existing market players and to get in a better market position in comparison to the incumbent.

H4: In regional telecommunication markets with a higher level of broadband competition the average connection speeds are higher.

H5: Lower customer prices for broadband access lead to a faster development of broadband connection speeds.

Actually, the customer willingness to pay does not increase heavily in terms of a rising broadband connection speed [6]. Furthermore, the customer willingness to pay determines the demand for broadband accesses. Because customers are only willing to pay higher prices if there is a substantial improvement of quality and availability of the broadband services [11][16][17].

New entrants usually have to pay access charges if they are willing to use existing infrastructures of other operators [6].

Despite the high significance of the customer part in this topic, the focus will be further in the analysis of the regulatory impact on market developments.

B. *Influence of Regulatory Frameworks on Market Developments*

Following the introduction of the presented competitive considerations, the relationships of the regulatory frameworks on the development of (a) market concentrations, (b) customer prices, (c) penetration rates, and (d) broadband connection speeds need to be analyzed too.

It can be almost confirmed that the huge range of governmental initiatives, involvements and regulatory instruments lead to different market conditions in the considered countries [18]-[24].

For example, the European Union forced the member states to liberalize the fixed telecommunication markets and to open up the past monopolistic state-owned infrastructures between 1985 and 1998. Liberalization should normally strengthen the forces of the market [20][21]. If the market forces are not strong enough to develop the telecommunication markets, the political and regulatory authorities have to intervene [18][19]. Based on the vast range of governmental initiatives and regulatory instruments, it is normally intended that the market regulates itself [18]-[21].

Kiesewetter et al. [22], and Waverman and Koutroumpis [23] found out that regulations (especially access regulations) directly influence the market concentration in broadband markets. Regulations are able to force the incumbent to open the networks for competitors [20]. Which means, the existing market structures and especially the market position of the incumbent can be influenced by the implementation of regulations. In this situation, the regulations shall remove burdens and constraints and may overcome the lack of competitive behavior [8][20][24]. A possible change of market structures allows new entrants to enter the market. However, regulations could only determine the competition within a network. Here, the access regulations are differentiated between regulations for intra-platform competition and service-based competition. The competition between operators with different broadband infrastructures is normally not targeted by regulations [6].

Nonetheless, regulations usually prescribe existing and dominating network operators to open their networks for new entrants [24]. On the one hand, the mandatory access allows competitors to join the broadband markets with only few investments in the provision of broadband services and without any investment in sunk costs assets [6]. On the other hand, the regulatory authority can improve the competitive situation and help to overcome possible competitive deficits [8][24]. Hence, the acceleration of competition should induce a stronger competition with a higher rate of broadband adoptions [7].

H6: Regulatory behavior and mandatory access regulations will positively enhance competitive market behaviors.

Furthermore, regulations also depend on the market power of the incumbent and existing network operators, because they try to avoid or overcome regulations with own behaviors or investments. Incumbents (and big operators) generally would not allow that a new provider could use their networks (without making investments for own broadband infrastructures) [24]. In this case, the regulatory authority has to pay attention that an incumbent (or other big/dominant operator) would not able to offer higher prices to hold the market position, to hinder further market developments and to foreclose other companies to join the market. The regulatory opening of infrastructures for entrants should (a) remove burdens and constraints, (b) allows the creation of retail competition, and (c) ensures that the incumbent cannot foreclosure (new) competitors [20][24].

On the other hand, access regulations for existing infrastructures allow operators to hold their power with their infrastructures and they are able to overview the competitors [7]. One intension of the regulatory authority could be that entrants get a market access and later, when they have had gained enough financial resources, they will invest in own infrastructures (so called “Ladder on Investment”). But, in several countries a couple of enterprises are quite comfortable with the access on an existing network. Consequently, regulations can open the market for further competition, but an infrastructure competition does not necessarily result.

Based on the literature regulatory measures influence competitive market behaviors. Furthermore, it would be necessary to analyze how these regulatory measures affect the development of the coverage and adoption of broadband infrastructures.

Besides the opening of accesses for existing broadband infrastructures by regulations, the offering of grants and subsidies could be regulatory or governmental interventions too. These funds should stimulate operators to invest in further broadband infrastructures and to enhance the quality of existing broadband infrastructures and services. Furthermore, the subsidies should support the operators in their investments to overcome possible investment gaps and to make investments quite reasonable [20][25].

Supporting the previous explanations, Gruber and Koutroumpis [8], and Wallsten [26] mention the fact that the implementation of regulations (especially unbundling) stimulate higher broadband penetration rates. However, Briglauer and Gugler [6] found that only few regulatory decisions influence broadband penetration rates directly. Possibly, regulations can also negatively influence the development of broadband penetration rates [4].

Nevertheless, the assumption here is that governmental interventions want to enhance the broadband penetration and therefore, the following hypothesis indicates a positive relationship between regulatory behaviors and broadband penetration.

H7: Regulatory behavior and mandatory access regulations will positively relate to broadband penetration.

Furthermore, regulatory authorities are able to set price regulations. Therefore, they have to check if the incumbent is trying to misuse his market power to set higher prices than a market with competitive structures. If the incumbent cannot force higher prices, the gained revenues, financial resources and the incentives for further broadband investments will decrease. Also, the new entrants are not willing to invest high amounts, because they would not be able to set higher prices as the incumbent [8][24].

As introduced, regulations are able to offer the opportunity for new market entrants to enter the broadband market. However obviously, the entrants have to pay charges for the usage of existing infrastructures. These fees represent additional costs for the competitors and tend to secure the (dominant) position of (incumbent) network operators [6][7]. Therefore, regulators need to ensure that network access charges are close to marginal costs.

Nonetheless, the entrance of the new competitors normally lead to a stronger competitive market situation which results in lower customer prices [6]. Due to the induction of competition by regulatory measures, it can be hypothesized that regulatory obligations reduces customer prices.

H8: Regulatory behavior and mandatory access regulations reduce to customer prices.

Regulations are able to change previous market structures, especially in the case of non-transitory barriers and a non-existent competition. Due to the implementation of regulations, incumbent could be limited to set higher prices, which normally lead to decreasing revenues. Falling revenues discourage the operators to invest in future infrastructures. Due to the high implementation costs (which are mainly sunk costs), operators and governmental authorities have to take into account the high investment risks [6]. Due to high investment requirements in network infrastructures, entrants have high market entry barriers. In contrast, the resale of broadband services (based on existing broadband infrastructure) is a relatively risk-free alternative for making profits [8][24]. Mandatory access regulations reduce incentives to invest in infrastructure; furthermore, strict cost-based/ex-ante regulatory approaches are suspect and hinder further broadband developments [4][24][25]. However, the providing operator (usually the incumbent) has to be compensated for release of broadband capacities [24].

The literature review does not provide a clear picture of how broadband developments could be supported by regulatory intervention with regulatory commitments and decisions. On the one hand, regulatory interventions reduce investment incentives of companies and operators to develop broadband. On the other hand, the regulatory authorities enable the possibility to enter the market and to offer several funds to support possible new market players that they could develop their own broadband services [6].

H9: Regulatory behavior and mandatory access regulations will positively affect stronger broadband developments and higher broadband connection speeds.

III. METHODOLOGY

As the previous explanations indicate, we will analyze relationships between broadband developments, the respective market concentrations and broadband market regulations in particularly Western European and Southeast Asian markets.

The focus lies on countries of the European Union 28 (EU28) and the Association of Southeast Asian Nations (ASEAN), as well as additional countries such as Switzerland, Norway, Japan, China, Hong Kong, and the Rep. of Korea. The reason why said regions of the world were selected are as follows: (1) EU28 and ASEAN are regions with (a) multiple countries, (b) a comparable number of inhabitants, and (c) national territories. (2) Like the EU28, the ASEAN system is also developing to get in the position of a central commission for economic, social, regulatory and juridical resolutions. The comparison of the countries of the two systems and the additional ones will be presented for period between the years 2004 and 2015. To limit the scope, some of the countries (Laos, Cambodia, Myanmar and Indonesia) in the named two analyses are excluded from the analysis due to the lack of data.

The evaluation of the competitive intensities follows different concentration models, Hirschmann-Herfindahl-Index (HHI) and Linda-Index (LI), which measure the intensity and disparity of the operators in the specific national broadband markets' competition and compare the market shares of the operators [27]-[30].

The HHI, as one of the most popular models to evaluate market concentrations, will be used to measure the intensity of competition based on key figures. In the economic theory, the HHI is signified as the total concentration measure, which analyzes the share of sales in comparison to the total market volume [27][28]. Here, the HHI will be measured with the customer share of one provider in relation to the whole number of the customers in the market. The collected market shares illustrate the number of customers of each of the biggest three providers in relation to the total number of customers in the specific national broadband market [27][28].

The possibly non-observance and non-implementation of all network operators base on the issue that there are some countries with only three network operators, which provide broadband accesses. To generate a comparable base over all countries, we choose to consider only the three biggest network operators for all countries.

The HHI describes the weighted average of concentration and squares the collected market shares (see (1), S describes

the market share of each specific network operator, i describes the considered operator) [28]-[30].

$$HHI = \sum_{i=1}^{m} S_i^2 \times 10.000 = \sum_{i=1}^{m} (100 \times S_i)^2 \quad (1)$$

The HHI follows the subsequent classification in Table I [28]-[30].

TABLE I. BOUNDARIES FOR THE ASSESSMENT OF THE HHI

HHI < 1.000	non concentrated market
HHI = 1.000 - 1.800	moderately concentrated
HHI > 1.800	highly concentrated

The LI does not reach the same usage and awareness level but the results show how much the market varies from perfect competition (LI-value of 1). Generally, the LI is used to examine the disparity between the biggest and following companies. Therefore, the disparity measures an existence of market dominance and describes if the inequalities between the operators lead to significant changes in the competitive behavior [28]. The LI value is based on a two times calculation and presents a double average index (see (2) and (3), CR stands for the Concentration Ratio, which is the single sum of the market shares of the considered number of network operators, i describes the considered operator) [26], which differentiates companies that are relevant to the market because of their size from less relevant companies. In general, the index compares the average market shares of the dominant enterprises in relation to the market shares of the insignificant enterprises. As mentioned before, only the three biggest operators are included in the further competition examinations.

$$V_{i,m} = \frac{\frac{CR_i}{i}}{\frac{CR_m - CR_i}{m-i}} \quad (2)$$

$$L_m = \frac{1}{m-1} \times \sum_{i=1}^{m-1} V_{i,m} \quad (3)$$

Both indicators are good measures to estimate the current existing market power situations in respective broadband markets.

Furthermore, we will only examine the developments in the fixed-line broadband markets, in which smaller network operators is of secondary importance for the competition situation.

As introduced in Section I, more and more people use the Internet and especially the mobile Internet, which is not considered in this study. Nonetheless, the mobile Internet needs also the connection with cable-bound infrastructures (mostly fiber) to deliver the high broadband connection speeds per mobile transmission. Based on this connection and for the reason that the most of the considered countries have already strong implemented fixed-line broadband infrastructures, the treatment of cable-bound broadband infrastructures is further important and present.

For the cross-sectional and longitudinal panel data analysis of the described relationships, we have collected secondary data from: (a) the regulatory authorities of the considered countries, (b) the International Telecommunication Union (ITU), (c) the Organization for Economic Cooperation and Development (OECD), (d) the European Union, (e) the World Bank, (f) telecommunication authorities and ministries, (g) telecommunication providers and suppliers, and (h) national institutions and governments. Due to the different sources, the elicitation of the data can vary. To take all sources into account, average values from all available data are used. Moreover, we test the data validity and reliability with exploratory factor analysis and Cronbach's Alpha to verify the trust in the collected secondary data [32]-[34]. As mentioned in the introduction of this section, for some countries, the data do not exist and therefore, these countries are not considered in detail.

Nevertheless, some discrepancies between the collected data and the anticipated time trend of the data cannot be excluded. It should also be pointed out that the time in the presented model is an important variable with a high influence.

The longitudinal analysis, which spans a time range from 2004 to 2015, will also cover some cross-sectional elements to conduct comparisons between the various countries in consideration. The needed data is composed of the network operators' market shares, introduction of regulations and regulatory frameworks for broadband markets, broadband penetration rates, broadband connection speeds, customer prices and some basic economic facts like Gross Domestic Product (GDP), exchange rates, price parities, households and population densities. The hypotheses will be analyzed and estimated using various econometric and panel data techniques. Generally, each hypothesis will be tested by a pooled ordinary least square regression to figure out if the results are significantly able to present the named relationships. For each hypothesis, we define the following regression equations, which can be seen in Table II. The different stated equations indicate that we try to differentiate the analysis of the equations and the effects between the dependent and independent variables. Furthermore, the application of the different equations for each hypothesis would be necessary to deal with possible autocorrelation and endogeneity effects. The approaches will be utilized to get a broader understanding of the collected data and the possible relationships.

Regarding the consideration of the regulatory measures, the implementation of regulations normally started with the conduct of the liberalization processes, which were applied, e.g., in the European Union in 1998 (and later). The regulations, which are able to limit the market behaviors by obligations, are needed to be investigated. Definitely, current market structures and concentrations are the result of the regulatory decisions of the past. This indicates that further regulatory decisions and regimentations will build up the future market structures [4][6][35].

Nevertheless, it is necessary to define how the regulatory measures will be examined in this study. From the literature, we already know that some of the researches have chosen a simple binary coding if a regulation is implemented or not [7][8][14]. Other approaches have focused on the estimation of regulatory measures regarding on the share of the lines, which are used through regulations, in comparison to the total number of sold lines [4][6][36]. From our point of view, both approaches have still weak points in the consideration.

The binary coding gives a good introduction to deal with, because the directly impact of a regulation on market behaviors can be analyzed. However, if the period between the moment of regulation implementation and the current moment becomes longer, the impact of the sole regulation introduction gets weaker, because the existing operators can estimate quite better the competitors, because the existing operators are better able to assess the competitors who use regulated access to lines. Therefore, the impact of a regulatory action (through the above-mentioned "learning effects") is expected to decrease significantly over time. The regulated network operators could still estimate very well the market and will use their market power.

The second approach, which covers the implementation of the variables, includes the share of the total lines which are reached by regulated obligations. Here, the problem arises that existing network operators can also stipulate access conditions for the access on broadband infrastructures with new entrants/competitors without any regulations. As a matter of principle, it should be noted in the quantitative assessment of regulated access lines that, of course, on a contractual basis (for example, unbundling or bitstream) are possible. Due to these potential problems, we arrange a double analysis approach.

Generally, the binary coding if a regulation is implemented or not is a good introduction, because this approach gives an overview about the several national markets, which regulations work in the market. As we have carried out, the single implementation does not illustrate possibly correct the influence of the regulations over time. Therefore, we consider how long the regulations are implemented in the markets and so, we are able to map, how the regulations work over time. Here, we use as variable for each regulation, the years since the regulation is implemented. However, there is only the problem that in specific broadband markets (e.g., in the Netherlands and Romania) the regulations were implemented in the past and later the regulatory authorities have decided to completely deregulate these markets. For this situation, it is quite difficult to measure the past impact of implemented regulations and therefore, we choose to present the results of the impact of the duration of already implemented regulations.

In this situation, the regulations have no impact in the market anymore. Due to the assumption that regulations affect the market developments over time, the previously implemented regulations continue to have an effect in the market behaviors of the operators. However, when the market is fully deregulated then the variables will be estimated with a zero. Here, we have to acknowledge that this treatment could lead to slightly discrepancies in the analysis. Contrary, we have to do this estimation in this way, because other reflected approaches do not lead to a better result.

Currently, the most studies just differentiate between infrastructure competition (by access regulations) and service-based competition [4][6][7]. Here, the researches often imply the regulations of unbundling and resale as measures. With the considerations of fiber lines, more and more studies also implement the kinds of regulations of fiber and bitstream [4][6][36]. However, line sharing and the virtual unbundled local access (VULA) are not considered in detail. Here, we want to consider all of the different kinds of access regulations, the previous considered and especially the currently unconsidered ones.

Based on the different approach in the assessment of the regulations and the inclusion of different kinds of regulations, our approach will deepen the insight of the impact of regulatory frameworks on the market developments over time.

Due to the status of the work in progress, the analysis of the influences of the regulatory frameworks on the broadband market developments is not completed. Here, we do the analysis of variances (ANOVA) to figure out, how the implementation and non-implementation of regulations affect in average (a) the competition between the network operators, (b) the adoption of broadband accesses, (c) customer prices, and (d) broadband connection speeds.

IV. DESCRIPTIVE RESULTS

A. Competition Analysis

In order to analyze the relationship between competition, broadband connection speeds, customer broadband penetration rates and prices, the intensity of competition (HHI) and the disparity (LI) between the market players will be examined.

For the analysis of the broadband market concentrations, the considered values of the HHI will be separated into the three parts: (1) HHI below the value of 2,000 (low concentration), (2) HHI between the values of 2,000 and 4,000 (moderate concentration), and (3) HHI above the value of 4,000 (high concentration), based on [27]-[30].

Ideally, the fixed-line broadband markets should have stable HHI market concentration values, which do not exceed 1,800 overt time.

Apart from Japan (divided consideration of NTT East and West), all countries with low HHI-values below 2,000 are European countries situated in the continent's Northern or Eastern parts (Lithuania, Denmark, Sweden, UK) (see Figures 1, 3, and 4). These countries are also in the Global top ten of highest average broadband connection speeds [37]-[41].

In general, most fixed-line broadband markets of the EU28 and ASEAN now reach HHI-values between 2,000 and 4,000 and are moderately concentrated.

TABLE II. REGRESSION EQUATIONS

H1: a) $PE_t = \alpha + \beta_1 CI_t + \beta_2 TI_t + \beta_3 PD_t + \beta_4 GDPC_t + \beta_5 HH_t + \beta_6 DM_t + \varepsilon$ b) $TPE_t = \alpha + \beta_1 CI_t + \beta_2 PD_t + \beta_3 GDPC_t + \beta_4 HH_t + \beta_5 DM_t + \varepsilon$ c) $PECHR_t = \alpha + \beta_1 CI_t + \beta_2 TI_t + \beta_3 PD_t + \beta_4 GDPC_t + \beta_5 HH_t + \beta_6 DM_t + \varepsilon$	PE – value of the broadband penetration TPE – trend based value of the broadband penetration PECHR – yearly change rate of broadband penetration CI – values of the competition index (HHI, LI) TCI – trend based values of the competition index SF – monthly subscription fee PD – population density BS – broadband connection speeds TF – termination fees (regulated) GDPC – Gross Domestic Product per Capita RI – regulatory index DM – years of membership in EU28 or ASEAN TI – time variable – capture the influence of time HH – number of households β – changing variable term ε – error term α – constant t – year of consideration
H2: $SF_t = \alpha + \beta_1 CI_t + \beta_2 GDPC_t + \beta_3 TF_t + \beta_4 TI_t + \beta_5 DM_t + \varepsilon$	
H3: a) $PE_t = \alpha + \beta_1 CI_t + \beta_2 TI_t + \beta_3 PD_t + \beta_4 GDPC_t + \beta_5 HH_t + \beta_6 DM_t + \beta_7 SF_t + \varepsilon$ b) $TPE_t = \alpha + \beta_1 CI_t + \beta_2 PD_t + \beta_3 GDPC_t + \beta_4 HH_t + \beta_5 DM_t + \beta_7 SF_t + \varepsilon$ c) $PECHR_t = \alpha + \beta_1 CI_t + \beta_2 TI_t + \beta_3 PD_t + \beta_4 GDPC_t + \beta_5 HH_t + \beta_6 DM_t + \beta_7 SF_t + \varepsilon$	
H4: $BS_t = \alpha + \beta_1 CI_t + \beta_2 PE_t + \beta_3 TI_t + \beta_4 DM_t + \varepsilon$	
H5: $BS_t = \alpha + \beta_1 SF_t + \beta_2 GDPC_t + \beta_3 TI_t + \beta_4 DM_t + \varepsilon$	
H6: a) $CI_t = \alpha + \beta_1 RI_t + \beta_2 TI_t + \beta_3 DM_t + \varepsilon$ b) $TCI_t = \alpha + \beta_1 RI_t + \beta_2 DM_t + \varepsilon$	
H7: a) $PE_t = \alpha + \beta_1 CI_t + \beta_2 TI_t + \beta_3 PD_t + \beta_4 GDPC_t + \beta_5 HH_t + \beta_6 DM_t + \beta_7 RI_t + \varepsilon$ b) $TPE_t = \alpha + \beta_1 CI_t + \beta_2 PD_t + \beta_3 GDPC_t + \beta_4 HH_t + \beta_5 DM_t + \beta_6 RI_t + \varepsilon$ c) $PECHR_t = \alpha + \beta_1 CI_t + \beta_2 TI_t + \beta_3 PD_t + \beta_4 GDPC_t + \beta_5 HH_t + \beta_6 DM_t + \beta_7 RI_t + \varepsilon$	
H8: $SF_t = \alpha + \beta_1 RI_t + \beta_2 GDPC_t + \beta_3 TF_t + \beta_4 TI_t + \beta_5 DM_t + \varepsilon$	
H9: $BS_t = \alpha + \beta_1 RI_t + \beta_2 PE_t + \beta_3 TI_t + \beta_4 DM_t + \varepsilon$	

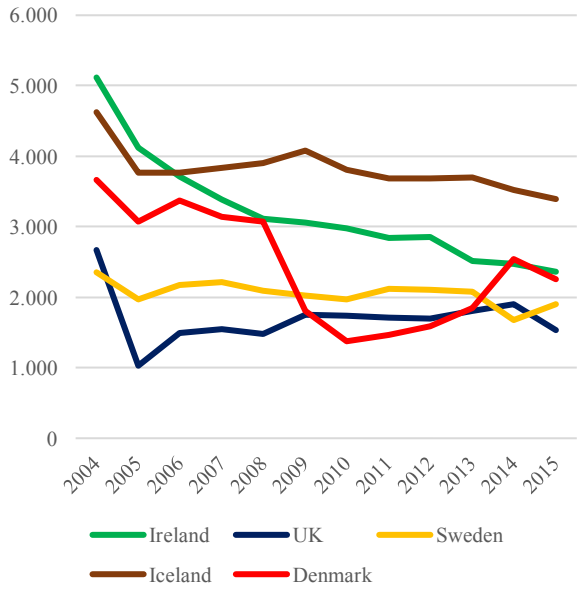

Figure 1. Market concentration of the three biggest fixed broadband network providers in Northern Europe from 2004 to 2015 (x-axis: years; y-axis: HHI values)

When considering the named period, it can be concluded that market concentrations in most countries have decreased from HHI-values above 4,000 (high concentrated) to moderate concentrated market structures.

This development presents diminished market forces and the change of strong monopolistic into rising competitive market structures. Generally, the considered broadband markets are moderately concentrated (e.g., Ireland, Germany, Portugal, South Korea) (see Figures 1, 2, 3, and 4). Nevertheless, some countries (Croatia, India, Philippines) still have HHI-values above 4,000, which implies that the biggest operators were able to hold their market powers and avoid strong competitive structures (see Figures 1, 3, and 4).

Generally, the moderate or high market concentrations in the broadband markets suggest that national regulatory authorities should review the current market behaviors of the existing network operators. To create better competitive and network access opportunities, regulatory authorities could introduce access regulations, which secure possible market entries by competitors.

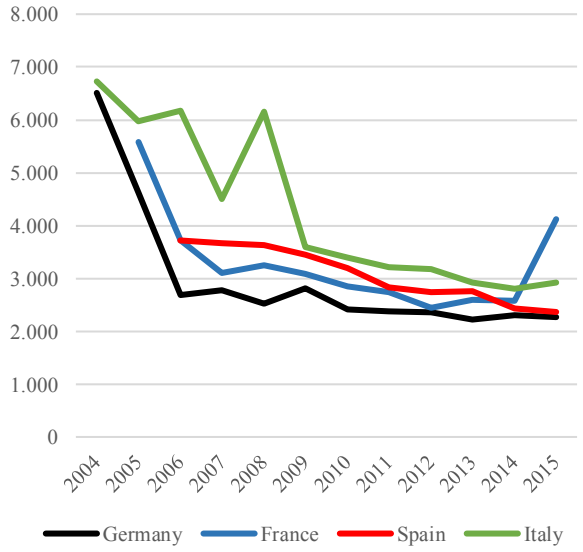

Figure 2. Market concentration of the three biggest fixed broadband network providers in the biggest four Western European countries (except UK) from 2004 to 2015 (x-axis: years; y-axis: HHI values)

Nevertheless, there are two main developments. (1) During the last ten years, the intensity of competition in the most considered broadband markets increased and the previous monopolistic structures could be diminished.

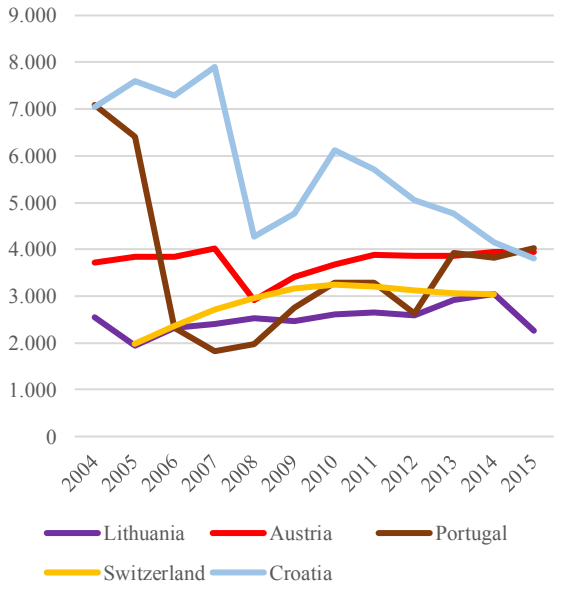

Figure 3. Market concentration of the three biggest fixed broadband network providers of further European countries from 2004 to 2015 (x-axis: years; y-axis: HHI values)

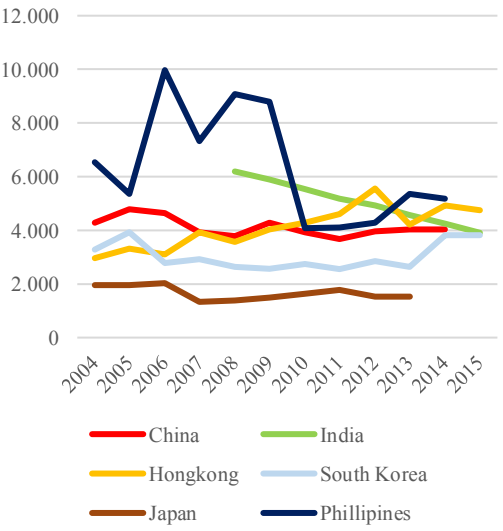

Figure 4. Market concentration of the three biggest fixed broadband network providers of Asian countries from 2004 to 2015 (x-axis: years; y-axis: HHI values)

(2) In the developed countries, the reduction of the power of the monopolistic incumbent is stronger than in the developing countries and the developed countries also have stronger competitive broadband market structures.

The used Linda-Index describes the disparity between the biggest three operators. In general, higher market concentrations translate into higher disparities between the operators. The disparity can be measured in two different ways. On the one hand, the LI examines the discrepancy between the biggest and second biggest companies in the market and on the other hand, the LI can evaluate the discrepancy between the biggest, the second biggest and third biggest companies in the considered market. Based on the evaluation of the three biggest operators in the broadband markets, we will consider the second option with the inclusion of the second and third biggest companies.

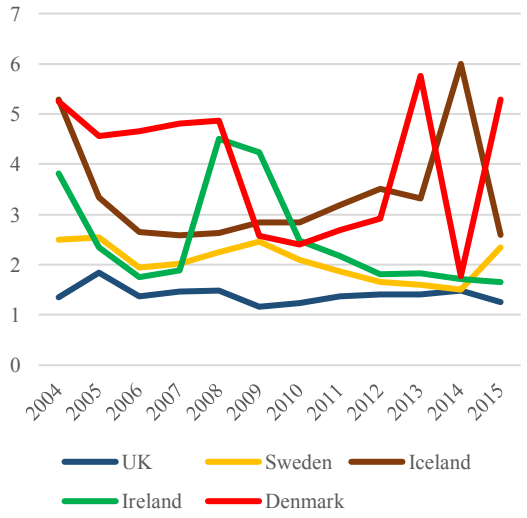

Figure 5. Market concentration of the three biggest fixed broadband network providers in Northern Europe from 2004 to 2015 (x-axis: years; y-axis: LI values)

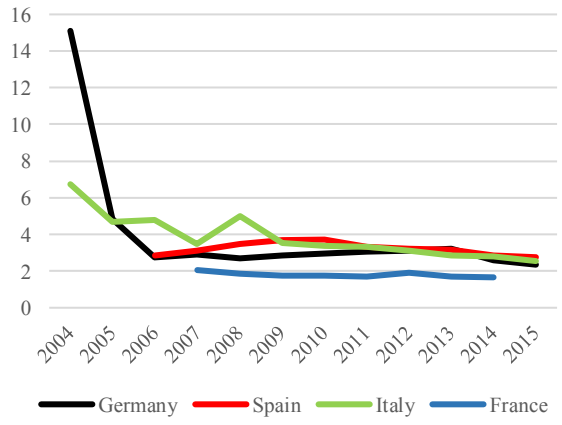

Figure 6. Market concentration of the three biggest fixed broadband network providers in the biggest four Western European countries (except UK) from 2004 to 2015 (x-axis: years; y-axis: LI values)

The consideration of the European and Asian fixed-line broadband markets yields LI-values between 2 and 5 for the most countries (see Figures 5, 6, and 8), which indicates that discrepancies between the operators still exist. Nevertheless, the declining trend of the LI-values shows that in most countries the differences between the incumbents and the new market entrants decrease (e.g., Germany, Italy, Slovenia, see Figures 6 and 7). In the future, these broadband markets could

reach a nearly equal distributed market power. However, the results also show that the disparities between the network operators in some markets increase (e.g., Austria, Switzerland, see Figure 7).

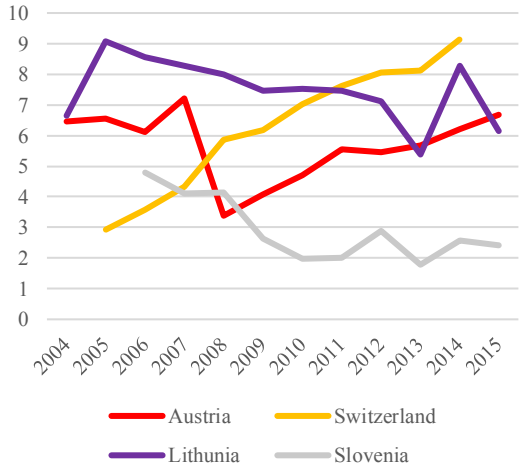

Figure 7. Market concentration of the three biggest fixed broadband network providers of further European countries from 2004 to 2015 (x-axis: years; y-axis: LI values)

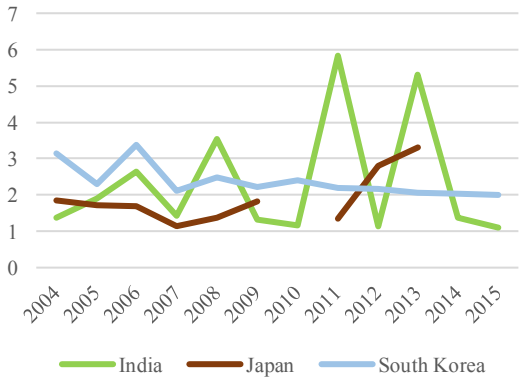

Figure 8. Market concentration of the three biggest fixed broadband network providers of Asian countries from 2004 to 2015 (x-axis: years; y-axis: LI values)

Only in the British market the LI-value is close to 1 and indicates a nearly equal distributed broadband market (between the different market operators, see Figure 5). Combining this result with the fact that the British market has the oldest history of liberalization, it can be concluded that longer open access market could lead to more equally distributed market shares. This issue needs verification by hypothesis testing and we will include this in the evaluations. Furthermore, a couple of countries show nearly the same LI-values over the whole-time frame (e.g., France, South Korea, see Figures 6 and 8). The reasons why, on the one hand, the disparities are very stable and, on the other hand, they vary, will be investigated in the future.

The variations between European and Asian markets are quite low, but nonetheless the LI-values of a couple of countries present higher values. These discrepancies are not sufficiently to draw conclusions from since the results of the LI-values also vary too strongly among network operators in a couple of countries. In general, the disparity (difference in market power and influence) between the incumbent and the competitors cannot be taken as reason for the different broadband connection speeds and developments. It can be just estimated that a more equal distribution of market power could lead to higher broadband connection speeds.

B. Penetration Analysis

Following the statements to the relations of the intensity of competition, we will also consider how the broadband penetration rates have been developed between 2004 to 2015. For the individual national markets, the data were used to provide appropriate average values. Based on these average values, a (unweighted) average was calculated and agglomerated in the overall considerations. [41]-[47] (and several national regulatory authorities).

In Figure 9, the agglomerated average broadband penetration over the considered countries in our model demonstrates that within the time period from 2004 to 2015 the penetration rate increased from 8 to 28 lines/inhabitant. In relative numbers, the score of the penetration in 2015 is 3.5 times higher than the score of the year 2004. The yearly growth of the broadband penetration level per inhabitant for the considered countries is 12.06%. Based on the considerations on the European and Asian countries, the reached broadband penetration rates differs quite heavily. On the one hand, some developed countries like Switzerland, Denmark, the Netherlands and South Korea reach broadband penetration rates per inhabitant between 40% and 50%, where Switzerland is the world leader with over 50% [49]-[51]. On the other hand, for example, the emerging economies of India (1%) and the Philippines (5%) have very low broadband penetration per capita, although it is not entirely due to the poorer economic data compared to the developed economies. Rather, the development of broadband penetration depends on several factors. Some of them, like competitive behavior, regulations and social economic basics (GDPC), we have already introduced in Section II. However, not all factors relevant to the evolution of broadband penetration rates can be fully captured. Also, cultural values and network effects influences the growth of broadband penetration. Furthermore, in the following regression analyses we also find a time effect. The time effect describes the fact that, in addition to the innovators, other market participants also consider the technology to be useful and adapt over time.

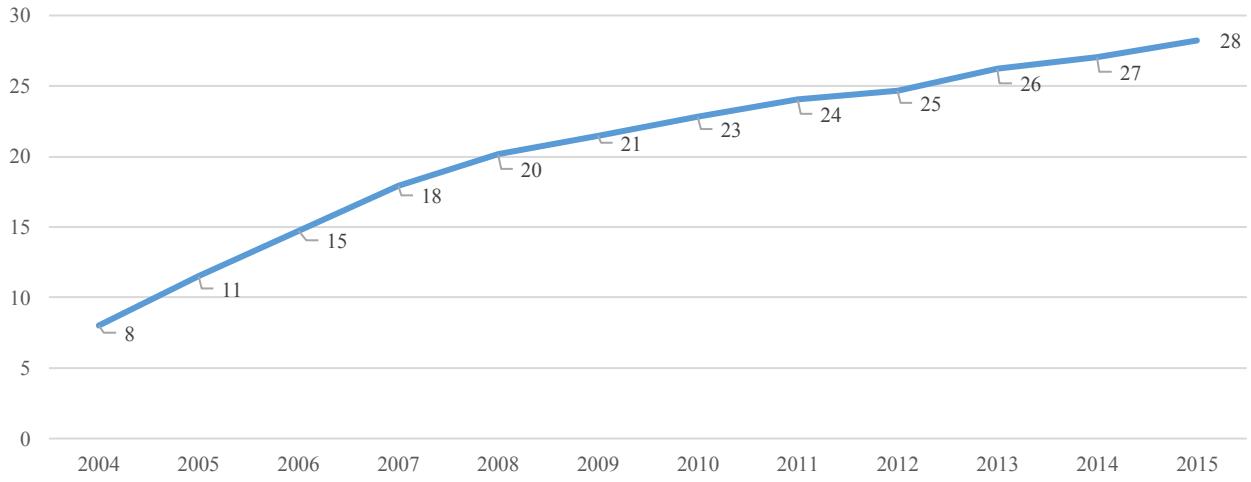

Figure 9. Average development of the broadband penetration of the considered broadband markets from 2004 to 2015 (x-axis: years; y-axis: access lines per 100 inhabitants)

Over time more and more people see the usefulness of this technology and will adopt this technology (in our case the broadband access). Normally, this behavior follows the distribution curve of Rogers [48]. We conclude here that more and more will adopt broadband accesses because they recognize their usefulness. This development we will cover with the so named time effect.

In the following, we will compare the results of the broadband penetration values of the considered countries in our model. Generally, in all countries the rising adoption of broadband accesses per inhabitants can be comprehended. However, in the consideration of Figures 10 to 13, the regional differences need to be addressed. All of the Scandinavian countries and the UK widely reach broadband penetration rates over 30% and therefore, all of them are quite above the calculated mean, which we have already visualized in Figure 9. Therefore, the Scandinavian countries and the UK can be seen as pioneers in broadband penetration. As mentioned above, Denmark is one of the leading providers, with broadband penetration of almost 42% per inhabitant (in 2015). Figure 10 shows that the United Kingdom and Iceland, with a broadband penetration rate of 37% in 2015, are close. In Figure 10, it can be followed that the big European countries like Germany, France, Spain and Italy reach broadband penetration rates between 25% and 40%. In average, these four countries present a quite good status of broadband penetration. Germany (37%) and France (40%) have nearly the same broadband coverage status as seen by the above-mentioned broadband frontrunners Denmark, South Korea and the Netherlands. However, in Spain (27%) and Italy (23%), broadband penetration is below average. For further economic development, it would be necessary for these countries to improve their broadband coverage.

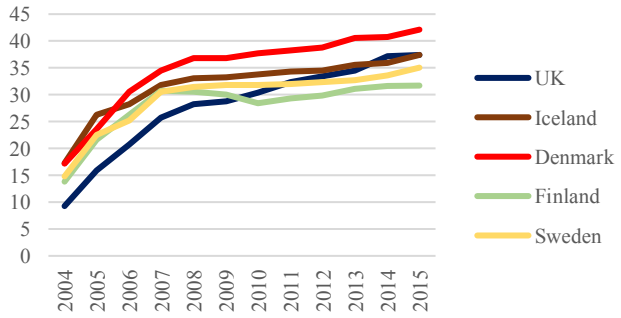

Figure 10. Average development of the broadband penetration rates of the Northern European countries of 2004 to 2015 (x-axis: years y-axis: penetration values per 100 inhabitants)

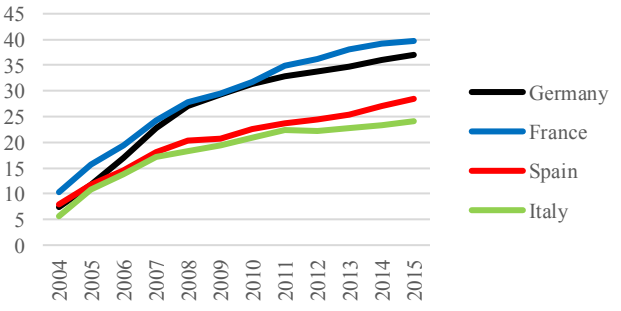

Figure 11. Average development of the broadband penetration rates of the "Big Four" European countries of 2004 to 2015 (x-axis: years y-axis: penetration values per 100 inhabitants)

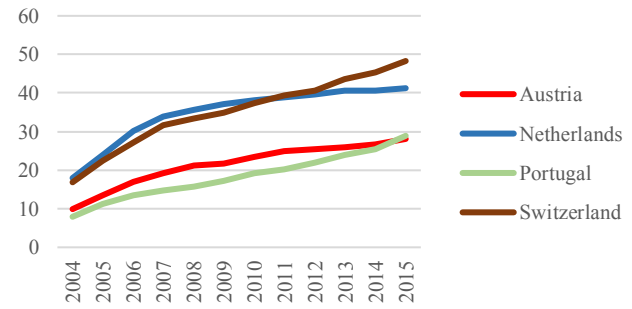

Figure 12. Average development of the broadband penetration rates of the Western European countries of 2004 to 2015 (x-axis: years y-axis: penetration values per 100 inhabitants)

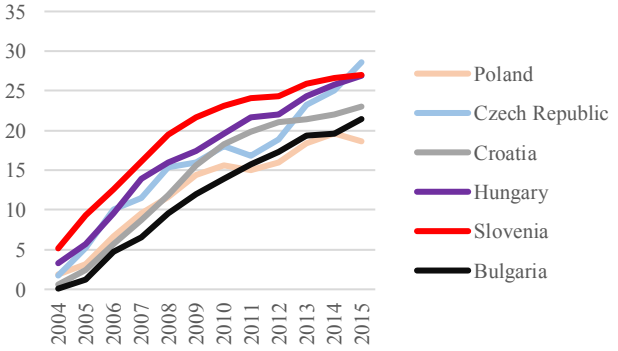

Figure 13. Average development of the broadband penetration rates of the Eastern European countries of 2004 to 2015 (x-axis: years y-axis: penetration values per 100 inhabitants)

Figure 12 illustrates that Switzerland and the Netherlands reach both broadband penetration rates over 40%. From the market review, it can be noted that both countries are counted as the world leaders in broadband penetration per inhabitants [49]-[51]. In 2015, Austria and Portugal, with 28% broadband penetration, have average broadband penetration in the range considered.

The Western and Northern European countries reach at least medium broadband penetration rates and some of them are the broadband penetration forerunners.

Regarding the situation in the Eastern European and the considered Asian countries, the broadband provision and adoption are quite divers. Figure 13 demonstrates that most of the Eastern European countries present a huge growth in the broadband penetration rates. However, only the Czech Republic reach a broadband penetration level quite above the average, which we have presented in Figure 9. Poland is one of the few considered European countries in the analysis, which does not reach a 20% fixed broadband penetration level. In average, the Eastern European countries vary in their broadband penetration between 21% and 28%, which present a lower level of broadband penetration in comparison to the Western and Northern European countries. Poland, with a penetration rate of only 19% (in 2015), is one of the broadband "laggards". Due to the different economic and socioeconomic developments, it can be assumed that the Eastern European countries do not reach the same broadband coverage as the Western and Northern European countries.

Despite that, all of the considered European countries are estimated as developed countries, the differences regarding the broadband penetration are the results from the past developments. It is necessary to mention that the Western and Northern European countries firstly reach the status of developed countries. The Eastern European countries reach this status in later stage of time. The fundamentals of the broadband infrastructure and broadband provision base on the developments and the implementation of the telecommunication networks in the past. Due to Eastern European countries begin on a later stage of the implementation of broadband infrastructures, the differences between the considered European countries can be comprehended.

The development of the broadband penetration rates and broadband networks in the Asian countries depends on the status of the whole country. The developed economies of Japan, South Korea, Singapore and Hong Kong have fairly high broadband penetration rates of between 25% and 40% (see Figure 14), with South Korea leading the pack with a penetration of 40% (in 2015). Overall, these four countries have a broadband penetration similar to Western and Northern European countries.

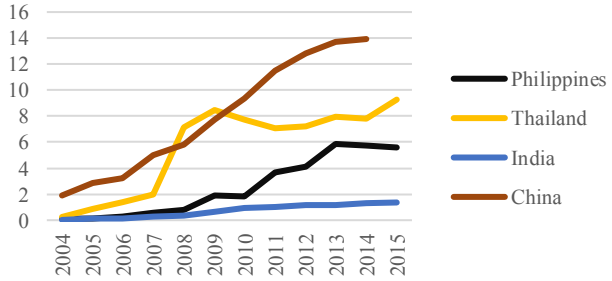

Figure 14. Average development of the broadband penetration rates of the emerging Asian countries of 2004 to 2015 (x-axis: years y-axis: penetration values per 100 inhabitants)

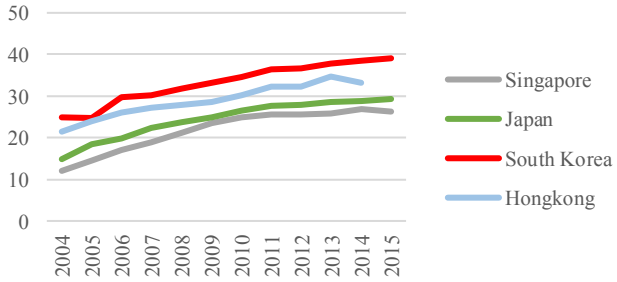

Figure 15. Average development of the broadband penetration rates of the developed Asian countries of 2004 to 2015 (x-axis: years y-axis: penetration values per 100 inhabitants)

However, the emerging countries in Asia do not reach a comparable level of fixed broadband penetration (see Figure 15). The considered countries Thailand, China and India fluctuate between 2% and 15% in terms of their broadband penetration. From the literature, it is already known that the level of broadband penetration depends on the economic situation of the country. We assume that if the named emerging countries would increase in their economic situation, they will also achieve a better broadband provision and better broadband penetration rates. For example, a very positive economic development has been observed in China over the past 10 years. In the same period, broadband penetration in China increased from 2% to nearly 15% (per capita). Looking at the other emerging economies in East and Southeast Asia, none of the countries considered reach the same development as China. At the end of the said 10-year period, only clearly low penetration rates were observed in India (1%), the Philippines (5%) and Thailand (8%). In Thailand, broadband penetration was in part even declining. As mentioned above, most of the recently developed and emerging countries do not have the same status of fixed broadband networks, and therefore supply is lacking. However, most countries are addressing this problem by introducing large and faster mobile broadband networks.

C. Price Analysis

Finally, we conclude the descriptive section with the consideration of the development of customer prices. Here, the data we gain mostly from the ITU [41] and OECD (Broadband Portal) [43]. In Figure 16, the development of the prices symbolizes that the monthly subscription fees decreased from an average fee of 27 Euro per month to nearly 18 Euro (including value added taxes) per month. This means in 2015, the level of the monthly subscription fees was only two thirds in comparison to the level of 2004.

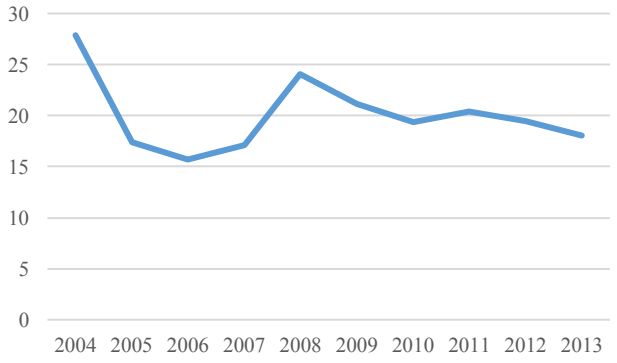

Figure 16. Average development of the monthly subscription fee in Euros from 2004 to 2015 (x-axis: years; y-axis: price values in Euros and price parity cleaned)

Combining the trends of the three considerations, we can conclude that the competition intensified, the penetration raised and customer prices decreased over the considered period. In addition to the achieved research hypotheses, the descriptive results give enough indications, which we will examine in the following section with the regression analyses.

V. REGRESSION ANALYSIS

A. Reliability and Validity Analysis

As introduced above, we proceed with a pooled ordinary least square regression. In the first step, the used concepts of regulations, competition and broadband penetration will be tested if the data can be trusted and if the data is reliable.

The results of the reliability analysis are visualized in Table III. For the further analysis, we use the following concepts: (a) regulations with a binary coding, (b) regulations with a year coding, (c) competition indexes, (d) broadband penetration rates, (e) prices, and (f) broadband connection speeds.

Following Cronbach, the Alpha values higher than 0.7 (0.6) stand for a good (acceptable) reliability [32][52][53]. Based on the results in Table III, 4 of the named concepts reach a good and 2 acceptable reliability.

After the testing of the reliability, the exploratory factor analysis includes the assessment of Kaiser-Meyer-Olkin criterion (KMO), the significance test from Bartlett, and the examination of the cumulative variances to evaluate the validity of the collected data [33][34][54]-[56]. To reach a good validity, the concepts should reach significant p values ($p<0.05$) in the Bartlett-Test and KMO values above 0.7 [33][34][54[56].

Table IV shows KMO-values above 0.6 (except the concept of competition indexes). Following Field [33] and Hair et al. [24], KMO-values above 0.6 describe an acceptable validity. For the concepts of the duration of the regulations, customer prices and broadband connection speeds, the KMO-values are even above 0.7, which indicate a good validity of the collected data/aspects. For the concept of the competition indexes, the validity of the achieved data could not be proved. The good validity scores (except competition indexes) are also supported by the significant results of the Bartlett-Test and the results of the cumulative variances higher than 50%, which indicate high explanation rates of the variances of the collected data [54]-[56]. Mostly, the reliability and validity of the collected data are proved.

B. Analysis of Variances

The consideration of the results of the analysis of variances (ANOVA) presents how the implementation of regulations affects in the mean, the developments of market concentrations, disparity and broadband penetration rates. Furthermore, we also implement a dummy variable if there is any influence if the specific country is a member of the European Union or the Association of Southeast Asian Nations (ASEAN). In the next steps, we present for the regulations displayed in Table V the model fit of the

ANOVA, the significance analysis if there would be a difference in means and how much would be the difference in average.

TABLE III. RELIABILITY ANALYSIS

Research Concepts	Cronbach's Alpha
Regulations (binary coding)	**0.662**
Regulations (duration coding)	**0.774**
Competition Indexes	**0.726**
Penetration Rates	**0.787**
Prices	**0.764**
Broadband Connection Speeds	**0.698**

TABLE IV. VALIDITY ANALYSIS

Research Concepts	KMO	Bartlett-Test	Cumulative Variance
Regulations (binary coding)	0.664	p< 0.000	60.24%
Regulations (duration coding)	0.780	p< 0.000	62.81%
Competition Indexes	0.526	p< 0.000	81.73%
Penetration Rates	0.651	p< 0.000	66.69%
Prices	0.713	p< 0.000	55.06%
Broadband Connection Speeds	0.702	p< 0.000	68.10%

Unbundling

Table V shows that the implementation of unbundling would lead to a significant difference in means of the development of broadband penetration. In comparison with the countries, which do not have implemented unbundling, the implementation of unbundling causes a five times higher broadband penetration per inhabitant in average. The F-Ratio is above the value of 3.87 [33] and therefore, a good model fit and a systematic variation is identified.

Furthermore, unbundling would lead to a significant difference in means in the consideration of the market concentration of the three biggest network operators. In average, countries, which have already implemented the unbundling regulation, have reduced market concentration values by HHI3 = 1,600 in mean. The systematic variation is better described than the unsystematic ones and due to a F-Ratio of 26.72 a good model fit is assumed.

Lastly, the examination of the difference in means in the consideration of the disparity of operators shows that in average, the implementation of the unbundling regulation is not significant. Consequently, there is no significant difference in means and a poor model fit. Due to the not existing difference in means, we possibly assume that unbundling would not affect the disparity of the network operators in a national broadband market.

Line Sharing

In Table V, we can also see that the implementation of line sharing would lead to a significant difference in means of the development of broadband penetration. Contrary to the countries, which do not have implemented line sharing, line sharing has averagely a 1.75 times higher broadband penetration per inhabitant. The F-Ratio is 44.58 and due to a value above 3.87 [33] a good model fit and a systematic variation can be concluded.

Additionally, line sharing is also a cause for the significant difference in means in the examination of the market concentration of the three biggest network operators. An implementation of line sharing would result in a 1,400 lower Herfindahl value. This indicates that the line sharing regulation could be an indicator for decreasing market concentrations. A systematic variation and a F-Ratio of 57.20 describe a good model fit.

The mean analysis of line sharing as influence factor for the development of disparities between the network operators illustrates no significant differences in means. The F-Ratio of 0.051 describes also a bad model fit. Consequently, we predict that line sharing would not possibly affect the changes in the disparity.

Bitstream

The implementation of bitstream lead also to significant differences in means for the development of broadband penetration. In comparison to the previously considered regulations of unbundling and line sharing, bitstream describes a slightly weaker effect, because countries, which have implemented bitstream, have only 1.4 times higher broadband penetration than countries, which did not implement bitstream as regulation for the broadband market. The F-Ratio is quite above the value of 3.87 [33] and therefore, a good model fit and a systematic variation can be concluded.

In comparison to the previous considered regulations of unbundling and line sharing, the results of the competition analyses are quite reversed. The implementation of bitstream do not imply a significance in means. The F-Ratio describes with a value of 0.92 a poor model fit [33]. Hence, we expect that bitstream does not change the relations of market concentrations in the considered broadband markets.

Oppositely, we identify a significant difference in means in the consideration of the implementation of bitstream. However, countries, which have implemented the bitstream regulation, possess in average a 1.2 times higher LI-value than countries, which did not implement this kind of regulation. Thus, bitstream would lead in average to a bigger disparity between the biggest network operator and the two following ones. The mean analysis describes a F-Ratio of 49.15, which covers a good model fit. The systematic variation is better than the unsystematic ones.

TABLE V. RESULTS OF THE ANALYSIS OF VARIANCES

ANOVA	Penetration per Inhabitant	HHI – Market Concentration	LI - Disparity
Unbundling	F-Ratio = 64.68 p < 0.05 good model fit difference in means	F-Ratio = 26.72 p < 0.05 good model fit difference in means	F-Ratio = 3.83 p > 0.05 bad model fit no difference in means
Line Sharing	F-Ratio = 44.58 p < 0.05 good model fit difference in means	F-Ratio = 57.20 p < 0.05 good model fit difference in means	F-Ratio =0.051 p > 0.05 bad model fit no difference in means
Bitstream	F-Ratio = 24.18 p < 0.05 good model fit difference in means	F-Ratio = 0.92 p > 0.05 bad model fit no difference in means	F-Ratio = 49.15 p < 0.05 good model fit difference in means
Resale	F-Ratio = 0.06 p > 0.05 bad model fit no difference in means	F-Ratio = 28.03 p < 0.05 good model fit difference in means	F-Ratio = 0.105 p > 0.05 bad model fit no difference in means
VULA	F-Ratio = 16.11 p < 0.05 good model fit difference in means	F-Ratio = 7.20 p < 0.05 good model fit difference in means	F-Ratio = 0.267 p > 0.05 bad model fit no difference in means
Fiber Regulation	F-Ratio = 17.36 p < 0.05 good model fit difference in means	F-Ratio = 28.03 p < 0.05 good model fit difference in means	F-Ratio = 0.211 p > 0.05 bad model fit no difference in means
Membership	F-Ratio = 0.20 p > 0.05 bad model fit no difference in means	F-Ratio = 4.33 p < 0.05 good model fit difference in means	F-Ratio = 1.034 p > 0.05 bad model fit no difference in means

Resale

Compared to the other regulations, the implementation of resale does not lead significant differences in means of broadband penetration rates. The F-Ratio of 0.06 describes nearly no change in means and the value illustrates a bad model fit [33].

However, the implementation of resale lead in average to a change of market concentration. The ANOVA is significant, which covers a significant difference in means. The value of the F-Ratio is 28.03, which implies a good model fit. National broadband markets, which have implemented resale as regulation, have averagely a 1,000 lower Herfindahl value than the countries, which have not implemented this kind of regulation. Consequently, we assume here that the resale regulation would lead to a reduced market concentration and a higher intensity of competition.

Finally, the implemented resale regulation does not lead to a significant difference in the mean analysis and the F-Ratio is quite poor, which indicates a bad model fit. We expect here for the further analysis that the resale regulation does not lead to significant changes in the development of the disparity between the operators.

VULA

Additionally, there is also a significant difference in means in the consideration of the average broadband penetration per inhabitant. Averagely, the implementation of VULA would lead to 1.38 times higher broadband penetration in comparison to the countries, which refuse the implementation of the VULA regulation. The F-Ratio is above the value of 3.87 [33] and therefore, a good model fit and a systematic variation is identified.

Considering the influence in the developments of the means in market concentration and penetration regarding the implementation of VULA, the means of the regarded market concentrations are significantly lower in the case, when the regulatory authority have decided to implement the VULA regulation. An implementation of VULA results in a 700 lower Herfindahl value. In average, the Herfindahl values are 700 less when VULA is implemented. In comparison to the previously considered significant model fits, the F-Ratio with a value of 7.20 indicates a quite weak significant model fit. Generally, the implementation of the VULA regulation lead to a higher intensity of competition and a lower market concentration.

In consideration of the impact of the implementation of VULA on the development of the disparity between the

network operators, there is no significant difference in means and a poor model fit. Due to the not existing difference in means, we possibly assume that the VULA regulation would not affect the disparity of the network operators in a national broadband market.

Fiber Regulation

Lastly, there will be now considered how would be the impact of possible implemented fiber regulation on the development of the broadband market. Unlike the other regulations, fiber regulation means different kind of access regulations in general and do not itemize a specific regulation. Based on the analysis of variances, we can see that fiber regulation could be also positive for the development of broadband penetration rates. On average, countries, which have implemented several fiber regulations, indicate a 1.28 times higher broadband penetration in comparison to countries, which do not have implemented them. The value of the F-Ratio is 17.356 and illustrates a good model fit.

Also, the implementation of fiber regulation reduces the market concentration in the considered broadband markets on average. There is a significant difference in means that countries, which have implemented fiber regulations, exhibits a 800 lower Herfindahl value than the countries, which refuse to implement fiber regulations. The systematic variation is better described than the unsystematic ones and due to a F-Ratio of 28.03 a good model fit is assumed.

The assessment of the difference in means in the consideration of the disparity of operators averagely shows that the implementation of fiber regulation is not significant. Concluding, there is no significant difference in means and the value of the F-Ratio is below 1 and describes a poor model fit. Due to the not existing difference in means, we possibly assume that fiber regulations do not lead to significant changes in the disparity of the network operators in a national broadband market.

Membership

In the last row, we have implemented the consideration of the influence of membership. We did this approach, because especially the European Union stipulates many regulatory approaches and the most countries follow these specifications. The consideration of the mean analysis regarding the impact of membership on the development of broadband penetration, no significance of the difference in means can be concluded. The value of the F-Ratio with 0.20 is also quite poor. Due to the broadband penetration development depends often on the national conditions, our expectation was here that the membership does not lead to a significant impact.

Contrary, membership leads to a significant difference in means when the market concentration values are considered. In average, countries, which are member in the EU or ASEAN, have a reduced Herfindahl value of 400. The F-Ratio of 4.33 is weakly above the critical bound of 3.87. However, the assumption can be hold and the model fits.

Lastly, membership does not lead to a significant difference in the mean analysis. The F-Ratio in Table V is below the above named bound and therefore, a poor model fit can be concluded. Despite the membership in a community can reduce the market concentration and would lead to more intense competition, the disparity between the operators exist further.

C. Further Approach

The first results of the regression analyses show that the calculated market concentrations correlate significantly (p-values below 0.05 [57]) with the development of the broadband connection speeds. The result supports the assumption that a stronger competition could lead to higher broadband connection speeds.

In addition, the same significant correlations between broadband penetration rates and market concentrations exist (p-values below 0.05 [57]). The correlations imply that higher competitive intensities and stronger competitive behaviors lead to rising broadband penetration rates.

Due to the focus on the impact of the regulatory behaviors on the market developments, we also find significant correlations (p-values below 0.05 [57]) between the single regulations unbundling, line sharing, bitstream, resale, fiber regulation, VULA (binary coding), and the development of market concentrations, broadband penetration rates and prices. Regarding the duration, how long the regulations are implemented in the specific broadband markets, the same significant correlations can be found.

However, the correlations between the regulations and the calculated market concentrations are negative (except for bitstream). Generally, regulations are able to reduce the concentration in a broadband market and increase the intensity of competition. Only the bitstream regulation correlates significantly positive with market concentrations. This indicates that the implementation and persistence of bitstream would strengthen the market power of the biggest network operators. If this relationship does really exist this kind of regulation does not fulfill the target of regulatory intervention. The governmental and regulatory intervention is performed to create better competitive market conditions and entrance possibilities for competitors. If a regulation strengthens the market power of one network operator (often the incumbent), then this kind of regulation should not be implemented.

Concerning the influence of the regulations on the development of broadband penetration rates, all different kinds of regulations support the growth of the broadband adoption and lead to a positive impact on broadband penetration. We will test this possible connection using also the pooled ordinary least square regression approach. The different regulations open various access possibilities to enter the broadband infrastructure, which means, new entrants come into the market with their own customers who may not yet have had access to these broadband structures. As a result, additional customers tend to be connected to the existing broadband infrastructure. In addition, the service providers are intensifying their customer acquisition

measures. Overall, the broadband penetration is thereby increased.

Finally, the implementation and the implemented duration of the regulations correlate significantly positive with the monthly subscription fees. This indicates that regulations would lead to increased prices.

Due to the status of a work in progress, the analyses are in an ongoing status and the results of the regression analyses are not finally completed.

VI. CONCLUSIONS AND FUTURE WORK

As aforementioned, the status of the paper is a work in progress and therefore, improvements in the results and in ongoing research will be necessary. Currently, we have collected the secondary data and have started to analyze the competitive intensities, broadband penetration rates and customer prices. Furthermore, we tested the reliability and validity of the collected data and we examined the data in the analysis of variances (ANOVA). Following this first overview, we will evaluate the above-mentioned hypotheses using the pooled ordinary least square regressions to test the established regression equations.

Despite the named conditions and the different developments in the national broadband markets, the general trend presents increasing competitive structures in fixed broadband markets. Combining the results of the HHI and LI analysis, the incumbents in each national broadband market have lost market shares and the disparity between the different providers is decreasing. As shown in the results, few countries (especially in Asia) still have very powerful incumbents and a general statement concerning all considered countries cannot be done at this status of work.

We have indicated that in all considered broadband markets, the fixed broadband penetration and adoption increase.

Finally, overall the customer prices decrease from 2004 to 2015. However, the examination over the recent years (2015 to 2017) shows that the monthly subscription fees are quite on a stable level.

At this time in evaluation work, the results are on an advanced but not final stage. For the concluding remarks in this topic, the ongoing research has to be deepened.

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