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# Tariff diversity and competition policy: Drivers for broadband adoption in the European Union

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# Tariff Diversity and Competition Policy – Drivers for Broadband Adoption in the European Union*

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July 2017

**Abstract**

While second-degree price discrimination is standard in commercial practice in many industries, consumer advocates and public interest groups have reacted with skepticism against tendencies to move away from flat rates and introduce greater tariff diversity. This paper provides an empirical analysis how the differentiation of broadband tariffs with respect to retail prices affects fixed broadband subscription using time-series data. The empirical analysis is based on a unique dataset of 10,200 retail broadband offers spanning the 2003–2011 period and including 23 EU member states. Results show that an increase in tariff diversity provides a significant impetus to broadband adoption, wherefore demands by some public interest groups to limit price discrimination in broadband markets should be viewed with some caution as reduced price discrimination may come at the cost of lower penetration rates.

*JEL classification:* L86, L96.

*Keywords: Broadband demand; Tariff diversity; Price discrimination; Dynamic panel data analysis.*

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# 1 Introduction

Increasing access to and usage of broadband internet has become a national policy priority for most governments since broadband penetration has been identified as a key driver for economic prosperity (e.g., OECD, 2008; ITU and UNESCO, 2013; Röller and Waverman, 2001; Czernich et al., 2011). However, positive economic effects can only materialize if subscribers make use of the deployed infrastructure, which is only partly the case. Notwithstanding substantial efforts, nearly 30% of Europeans had never been using the internet in 2010, and in 2015 still an 18% of EU population aged 16–74 had no usage history (Eurostat, 2015). Regarding Next Generation Access (NGA) networks, a recent study reveals that, for instance, in Germany only a small fraction of the deployed fibre infrastructure is actually used.[1]

As a result, in recent years a large body of empirical literature emerged, carving out determinants of broadband adoption (Denni and Gruber, 2007; Gruber and Koutroumpis, 2013; Kongaut and Bohlin, 2014; Briglauer, 2014), but despite a general consensus that the price level plays an important role, neither the determinants of broadband internet access prices nor the resulting pricing structure came under increased scrutiny. However, both seem utterly important to be analyzed to ensure sound regulation and competition policy in this sector.[2]

Broadband customers in the European Union have been used to choosing from a menu of broadband offerings, varying with respect to down- and upload speeds, contract duration, price structure, and possibly bundled services.[3] Differentiation strategies by Internet service providers (ISPs) on fixed and mobile broadband have broadly been accepted as legitimate business strategies and were generally not a matter of policy concern. However, price discrimination has generated a lively debate in some countries with some public interest groups demanding more uniform tariffs (see, e.g., Odlyzko et al., 2012; Lyons, 2013). Critics have claimed that market segmentation leads to consumer confusion and unjustified high prices in the presence of too much variety caused by too many tariffs. Price discrimination in the telecommunications sector, especially usage-based pricing (UBP), is thus seen as a serious threat to consumer welfare. Consequently, different policy actions aimed at

[1] FTTH Council Europe (2016), *Der FTTH Markt in Europa: Status, Ausblick und die Position Deutschlands*, only available in German, (see, https://langmatz.de/wp-content/uploads/2016/03/1-jan-schindler-ftthcouncil-der-ftth-markt-in-europa.pdf).

[2] Howell (2008) emphasizes that with price structures, such as flat-rates, where low-usage consumers extremely cross-subsidize high-usage customers, customers' true valuations of access and usage are obfuscated. In view of a lack of more precise information operators, regulators, and policy-makers might eventually make wrong decisions to invest or to regulate.

[3] Bundles may include any combination of broadband internet, fixed-line telephony, delivered via PSTN or VoIP telephony, TV or entertainment services as well as mobile voice and data services.

reducing or prohibiting differentiated pricing schemes. For example, the Data Cap Integrity Act of 2012[4] demands that "an Internet service provider may not impose a data cap on the consumers of the provider" (p. 3) and the more recent merger between the fixed broadband providers Charter Communications, Time Warner Cable, and Bright House Networks in 2016 was subject to the agreement to refrain from differentiated pricing practices by prohibiting usage-based pricing for seven years.[5] In addition, universal service obligations sometimes explicitly prohibit to differentiate prices geographically and/or between consumer types.[6]

On the other hand, academics and regulators have argued in favor of tariff diversity and have stressed its positive effect on broadband adoption and network management. Regarding the supply side, Lyons (2013), for example, considers pricing flexibility a useful tool for operators to spread network costs, to promote greater efficiency, and to recover costs that can be used to invest in future network infrastructure. Regarding the demand side, Bauer and Wildman (2012) show that tariff diversity gives consumers more choices to better fit their bandwidth needs by distinguishing between low-volume and high-volume users. Pointing out that especially inexperienced broadband users find it difficult to predict which online activities they will engage in and how much they will value them, low cost-low usage tier options can be used to incentivize broadband subscription for the first time.[7] The objective of this paper is to empirically test the relevance of this second effect.

So far, related studies have explored the determinants of (a) broadband demand and (b) broadband prices. The first strand examines socio-economic, geographic, and policy factors, such as income, level of urbanization, and the regulatory regime (e.g., Garcia-Murillo, 2005; Lin and Wu, 2013; Galperin and Ruzzier, 2013; Kongaut and Bohlin, 2014). Regarding inter- and intra-platform competition, the former is found to be a stimulus to broadband demand, whereas results for intra-platform competition are ambiguous (Distaso et al., 2006; Bouckaert et al., 2010; Gruber and

[4] Data Cap Integrity Act of 2012, S.3703 – 112th Congress (see, https://www.congress.gov/112/bills/s3703/BILLS-112s3703is.pdf).

[5] See the Memorandum Opinion and Order of the FCC from May 2016, FCC 16.59 (see, http://transition.fcc.gov/Daily_Releases/Daily_Business/2016/db0510/FCC-16-59A1.pdf).

[6] International Telecommunication Union (see, http://www.itu-coe.ofca.gov.hk/vtm/universal/faq/q1.htm).

[7] Demand for diversified offers is also prevalent in the TV market. In the US, for instance, the cable companies Verizon, Dish, and Cablevision started offering cheaper, slimmed-down bundles of dozens of TV channels as opposed to hundreds, and immediately saw a substantial shift from their installed subscribers and at the same time gained new subscribers (The Washington Post (2015), *Cable companies pare down bloated TV bundles to stem tide of cord-cutters* (see, https://www.washingtonpost.com/business/economy/cable-companies-pare-down-bloated-tv-bundles-to-stem-tide-of-cord-cutters/2015/09/18/ac67a0a8-5e53-11e5-b38e-06883aacba64_story.html).

Koutroumpis, 2013; Nardotto et al., 2015).[8] These findings challenge the viability of the existing regulatory framework. Currently it targets the effectiveness of wholesale broadband access regulation imposed on the incumbent's first generation network which, however, might impede the rollout of future ultra-fast networks (Briglauer, 2014; European Parliamentary Research Service, 2015). The second strand analyzes broadband retail prices and shows that data restrictions lead to lower prices and that increased quality, in terms of increased download-speed, drives prices upwards (Wallsten and Riso, 2010). Calzada and Martínez-Santos (2014) document that DSL-based offers are the most expensive and incumbents' prices exceed those of entrants. The latter may stem from their wider coverage, their reputation or the incumbents' concerns about the price-squeeze tests set by competition authorities.[9]

Yet, with the exception of Haucap et al. (2016), the empirical literature has been silent on the impact of retail pricing structures on demand, though the effect might be ambiguous. Price discrimination in the retail broadband market might either (a) increase demand by allowing suppliers to serve low-value customers without lowering the price for high-value customers, or (b) decrease demand, as consumers may become confused over the variety of tariffs, potentially intended to obfuscate them, and finally reluctant to sign a contract (Spiegler, 2006). The success of easy to grasp flat-rate tariffs, associated with a rather modest price difference between offerings, may suggest that simple tariffs in fact outclass more diverse and complicated offerings when it comes to fostering broadband demand.

In line with classical industrial economic theory that price discrimination enlarges output and demand, Haucap et al. (2016) provide empirical evidence that an increase in tariff diversity provides a significant impetus to broadband adoption. The authors use an instrumental variable approach to estimate demand for fixed broadband services in 82 countries. To measure tariff diversity on a country-level a dataset comprising over 1000 fixed-line broadband tariffs is used. However, and in comparison to the present study, their analysis is based on a cross-sectional dataset with a relative small number of analyzed fixed broadband plans and a majority of non-OECD countries. Consequently, the authors cannot take into account dynamic developments and their results may not be applicable to more technologically ad-

[8] Broadband competition can occur as facility-based competition between different technologies (e.g., DSL-, cable-, and fibre-based technologies), referred to as inter-platform competition, or as service-based competition over the same infrastructure through open access provisions at various network layers, referred to as intra-platform competition.

[9] Although retail prices are not a matter of continuing regulatory concerns in the EU anymore, they are assessed in order to prevent a "margin squeeze", which occurs when incumbents set wholesale and retail prices with a narrow margin such that a downstream firm cannot survive or effectively compete.

vanced countries like the European Union member states. This paper aims to fill this void.

The present paper analyzes how the differentiation of broadband tariffs influences fixed broadband demand including subscriptions to NGA networks. In the following, the term *tariff diversity* refers to the possibility that each broadband provider may offer potential customers a diversity of tariffs to choose from, each associated with a different level of quality. This is often referred to as usage-based pricing when referring to variation in tariffs associated with different bandwidths and data caps. We account for, first, second-degree price discrimination from selling tariffs with different download speeds, varying contract durations, tiered plans or volume- and time-based pricing and, second, third-degree price discrimination by selling to different consumer groups, e.g., offering 'student' or special 'internet starter' plans.[10] When price variation is associated with bundling, in which case individual prices are not cleanly identified, we are looking at implicit price discrimination which, however, is not the focus of this paper.[11] The analysis is based on a rich dataset that originally contains 10,200 residential retail broadband offers for 23 European states between 2003 and 2011. The econometric estimation explicitly accounts for endogeneity due to omitted variables or reverse causality. A multiplicity of measures for price dispersion in conjunction with a broad set of control variables ensures the robustness of the analysis.

The results indicate that broadband demand is positively related to increased tariff diversity, suggesting that policy makers should be lenient towards price discrimination in broadband markets as reduced price discrimination may come at the cost of lower penetration rates. Moreover, facility-based competition is found to be a stronger driver of broadband penetration than service-based competition. The intention of the European Commission to promote facility-based competition therefore seems to be the appropriate policy for regulators in order to further promote broadband adoption.

The remainder is structured as follows: Section 2 outlines the empirical strategy and provides a detailed description of the dataset. Results are presented in Section 3, Section 4 concludes.

[10]Note that the analysis does not directly test the effect of UBP versus flat-rate pricing, as nicely done in Nevo et al. (2016) for broadband usage. We rather look at price dispersion at an aggregated level, accounting for different forms of second-degree and third-degree price discrimination. Hence, the observed tariff diversity is inevitably influenced by the difference of metered and unlimited offers, but not exclusively.

[11]The impact of bundles is evaluated as a robustness check, see Section 3.2.

# 2 Model specification and data

## 2.1 Empirical strategy

In line with previous empirical research, broadband adoption is specified as a function of the competitive environment as well as topographic and socio-demographic factors, such as population density and economic prosperity. Plan-specific variables are included and network effects are accounted for by adding the lagged dependent variable. Following Kim et al. (2003) and Cava-Ferreruela and Alabau-Muñoz (2006), the dynamic reduced-form model of fixed broadband adoption for country $i$ at time $t$ reads

$$fbb\_sub_{it} = \alpha_0 + \beta_0 fbb\_sub_{i(t-1)} + \gamma^{'}\mathbf{T}_{it} + \delta^{'}\mathbf{C}_{it} + \varphi^{'}\mathbf{X}_{it} + \theta_i + \lambda_t + \epsilon_{it}, \quad (1)$$

where $fbb\_sub$ denotes the number of broadband subscriptions. $\beta_0$ measures endogenous growth in terms of network effects. If the process is stationary, it holds that $|\beta_0| < 1$. $\mathbf{T}_{it}$, $\mathbf{C}_{it}$, and $\mathbf{X}_{it}$ are vectors of tariff characteristics, market structure as well as demand and costs controls, respectively. Equation (1) also contains country-specific effects, $\theta_i$, and period effects, $\lambda_t$, to control for unobserved heterogeneity across countries and periods, plus an unobservable error term, $\epsilon_{it}$.

### 2.1.1 Independent variables

The key tariff characteristics in vector $\mathbf{T}_{it}$ are the monthly access price, the measures for price dispersion, and the advertised download speed. For the price variable a negative effect on broadband adoption is predicted. In accordance with classical industrial economics that price discrimination in final consumer markets may lead to an expansion of output and demand, a positive relationship between tariff diversity and the number of broadband subscribers is expected.[12] The average connection speed is another relevant tariff characteristic that resembles the quality of service. Increased download/upload speeds are predicted to positively affect consumers' willingness to pay, thereby increasing demand for broadband services for a given price level.

In $\mathbf{C}_{it}$ the following market structure related variables are subsumed: (i) the intensity of facility-based competition, (ii) the degree of service-based competition,

[12] To account for a potential non-linear effect of price discrimination on demand, as too much variety in pricing schemes may eventually make consumers reluctant to buy, a quadratic term was added which, however, turned out to be insignificant irrespective of the underlying measure. Results are not reported but available upon request.

and (iii) the extent of fixed-to-mobile substitution. As suggested by several studies, a positive effect of facility-based competition on adoption is expected. Given that DSL remains the main form of delivery for broadband services in most European countries, we account for intra-platform competition between different DSL providers. Furthermore, it is common in the telecommunications industry that carriers are active in multiple market segments, causing interdependencies. Whilst incumbent operators may be able to leverage their position in the fixed telephony and narrowband market into the broadband market, the market power of fixed broadband operators is likely constrained by mobile services since mobile telephony subscribers often access the internet via their smartphones. Hence, mobile operators enter into competition with fixed broadband providers. The phenomenon of fixed-to-mobile substitution (FMS), that is an increasing importance of mobile telephony at the expense of fixed telephony, has been studied intensively (e.g. Ward and Woroch, 2010; Barth and Heimeshoff, 2014; Grzybowski and Verboven, 2016; Lange and Saric, 2016) and it has been shown that FMS even affects the broadband market. According to Briglauer (2014), FMS and NGA adoption follow an inverted U-shaped relationship. On the one hand, competition in the legacy market incentivizes investments to escape the competition and gain a firm position in the new frontier market, leading to a positive relationship ("escape competition effect"). On the other hand, too pronounced competition may lower rents and investment capital, eventually yielding a slower average innovation rate and less broadband deployment and adoption in the case at hand ("Schumpeterian effect").

Vector $\mathbf{X}_{it}$ includes supply and demand controls. The costs of deploying and operating networks depend to a large extent on the underlying technology, population density, population dispersion, and geographic conditions. A higher population density and/or a larger share of urban inhabitants allow carriers to exploit economies of scale as they are enabled to connect more subscribers to the deployed infrastructure. The rollout per capita is therefore less costly and broadband supply should be promoted. The baseline demand controls are population size, income, and PC penetration. All are predicted to increase broadband adoption via different channels. With the number of broadband connections as the dependent variable, we include the overall number of inhabitants since ceteris paribus a larger population should induce more connected broadband lines. Increases in economic prosperity allow to spend more on information and communication services and PC availability is a prerequisite for fixed broadband usage.

### 2.1.2 Estimation and identification strategy

The dynamic setup induces potential endogeneity problems that are tackled by using the Arellano-Bond Generalized Method of Moments (GMM) estimator (Arellano and Bond, 1991). Other estimation approaches, for example, pooled OLS, fixed-effects or (bias-corrected) least-squares-dummy-variables estimator (LSDVC), are inappropriate in view of the present analysis.[13] We apply the difference GMM instead of the more efficient system GMM estimator since the latter suffers from inconsistency if explanatory variables and individual time-invariant effects are correlated (cf. Arellano and Bover, 1995; Blundell and Bond, 1998). Individual time-invariant effects capture a broad range of unobserved factors such as consumer preferences, geographic characteristics, and initial infrastructure stock. Each of these variables is correlated with retail prices and subscription levels, rendering the system GMM estimator inconsistent (see, e.g., Grzybowski, 2014; Grzybowski and Verboven, 2016).

The difference GMM estimator eliminates the country-specific effects, $\theta_i$, and the associated omitted-variable bias by applying a first-difference transformation.[14] Taking first differences, however, induces another source of endogeneity: the lagged dependent variable becomes correlated with the error term. In addition, there are further concerns about endogenous variables. First, observed retail prices are determined by the interaction between supply and demand and are consequently endogenous. Second, due to unobserved demand and supply shocks, the measures of tariff diversity and the market structure variables are likely to be endogenous, too. Third, we face reversed causality between broadband adoption and economic prosperity as increased income may raise telecommunications infrastructure investments which in turn boost future income (see, Röller and Waverman, 2001; Czernich et al., 2011).

Following Arellano and Bond (1991), endogeneity in the first-differenced equation is addressed by applying an instrumental variable approach. The GMM estimator allows to use external as well as internal instruments. Internal instruments are lags

[13]Results from a pooled OLS estimation are inconsistent because the unobserved time and regional effects are disregarded and the lagged dependent variable is correlated to the error term (Roodman, 2007). Employing a fixed-effects model does not resolve the problem either. The demeaning transformation produces inconsistencies due to the large cross-sectional but small time dimension of the dataset (Nickell, 1981). Finally, the LSDVC estimator for dynamic unbalanced panel-data models requires strict exogeneity of all regressors (Bruno, 2005a,b), which is an unfulfillable assumption in the conducted study.

[14]Estimating Equation (1) in differences also avoids spurious correlations which occur when non-stationary time series are used in a regression model. For further information see Hamilton (1994). Testing for the presence of a stochastic trend in each variable, we find that the dependent variable is stationary whereas the explanatory variables are integrated of order-zero or order-one. Hence, the specification does not suffer from the spurious correlation problem and cointegration cannot be present. For brevity, results of the Maddala-Wu unit root test are not reported but available upon request.

of the independent, but potentially endogenous, variables. We employ lagged levels as instruments for (i) the lagged dependent variable, (ii) all price-related variables (prices, diversity measures, and income), and (iii) the market structure variables. With contract durations up to 24-months and half-yearly data, the fourth lags of the respective variables are implemented. Earlier lags may still be correlated with the error term and would not resolve the endogeneity problem. Besides the inclusion of lagged variables, the instrumentation strategy relies on external instruments in the tradition of Hausman (1996) based on neighboring effects. This type of instrument is applied for the retail price as well as the five different measures of price diversity. This instrumentation strategy is reasonable if geographical and thus cost conditions are comparable across neighboring countries but demand shocks are on a national level. For each of the price-related variables the average in the neighboring countries is calculated and then incorporated as an instrument. Using averages levels out potential differences in the geographical and cost conditions across neighboring countries.

## 2.2 Data

Most of the data is drawn from Analysys Mason. Data on the subscription levels are retrieved from Analysys Mason's 'Telecoms Market Matrix' and all tariff specific information (prices, speed, bundled services, and usage allowance) from the 'Tripleplay pricing study'[15]. The data on broadband tariffs cover in total 10,200 residential retail broadband offers by incumbent and entrant operators encompassing both the commercial and technical characteristics over the period 2003–2011 on a semi-annual basis from 23 European countries.[16] Further supply and demand controls are taken from Eurostat, the World Bank, and the Heritage Foundation. Prices and income are measured in euros and deflated using the consumer price index. All price-related variables, the numbers of subscribers, and the population size are expressed in logarithms in Equation (1) in order to be interpreted as elasticities. Summary statistics in levels are stated in Table 1 and a detailed description of the dataset, including the variables used for robustness checks, is provided in Table A2.

Fixed broadband adoption is represented as the number of active retail subscribers, constituting the sum of actively used DSL, cable modem, residential fibre, and other fixed broadband connections (including satellite, broadband over power

[15] Analysys Mason's 'Tripleplay pricing study' is an international benchmarking survey covering DSL, cable modem, and residential FTTB-based multi-play services for consumers. To ensure data reliability, the information is directly gathered from the companies profiled.

[16] All countries included in this study are listed in Table A1. Not all countries enter the data in 2003, thus we have an unbalanced panel.

Table 1: Summary statistics

| Variable | Measured in | Mean | Std. Dev. | Min. | Max. | N |
|---|---|---|---|---|---|---|
| *fbb_sub* | Subscribers | 4716463 | 5896244 | 32000 | 26902000 | 324 |
| *fbb_price* | Euro | 21.17 | 22.02 | 0.67 | 150.56 | 324 |
| *diversity_sd* | Euro | 17.62 | 15.30 | 0.16 | 98.19 | 324 |
| *diversity_minmax* | Euro | 58.58 | 55.56 | 0.22 | 352.69 | 324 |
| *diversity_minmean* | Euro | 15.45 | 14.34 | 0.11 | 87.39 | 324 |
| *diversity_admedian* | Euro | 11.16 | 9.33 | 0.11 | 49.69 | 324 |
| *diversity_admean* | Euro | 12.85 | 11.01 | 0.11 | 73.64 | 324 |
| *speed* | Mbps | 15.18 | 20.52 | 0.44 | 212.10 | 324 |
| *pc_hh* | 0–1 | 0.68 | 0.14 | 0.29 | 0.97 | 324 |
| *gdp_percapita* | Euro | 6700.80 | 2732.30 | 1459.79 | 12618.30 | 324 |
| *hhi_inter* | 0–1 | 0.58 | 0.17 | 0.34 | 0.97 | 324 |
| *hhi_intra* | 0–1 | 0.77 | 0.17 | 0.50 | 1.00 | 324 |
| *population* | Inhabitants | 24063292 | 25343032 | 1327439 | 82534176 | 324 |
| *urban* | 0–100 | 73.22 | 11.70 | 49.88 | 97.72 | 324 |
| *pop_density* | Inhabitants per km$^2$ | 146.24 | 118.23 | 17.17 | 496.39 | 324 |
| *fms* | 0–1 | 0.22 | 0.07 | 0.08 | 0.42 | 324 |
| *fms_sq* | 0–1 | 0.05 | 0.04 | 0.01 | 0.18 | 324 |
| *bundles_share* | 0–1 | 0.40 | 0.34 | 0 | 1 | 324 |
| *caps_share* | 0–1 | 0.54 | 0.47 | 0 | 1 | 324 |
| *cost_cons* | Percentage (2010=100) | 105.37 | 29.56 | 67.41 | 254.66 | 314 |
| *investment_freedom* | 0–100 | 76.42 | 11.20 | 50 | 95 | 324 |
| *business_freedom* | 0–100 | 80.77 | 10.55 | 53.7 | 100 | 324 |
| *telecom_rev* | Euro | 1400657284 | 1596697482 | 55694072 | 5617589760 | 311 |
| *inter_high* | 0/1 | 0.66 | 0.47 | 0 | 1 | 324 |
| *mobile* | Subscribers | 901478 | 1237031 | 7535 | 6175000 | 256 |
| *av_fbb_price* | Euro | 19.51 | 16.81 | 1.26 | 122.30 | 324 |
| *av_diversity_sd* | Euro | 17.34 | 10.44 | 0.97 | 49.35 | 324 |
| *av_diversity_minmean* | Euro | 15.02 | 11.49 | 0.65 | 77.39 | 324 |
| *av_diversity_minmax* | Euro | 57.95 | 39.03 | 2.69 | 200.05 | 324 |
| *av_diversity_admedian* | Euro | 10.93 | 6.99 | 0.52 | 35.85 | 324 |
| *av_diversity_admean* | Euro | 12.56 | 7.92 | 0.70 | 36.40 | 324 |

lines, and WiMax).[17] The price variable, *fbb_price*, refers to the average monthly subscription charge for fixed broadband internet service per Mbps download speed.[18] The monthly price is calculated from the 10,200 original tariffs as the unweighted average per country and period. *fbb_price* reflects the access charge plus any extra access charges from the incumbent for line rental and excluding promotional discounts. For flatrate tariffs these charges equal the final bill whereas they constitute a lower boundary for capped or volume- and time-based tariffs.

The measures for a country's tariff diversity are based on the original dataset likewise, but only including broadband-only offers. Precisely, tariff diversity is calculated as the following five measures of central tendency per country and period: the standard deviation (*sd*), the difference between minimum and mean (*minmean*), the difference between minimum and maximum (*minmax*), the average absolute deviation from the median (*admed*), and the average absolute deviation from the mean (*admean*). As consumption decisions might be somewhat sluggish due to habits and contractual obligations, the price and diversity measures are lagged by one period.

The variable *speed* is calculated as the unweighted average download speed in country $i$ at time $t$ using all 10,200 offered tariffs. It refers to the average advertised maximum download speed in Mbps and not to speeds guaranteed to users associated with a monthly subscription. The realized speed might vary due to congestion or the distance between the households and its ISP's cabinet.

The intensity of competitive rivalry between different technologies is expressed as the Herfindahl-Hirschman Index (HHI) of DSL, cable, fibre as well as all other fixed broadband technologies and is denoted by *hhi_inter*. Service-based competition, *hhi_intra*, is calculated as the HHI between the incumbent's and the entrants' share in the national DSL market. The HHI is defined as the sum of technologies' (operators') squared market shares. A higher HHI is equivalent to a more asymmetric market structure, implying less competition between the technologies (operators). The intensity of fixed-to-mobile substitution (*fms*) is expressed as the share of fixed landlines in the total number of fixed landlines and mobile telephony subscriptions.

The included cost conditions are *pop_density*, measured as the number of inhabitants per km$^2$ of land area, and *urban*, the share of urban population. Since these

[17] Other metrics commonly used refer to fixed-line broadband penetration levels measured in 100 of population (e.g., used in Cava-Ferreruela and Alabau-Muñoz, 2006; Lee et al., 2011; Gulati and Yates, 2012; Lin and Wu, 2013) or in 100 of households (Höffler, 2007; Galperin and Ruzzier, 2013). Results do not change qualitatively if the model is estimated with these alternative specifications.

[18] Standardizing the price with the download speed is common in the empirical literature to capture quality differences (Kongaut and Bohlin, 2014; Garcia-Murillo, 2005; Lin and Wu, 2013; Lee et al., 2011). Unfortunately, there is no information available about the number of subscribers to each plan, consequently the price is calculated as an unweighted average per country and period.

supply controls vary within countries, some information on the local heterogeneity of access markets is lost by using national averages, however, it is reasonable to assume that the effects of these drivers are visible at an aggregated level. Income is measured as the quarterly GDP per capita (*gdp_percapita*) and *pc_hh* expresses the percentage of households with access to a PC over one of its members.[19] Network effects are considered by adding the lagged dependent variable which denotes the aggregate demand in the previous period and measures the installed subscriber base.

# 3 Empirical results

Estimation results from the baseline specification, incorporating the different measures of tariff diversity, are presented in Table 2. Columns (1)–(5) state the results measuring tariff diversity by the standard deviation of retail prices (*sd*), the difference between minimum and mean (*minmean*), the difference between minimum and maximum (*minmax*), the average absolute deviation from the median (*admed*), and the average absolute deviation from the mean (*admean*), respectively.

Due to the first-difference transformation of the GMM estimator, the residuals have a moving average structure and are possibly first-order autocorrelated. The null of no autocorrelation is rejected for AR(1) and AR(2) but not for a higher order, confirming that deeper lags have to be used as instruments. Serial correlation at order one in the first-differenced errors is a consequence of the transformation and does not imply that the model is misspecified. Autocorrelation of a higher-order AR($s$), however, indicates that the moment conditions are not valid and that the $s$-th lag of the dependent variable is not a valid instrument. To test for the exogeneity of the included instruments, the Sargan-Hansen's $J$ test is applied. With $p$-values between 0.15 and 0.40, the test statistics indicate that the null hypothesis of valid over-identifying restrictions cannot be rejected in either regression. The reported standard errors are robust to arbitrary forms of heteroscedasticity and autocorrelation.

## 3.1 Main results

Irrespective of the included measure of tariff diversity, all significant variables have the expected signs. The lagged subscription level, $fbb\_sub_{t-1}$, is highly significant and substantial (0.64–0.66), pointing to the importance of network effects which

[19]Note that the information presented covers only desktop PCs and that this particular market has been relatively stagnant in recent years as an increasing share of people have chosen to buy more portable formats, such as laptops, netbooks or tablets.

Table 2: Main results

| **Dependent variable**: *fbb_sub* | (1) | (2) | (3) | (4) | (5) |
|---|---|---|---|---|---|
| L.*fbb_sub* | 0.642*** | 0.645*** | 0.642*** | 0.642*** | 0.662*** |
| | (0.059) | (0.062) | (0.067) | (0.059) | (0.059) |
| L.*fbb_price* | -0.054** | -0.060** | -0.040** | -0.054* | -0.048* |
| | (0.028) | (0.029) | (0.019) | (0.030) | (0.027) |
| L.*diversity_sd* | 0.039* | | | | |
| | (0.022) | | | | |
| L.*diversity_minmean* | | 0.044* | | | |
| | | (0.024) | | | |
| L.*diversity_minmax* | | | 0.028* | | |
| | | | (0.016) | | |
| L.*diversity_admedian* | | | | 0.039* | |
| | | | | (0.023) | |
| L.*diversity_admean* | | | | | 0.034* |
| | | | | | (0.021) |
| *speed* | 0.000 | -0.000 | 0.000 | 0.000 | -0.000 |
| | (0.001) | (0.001) | (0.001) | (0.001) | (0.001) |
| *hhi_inter* | -0.949** | -0.996** | -1.021*** | -0.931** | -0.924** |
| | (0.410) | (0.417) | (0.365) | (0.407) | (0.401) |
| *hhi_intra* | -0.129 | -0.0961 | -0.150 | -0.0897 | -0.106 |
| | (0.151) | (0.143) | (0.155) | (0.145) | (0.139) |
| *fms* | 4.331** | 3.795*** | 4.073*** | 4.548*** | 4.275*** |
| | (1.736) | (1.398) | (1.538) | (1.734) | (1.620) |
| *fms_sq* | -8.435*** | -7.875*** | -8.447*** | -8.880*** | -8.333*** |
| | (3.260) | (2.739) | (3.008) | (3.313) | (3.084) |
| *pop_density* | -0.002 | 0.003 | 0.003 | 0.001 | 0.001 |
| | (0.012) | (0.012) | (0.013) | (0.013) | (0.012) |
| *urban* | 0.026 | 0.009 | 0.001 | 0.020 | 0.025 |
| | (0.028) | (0.036) | (0.031) | (0.032) | (0.027) |
| *gdp_percapita* | 0.295*** | 0.240*** | 0.279*** | 0.312*** | 0.305*** |
| | (0.076) | (0.061) | (0.069) | (0.078) | (0.077) |
| *pc_hh* | 1.095*** | 1.158*** | 1.064*** | 1.029*** | 0.965*** |
| | (0.368) | (0.368) | (0.332) | (0.361) | (0.334) |
| *population* | 1.314 | 0.557 | 0.799 | 1.228 | 1.062 |
| | (1.063) | (0.971) | (0.920) | (1.060) | (1.050) |
| *N* | 301 | 301 | 301 | 301 | 301 |
| Sargan Test $\chi^2$-stat | 80.65 | 76.68 | 75.48 | 84.24 | 85.39 |
| p-value | 0.25 | 0.36 | 0.40 | 0.17 | 0.15 |
| AR(4), Prob>$z$ | 0.09 | 0.10 | 0.10 | 0.10 | 0.10 |

Heteroscedasticity and autocorrelation robust standard errors in parentheses.
Significance levels: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.
All regressions include a constant as well as a linear and squared time trend which are not reported for brevity.

autonomously push adoption in the broadband market. The retail price elasticity is negative and with coefficients between -0.04 and -0.06, the long-run elasticities are estimated to lie in the interval [-0.168, -0.112].[20] In the long-run a price decrease of 10% induces an increase of 52,824–79,237 connections on average which, for instance, nearly resembles half of the fibre-based connections in Germany at the end of 2011.

The coefficients of the diversity measures are positive and significant in each specification, verifying the findings in Haucap et al. (2016). Although the coefficients are only weakly significant at the 10%-level (and for some robustness checks at the 5%-level), the persistent positive signs suggest that there is in fact a positive effect. Regarding the economic significance the effect is less pronounced than for prices, but still noticeable. A 10% increase in tariff diversity, results on average in nearly 50,000 new connections in the long-run. Supporting the classical perspective, price differentiation and diversified tariff structures seem to increase broadband adoption, most likely by attracting consumers with a low willingness to pay. This effect seems thus to prevail a potential negative effect from segmenting consumers to extract more surplus. Consequently, the results suggest that prohibiting price-discrimination can impede broadband adoption as some consumers may not find a suitable offer. Claims that merely flat-rate tariffs, associated with a modest level of price dispersion, should be offered should therefore be viewed with some caution.[21]

Regarding the market structure variables, we observe a clearly negative impact of concentration in the fixed broadband market, or put differently, a positive impact of facility-based competition. The same does not hold for service-based competition. Following Nardotto et al. (2015), a possible explanation might be that local loop unbundling entry only triggered broadband subscriptions in the early stage of adoption, but no longer when the market matured. The current emphasis on regulated wholesale access with the objective of encouraging investments by both incumbents and entrants might not be as effective as promoting inter-platform competition. In line with this finding, the European Commission aims at re-designing the regulatory framework in order to encourage investments in new but capital intensive ultra-fast broadband networks, since the current telecommunications policies and regulation

[20]One advantage of the dynamic estimation approach is the possibility to disentangle short and long-run elasticities. While the short-run elasticities are directly estimated as the coefficients $\gamma_i$, $\delta_i$, and $\varphi_i$, the long-run elasticities can be easily obtained as the fraction of the coefficient and the "speed of diffusion", $1 - \beta_0$.

[21]From a dynamic perspective, as argued by Heatley and Howell (2010), price-discrimination can also enable firms to increase welfare by accessing scale economies (static efficiency gains) and to introduce a new technology earlier than under the counterfactual of a single price by capitalizing on economies of scale arising from a steeply-decreasing average cost curve (dynamic efficiency gains). The latter aspect might be especially important for fibre-based technologies given that its demand is still modest in many countries.

seem to oppose these attempts (European Parliamentary Research Service, 2015). As in Briglauer (2014), a non-linear relationship with respect to *fms* is detected. The optimal competitive market condition for broadband adoption is estimated to range between 24.1% and 25.7%. An European average of $\overline{fms} = 22.1\%$ suggests that the escape competition effect is dominated by the Schumpeterian effect; fierce competition in the voice market might have slowed down the deployment of (ultra-fast) broadband and its adoption.

The demand controls are positive and highly significant, providing evidence that adoption increases in income and pointing to the necessity of complementary products and skills and overall ICT affinity (cf. Bauer et al., 2014). In contrast, neither *speed* nor one of the cost controls is statistically different from zero which is likely due to the low degree of variation and the aggregation at the national level.

## 3.2 Robustness checks

This section presents additional estimations which confirm the findings from the previous section (see Tables A3–A7 in the Appendix).[22] Regarding the main variable of interest, we find a positive effect of the degree of price-discrimination throughout all specifications. Thus, irrespective of the measure of tariff diversity and the included control variables, price-discrimination in the broadband market is found to foster adoption.

We start by investigating whether the results are driven by low income countries, as one could infer from Haucap et al. (2016). In order to test whether the positive effect of tariff diversity persists for higher incomes and probably more data-intensive broadband demand, the sample is split in half by restricting the analysis to observations with a quarterly income per capita above 7,000 euro. As can be seen in Table A3, the results do not change qualitatively.

Second, additional dimensions of fixed broadband plans are scrutinized. Table A4 presents the estimation results including the share of bundled[23] and tiered tariffs. Both may be used as second-degree price-discrimination mechanisms, allowing (a) to offer packages of services which satisfy different needs and (b) to vertically differentiate offers in the quality domain, now commonly referred to as “versioning”. The coefficients of both variables are positive and mostly significant, affirming that data caps and other forms of differentiation seem not to impede broadband adoption but rather to stimulate it. While bundles may reduce the perceived cost of the service,

[22]Variable descriptions can be found in Table A2.

[23]Stand-alone offers are by far the most common (46.2%), followed by double-play (28.9%) and triple-play offers (18.3%) of fixed broadband and fixed voice telephony and/or TV. Only a comparatively small share of offers includes mobile services.

capped plans are usually cheaper than unlimited offers for the same quality (see, e.g., Wallsten and Riso, 2010) and allow low cost-low usage offers for low-value customers who may otherwise refrain from buying. This is particularly interesting since it is service quality-based discrimination that has been the subject of the controversy in the public and policy debate. By controlling for the share of tired plans separately, some part of the positive effect of tariff diversity is extracted. The remaining positive coefficients of the different diversity measures assure that generally second- and third-degree differentiation, e.g., due to different contract durations and speeds or tariffs targeting different consumer groups, are not an impediment to broadband demand. All other previous results are confirmed.

Third, further cost and demand controls are added. Construction costs, mostly due to digging, are substantial for network providers and influence operators roll-out and price setting. Following the line of argument in Briglauer (2014), the per capita costs of deployment and maintaining might be reduced with an increased number of connections in densely populated regions, but at the same time carrying out these works might be pricier in urban areas. Accounting for these counteracting forces, an interaction term *urban*cost_cons* is included, where varying costs of construction are captured by the construction price index. However, no significant effect is detected. We further control for the legal and regulatory surrounding which is crucial for the supply side in a capital-intensive network industry. The indices *investment_freedom* and *business_freedom* evaluate a country with respect to a variety of restrictions that are typically imposed on investments and to the efficiency of government regulation of business, respectively. Both measures rate a country on a scale from 0 to 100 with an ideal score of 100. Any economic restrictions on the flow of investment capital and any difficulties in starting, operating, and closing a business are expected to constitute an impediment to broadband deployment and adoption. The positive impact of *business_freedom* on fixed broadband demand, indeed points to the importance of a reliable political and legal environment in industries with largely irreversible investments. As an additional demand control the total national telecommunications revenues measured in logs, *telco_rev*, are included. Higher expenditures mirror higher ICT affinity and are, unsurprisingly, found to increase broadband demand.

Fourth, more attention is paid to the mode of competition and its relation to tariff diversity. Besides the finding that price discrimination stimulates demand, there is convincing evidence that competition fosters broadband adoption whereas the exertion of market power hinders it. While market power is often seen as a prerequisite for the existence of price discrimination (Varian, 1989; Posner, 1976), various papers show that price discrimination and market power are not necessarily positively correlated (see, e.g., Armstrong and Vickers, 2001; Borenstein, 1985; McAfee et al., 2006). If, however, the former holds, regulators might face a trade-off between the intensity of competition and the extent of tariff diversity.[24] To account for this potential trade-off *inter_high*diversity* is included, where *inter_high* equals 1 if there are DSL, cable, and fibre broadband providers active in country $i$ at period $t$, and 0 otherwise. The results suggest that tariff diversity exerts a positive impact on demand in countries with a distinct level of facility-based competition, falsifying the hypothesis that a trade-off between competition and tariff diversity exists. The European Commission's intention to cut down the regulation on unbundled access and to promote facility-based competition seems therefore to be the appropriate policy for regulators (see, also Bourreau and Doğan, 2006).

Fifth, and finally, we account for potential (non-linear) substitution patterns between fixed and mobile broadband.[25] Since there may be common driving factors, we instrument mobile broadband subscription with its fourth lag and in order to be interpreted as an elasticity *mobile* is included in logs. We find an U-shape relationship and, like Cincera et al. (2014), significant substitution between fixed and mobile broadband on average. Bearing in mind the pronounced fixed-to-mobile substitution in the telephony market, mobile broadband might soon be able to dominate fixed broadband, rising the question whether any fixed-broadband technologies, including fibre-based broadband, which is currently considered the main infrastructure for high-speed internet, can compete with mobile broadband in the long-run.

# 4 Conclusion

This paper is the first to use a rich dataset of 10,200 residential broadband plans to study the impact of price differentiation on broadband adoption using longitudinal data. We use a sample of 23 European countries from 2003 to 2011 and apply dynamic panel data techniques while carefully accounting for possible endogeneity problems. The paper contributes in several ways to the research literature. At a methodological level, this article goes beyond the existing literature on price-discrimination in the retail broadband market by accounting for several sources of endogeneity, and utilizing GMM estimation methods. Furthermore, we can show

[24] Note that even if price discrimination implies the existence of market power, a high degree of price differentiation does not provide proof that market power is substantial in antitrust trials (e.g., McAfee et al., 2006; McAfee, 2008; Klein, 2008).

[25] Mobile broadband subscription is not part of the baseline specification as its inclusion results in a 20% sample size reduction.

that the results of Haucap et al. (2016) are applicable for developed markets alike, that the effect persists over time, and that it is reasonably robust.

Most notably, second-degree price discrimination to segment customers seems to be a means to foster broadband adoption. Demands by some public interest groups to limit price discrimination in broadband markets (see, e.g., Lyons, 2013) should therefore be viewed with some caution as reduced price discrimination may come at the cost of a reduced number of subscribers. Regarding the competitive environment, the results suggest that facility-based competition is a stronger driver of broadband penetration compared to the intensity of service-based competition. Starting from a legacy infrastructure with a sole telephony network, regulation in the EU has aimed at increasing service-based competition. However, it has been shown that with various broadband access technologies available it is inter-platform competition that promotes broadband demand and induces a positive impact of price differentiation on demand. Consequently, the favoritism of service-based competition may be outmoded and policymakers should intensify their focus on facility-based competition.

One limitation of this study is that the number of subscribers to a given plan is unknown wherefore unweighted averages for some variables have to be used. However, by including numerous measures for tariff diversity as well as utilizing an instrumental variables approach and several robustness checks, we are able to show that our results are robust. Furthermore, although the analysis is based on broadband demand as an aggregated measure, there is no reason to assume that consumer behavior systematically differs with respect to mobile broadband and NGA demand or any further network enhancements that we are likely to see in the future. In conclusion, this article advances the existing literature in several ways and points to the importance of diversified pricing schemes to foster broadband demand.

# References

Arellano, M. and Bond, S. (1991). Some tests of specification for panel data: Monte Carlo evidence and an application to employment equations. *Review of Economic Studies*, 58(2):277–297.

Arellano, M. and Bover, O. (1995). Another look at the instrumental variable estimation of error-components models. *Journal of Econometrics*, 68(1):29–51.

Armstrong, M. and Vickers, J. (2001). Competitive price discrimination. *RAND Journal of Economics*, 32(4):1–27.

Barth, A.-K. and Heimeshoff, U. (2014). Does the growth of mobile markets cause the demise of fixed networks? – Evidence from the European Union. *Telecommunications Policy*, 38(11):945–960.

Bauer, J. M., Madden, G., and Morey, A. (2014). Effects of economic conditions and policy interventions on OECD broadband adoption. *Applied Economics*, 46(12):1361–1372.

Bauer, J. M. and Wildman, S. S. (2012). The economics of usage-based pricing in local broadband markets. Michigan State University, East Lansing.

Blundell, R. and Bond, S. (1998). Initial conditions and moment restrictions in dynamic panel data models. *Journal of Econometrics*, 87(1):115–143.

Borenstein, S. (1985). Price discrimination in free-entry markets. *RAND Journal of Economics*, 16(3):380–397.

Bouckaert, J., van Dijk, T., and Verboven, F. (2010). Access regulation, competition, and broadband penetration: An international study. *Telecommunications Policy*, 34(11):661–671.

Bourreau, M. and Doğan, P. (2006). 'Build-or-buy' strategies in the local loop. *The American Economic Review*, 96(2):72–76.

Briglauer, W. (2014). The impact of regulation and competition on the adoption of fiber-based broadband services: Recent evidence from the European Union member states. *Journal of Regulatory Economics*, 46(1):51–79.

Bruno, G. S. (2005a). Approximating the bias of the LSDV estimator for dynamic unbalanced panel data models. *Economics Letters*, 87(3):361–366.

Bruno, G. S. (2005b). Estimation and inference in dynamic unbalanced panel-data models with a small number of individuals. *The Stata Journal*, 5(4):473–500.

Calzada, J. and Martínez-Santos, F. (2014). Broadband prices in the European Union: Competition and commercial strategies. *Information Economics and Policy*, 27:24–38.

Cava-Ferreruela, I. and Alabau-Muñoz, A. (2006). Broadband policy assessment: A cross-national empirical analysis. *Telecommunications Policy*, 30(8-9):445–463.

Cincera, M., Dewulf, L., and Estache, A. (2014). How much does speed matter in the fixed to mobile broadband substitution in Europe? iCite Working paper 10.

Czernich, N., Falck, O., Kretschmer, T., and Woessmann, L. (2011). Broadband infrastructure and economic growth. *The Economic Journal*, 121(552):505–532.

Denni, M. and Gruber, H. (2007). The diffusion of broadband telecommunications in the U.S – The role of different forms of competition. *Communications & Strategies*, 68:139–157.

Distaso, W., Lupi, P., and Manenti, F. M. (2006). Platform competition and broadband uptake: Theory and empirical evidence from the European Union. *Information Economics and Policy*, 18(1):87–106.

European Parliamentary Research Service (2015). Broadband infrastructure – Supporting the digital economy in the European Union. European Parliament, Brussels, Belgium.

Eurostat (2015). Individuals who have never used the internet. Technical report, Eurostat.

Galperin, H. and Ruzzier, C. A. (2013). Price elasticity of demand for broadband: Evidence from Latin America and the Caribbean. *Telecommunications Policy*, 37(6-7):429–438.

Garcia-Murillo, M. (2005). International broadband deployment: The impact of unbundling. *Communications & Strategies*, 57:83–105.

Gruber, H. and Koutroumpis, P. (2013). Competition enhancing regulation and diffusion of innovation: The case of broadband networks. *Journal of Regulatory Economics*, 43(2):168–195.

Grzybowski, L. (2014). Fixed-to-Mobile Substitution in the European Union. *Telecommunications Policy*, 38(7):601–612.

Grzybowski, L. and Verboven, F. (2016). Substitution between fixed-line and mobile access: The role of complementarities. *Journal of Regulatory Economics*, 49(2):113–151.

Gulati, G. J. and Yates, D. J. (2012). Different paths to universal access: The impact of policy and regulation on broadband diffusion in the developed and developing worlds. *Telecommunications Policy*, 36(9):749–761.

Hamilton, J. D. (1994). *Time Series Analysis*. Princeton University Press.

Haucap, J., Heimeshoff, U., and Lange, M. R. J. (2016). The impact of tariff diversity on broadband penetration – An empirical analysis. *Telecommunications Policy*, 40(8):743–754.

Hausman, J. A. (1996). *Valuation of New Goods under Perfect and Imperfect Competition*, pages 207–248. University of Chicago Press.

Heatley, D. and Howell, B. E. (2010). Structural separation and prospects for welfare-enhancing price discrimination in a new 'natural monopoly' network: comparing fibre broadband proposals in Australia and New Zealand. New Zealand Institute for the Study of Competition and Regulation, Wellington, New Zealand.

Höffler, F. (2007). Cost and benefits from infrastructure competition. Estimating welfare effects from broadband access competition. *Telecommunications Policy*, 31(6-7):401–418.

Howell, B. E. (2008). The role of pricing structure in telecommunications technology diffusion. New Zealand Institute for the Study of Competition and Regulation, Wellington, New Zealand.

ITU and UNESCO (2013). The state of broadband 2013: Universalizing broadband.

Kim, J., Bauer, J. M., and Wildman, S. S. (2003). Broadband uptake in OECD countries: Policy lessons from comparative statistical analysis. SSRN Scholarly Paper, Rochester, NY.

Klein, B. (2008). Price discrimination and market power. In Collins, W. D., editor, *Issues in Competion Law and Policy*, volume 2, chapter 41, pages 977–996. American Bar Association Section of Antitrust Law.

Kongaut, C. and Bohlin, E. (2014). Unbundling and infrastructure competition for broadband adoption: Implications for NGA regulation. *Telecommunications Policy*, 38(8-9):760–770.

Lange, M. R. J. and Saric, A. (2016). Substitution between fixed, mobile, and Voice over IP telephony – Evidence from the European Union. *Telecommunications Policy*, 40(10-11):1007–1019.

Lee, S., Marcu, M., and Lee, S. (2011). An empirical analysis of fixed and mobile broadband diffusion. *Information Economics and Policy*, 23(3-4):227–233.

Lin, M.-S. and Wu, F.-S. (2013). Identifying the determinants of broadband adoption by diffusion stage in OECD countries. *Telecommunications Policy*, 37(4-5):241–251.

Lyons, D. (2013). Internet policy's next frontier: Usage-based broadband pricing. *Federal Communications Law Journal*, 66(1):1–44.

McAfee, R. P. (2008). Price discrimination. In Collins, W. D., editor, *Issues in Competion Law and Policy*, volume 1, chapter 20, pages 465–484. American Bar Association Section of Antitrust Law.

McAfee, R. P., Mialon, H. M., and Mialon, S. H. (2006). Does large price discrimination imply great market power? *Economics Letters*, 92(3):360–367.

Nardotto, M., Valletti, T., and Verboven, F. (2015). Unbundling the incumbent: Evidence from UK broadband. *Journal of the European Economic Association*, 13(2):330–362.

Nevo, A., Turner, J. L., and Williams, J. W. (2016). Usage-based pricing and demand for residential broadband. *Econometrica*, 84(2):411–443.

Nickell, S. J. (1981). Biases in dynamic models with fixed effects. *Econometrica*, 49(6):1417–1426.

Odlyzko, A., Arnaud, B. S., Stallman, E., and Weinberg, M. (2012). Know your limits: Considering the role of data caps and usage based billing in internet access service. Public Knowledge, White Paper.

OECD (2008). Broadband growth and policies in OECD countries.

Posner, R. A. (1976). *Antitrust Law: An Economic Perspective*. University of Chicago Press.

Röller, L.-H. and Waverman, L. (2001). Telecommunications infrastructure and economic development: A simultaneous approach. *The American Economic Review*, 91(4):909–923.

Roodman, D. (2007). How to do xtabond2: An introduction to 'difference' and 'system' GMM in Stata. Center for global development, Washington, DC.

Spiegler, R. (2006). Competition over agents with boundedly rational expectations. *Theoretical Economics*, 1(2):207–231.

Varian, H. R. (1989). Price discrimination. In Schmalensee, R. and Willig, R. D., editors, *Handbook of Industrial Organization, Handbook in Economics*, volume 10, pages 597–654. North-Holland.

Wallsten, S. and Riso, J. L. (2010). Residential and business broadband prices: Part 1: An empirical analysis of metering and other price determinants. Technology Policy Institute, Washington, DC.

Ward, M. R. and Woroch, G. A. (2010). The effect of prices on fixed and mobile telephone penetration: Using price subsidies as natural experiments. *Information Economics and Policy*, 22(1):18–32.

# Appendix

Table A1: Countries

| | | |
|---|---|---|
| Austria; 2003–2011 | Germany; 2003–2011 | Portugal; 2003–2011 |
| Belgium; 2003–2011 | Hungary; 2007–2011 | Romania; 2008–2011 |
| Bulgaria; 2008–2011 | Ireland; 2005–2011 | Slovakia; 2007–2011 |
| Czech Rep.; 2007–2011 | Italy; 2003–2011 | Slovenia; 2007–2011 |
| Denmark; 2003–2011 | Latvia; 2008–2011 | Spain; 2003–2011 |
| Estonia; 2008–2011 | Lithuania; 2008–2011 | Sweden; 2003–2011 |
| Finland; 2003–2011 | Netherlands; 2003–2011 | UK; 2003–2011 |
| France; 2003–2011 | Poland; 2007–2011 | |

Table A2: Variables description and source

| Variable | Description | Source |
|---|---|---|
| *fbb_sub* | Number of active retail broadband subscribers, including DSL, cable, fibre, and other fixed broadband connections, i.e., satellite, broadband over power lines, and WiMax. | Analysys Mason ('Telecoms Market Matrix') |
| *fbb_price* | Unweighted average monthly access charge for fixed broadband internet service per Mbps download speed in euro PPP. | Analysys Mason ('Tripleplay pricing study') |
| *diversity_sd* | Standard deviation of access prices for stand-alone fixed broadband offerings. | Analysys Mason ('Tripleplay pricing study') |
| *diversity_minmean* | Difference between minimum and mean of access prices for stand-alone fixed broadband offerings. | Analysys Mason ('Tripleplay pricing study') |
| *diversity_minmax* | Difference between minimum and maximum of access prices for stand-alone fixed broadband offerings. | Analysys Mason ('Tripleplay pricing study') |
| *diversity_admedian* | Average absolute deviation from the median of access prices for stand-alone fixed broadband offerings. | Analysys Mason ('Tripleplay pricing study') |
| *diversity_admean* | Average absolute deviation from the mean of access prices for stand-alone fixed broadband offerings. | Analysys Mason ('Tripleplay pricing study') |
| *speed* | Unweighted average advertised maximum download speed for fixed broadband connection in Mbps. | Analysys Mason ('Tripleplay pricing study') |
| *pc_hh* | Percentage of households with access to a PC over one of its members. | Eurostat |
| *gdp_percapita* | Quarterly real GDP per capita in euro PPP. | Eurostat |
| emphhhi_inter | Herfindahl-Hirschman Index of DSL, cable, fibre, and other fixed broadband connections. | Analysys Mason ('Telecoms Market Matrix') |
| *hhi_intra* | Herfindahl-Hirschman Index of incumbent's and entrants' DSL connections. | Analysys Mason ('Telecoms Market Matrix') |
| *bundles_share* | Share of bundled offers consisting of any combination of fixed broadband and fixed voice, TV, mobile voice, and mobile data. | Analysys Mason ('Tripleplay pricing study') |
| *caps_share* | Share of tariffs with a monthly usage tier. | Analysys Mason ('Tripleplay pricing study') |
| *mobile* | Number of mobile broadband subscribers (includes all mobile broadband PC or laptop connections via an USB modem or datacard and excludes handset access or use of the handset as a modem). | Analysys Mason ('Telecoms Market Matrix') |
| *population* | Population size. | World Bank |
| *pop_density* | Population density. Inhabitants per sq. km of land area. | World Bank |
| *urban* | Share of urban population. | World Bank |
| *fms* | Share of fixed landlines in the total number of fixed landlines and mobile (pre-paid and postpaid) telephony subscriptions. | Analysys Mason ('Telecoms Market Matrix') |
| *telco_rev* | Telecommunications revenues from fixed landline, mobile, and VoIP telephony plus broadband internet. | Analysys Mason ('Telecoms Market Matrix') |
| *cost_cons* | Labor input in construction (gross wages and salaries, 2010=100). | Eurostat |
| *inter_high* | Dummy variable, equals 1 if there are DSL, cable, and fibre broadband providers active in country $i$ at period $t$, 0 otherwise. | Analysys Mason ('Telecoms Market Matrix') |
| *investment_freedom* | Index of Freedom of Investment [0-100]. | Heritage Foundation |
| *business_freedom* | Index of Business Freedom [0-100]. | Heritage Foundation |

Table A3: GDP per capita $\geq$ 7,000 euro

| **Dependent variable:** *fbb_sub* | (1) | (2) | (3) | (4) | (5) |
|---|---|---|---|---|---|
| L.*fbb_sub* | 0.617*** | 0.703*** | 0.613*** | 0.653*** | 0.609*** |
| | (0.056) | (0.054) | (0.080) | (0.040) | (0.044) |
| L.*fbb_price* | -0.091** | -0.083*** | -0.062** | -0.119*** | -0.095*** |
| | (0.038) | (0.032) | (0.027) | (0.045) | (0.034) |
| L.*diversity_sd* | 0.067** | | | | |
| | (0.034) | | | | |
| L.*diversity_minmean* | | 0.063** | | | |
| | | (0.028) | | | |
| L.*diversity_minmax* | | | 0.047* | | |
| | | | (0.024) | | |
| L.*diversity_admedian* | | | | 0.088** | |
| | | | | (0.039) | |
| L.*diversity_admean* | | | | | 0.070** |
| | | | | | (0.030) |
| *speed* | -0.001 | 0.000 | -0.001 | -0.001 | -0.001 |
| | (0.001) | (0.000) | (0.00) | (0.00) | (0.00) |
| *hhi_inter* | -0.937*** | -0.924** | -1.117*** | -0.670** | -0.909*** |
| | (0.309) | (0.403) | (0.313) | (0.322) | (0.352) |
| *hhi_intra* | -0.153 | -0.053 | -0.110 | -0.060 | -0.153 |
| | (0.130) | (0.102) | (0.173) | (0.127) | (0.113) |
| *fms* | 2.216 | 3.049 | 2.954 | 0.980 | 1.367 |
| | (2.112) | (2.320) | (1.978) | (1.589) | (1.960) |
| *fms_sq* | -4.938 | -7.826* | -7.879** | -2.761 | -3.616 |
| | (3.646) | (4.593) | (3.388) | (2.651) | (3.363) |
| *pop_density* | -0.002 | 0.007 | 0.006 | -0.002 | -0.003 |
| | (0.005) | (0.007) | (0.008) | (0.005) | (0.005) |
| *urban* | 0.034 | -0.028 | -0.031 | 0.043 | 0.059 |
| | (0.045) | (0.069) | (0.062) | (0.054) | (0.052) |
| *gdp_percapita* | 0.354*** | 0.279*** | 0.335*** | 0.380*** | 0.359*** |
| | (0.126) | (0.088) | (0.098) | (0.140) | (0.136) |
| *pc_hh* | 0.727** | 0.877** | 0.801** | 0.855** | 0.812** |
| | (0.336) | (0.367) | (0.373) | (0.342) | (0.373) |
| *population* | 1.232* | 0.382 | 1.116 | 0.617 | 1.401* |
| | (0.744) | (1.044) | (1.323) | (0.683) | (0.760) |
| *N* | 164 | 164 | 164 | 164 | 164 |
| Sargan Test $\chi^2$-stat | 62.51 | 66.26 | 55.16 | 72.14 | 67.51 |
| p-value | 0.80 | 0.70 | 0.94 | 0.51 | 0.66 |
| AR(4), Prob>$z$ | 0.21 | 0.18 | 0.22 | 0.22 | 0.23 |

Heteroscedasticity and autocorrelation robust standard errors in parentheses.
Significance levels: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.
All regressions include a constant as well as a linear and squared time trend which are not reported for brevity.
Countries included in this analysis are Austria, Belgium, Denmark, Finland, France, Germany, Ireland, Italy, Netherlands, Sweden, and UK.

Table A4: Dimensions of fixed broadband plans

| **Dependent variable:** *fbb_sub* | (1) | (2) | (3) | (4) | (5) |
|---|---|---|---|---|---|
| L.*fbb_sub* | 0.620*** | 0.646*** | 0.621*** | 0.631*** | 0.652*** |
| | (0.061) | (0.077) | (0.063) | (0.062) | (0.061) |
| L.*fbb_price* | -0.053* | -0.051* | -0.038** | -0.051* | -0.046 |
| | (0.030) | (0.028) | (0.019) | (0.031) | (0.029) |
| L.*diversity_sd* | 0.041* | | | | |
| | (0.023) | | | | |
| L.*diversity_minmean* | | 0.042* | | | |
| | | (0.024) | | | |
| L.*diversity_minmax* | | | 0.030* | | |
| | | | (0.015) | | |
| L.*diversity_admedian* | | | | 0.039 | |
| | | | | (0.024) | |
| L.*diversity_admean* | | | | | 0.035 |
| | | | | | (0.022) |
| *speed* | -0.000 | -0.001 | -0.000 | -0.000 | -0.000 |
| | (0.001) | (0.001) | (0.001) | (0.001) | (0.001) |
| *bundles_share* | 0.051 | 0.052* | 0.059* | 0.044 | 0.043 |
| | (0.033) | (0.030) | (0.033) | (0.029) | (0.030) |
| *caps_share* | 0.049** | 0.073*** | 0.051** | 0.046** | 0.050** |
| | (0.025) | (0.021) | (0.023) | (0.022) | (0.024) |
| *hhi_inter* | -1.037** | -1.081** | -1.128*** | -0.996** | -0.998** |
| | (0.470) | (0.505) | (0.431) | (0.461) | (0.456) |
| *hhi_intra* | -0.079 | -0.051 | -0.092 | -0.045 | -0.066 |
| | (0.132) | (0.138) | (0.135) | (0.121) | (0.119) |
| *fms* | 3.818* | 2.175 | 3.417* | 3.920* | 3.544* |
| | (2.153) | (1.862) | (1.798) | (2.111) | (2.009) |
| *fms_sq* | -7.651** | -5.746* | -7.374** | -7.907** | -7.321** |
| | (3.754) | (3.437) | (3.273) | (3.672) | (3.525) |
| *pop_density* | -0.008 | -0.005 | -0.003 | -0.004 | -0.005 |
| | (0.013) | (0.013) | (0.013) | (0.013) | (0.013) |
| *urban* | 0.046 | 0.038 | 0.019 | 0.038 | 0.046 |
| | (0.034) | (0.045) | (0.034) | (0.031) | (0.031) |
| *gdp_percapita* | 0.286*** | 0.236*** | 0.269*** | 0.304*** | 0.296*** |
| | (0.079) | (0.064) | (0.072) | (0.079) | (0.079) |
| *pc_hh* | 1.328*** | 1.511*** | 1.273*** | 1.225*** | 1.206*** |
| | (0.429) | (0.471) | (0.371) | (0.412) | (0.409) |
| *population* | 1.279 | 0.252 | 0.641 | 1.152 | 0.958 |
| | (1.085) | (0.998) | (0.811) | (1.065) | (1.076) |
| $N$ | 301 | 301 | 301 | 301 | 301 |
| Sargan Test $\chi^2$-stat | 74.29 | 65.29 | 68.87 | 79.10 | 79.23 |
| p-value | 0.37 | 0.67 | 0.55 | 0.24 | 0.24 |
| AR(4), Prob>$z$ | 0.11 | 0.14 | 0.11 | 0.11 | 0.12 |

Heteroscedasticity and autocorrelation robust standard errors in parentheses.
Significance levels: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.
All regressions include a constant as well as a linear and squared time trend which are not reported for brevity.

## Table A5: Additional cost and demand controls

| **Dependent variable:** *fbb_sub* | (1) | (2) | (3) | (4) | (5) |
|---|---|---|---|---|---|
| L.*fbb_sub* | 0.591*** | 0.604*** | 0.570*** | 0.590*** | 0.590*** |
| | (0.084) | (0.080) | (0.092) | (0.083) | (0.081) |
| L.*fbb_price* | -0.054** | -0.054* | -0.040** | -0.059* | -0.055* |
| | (0.028) | (0.028) | (0.019) | (0.031) | (0.030) |
| L.*diversity_sd* | 0.038* | | | | |
| | (0.023) | | | | |
| L.*diversity_minmean* | | 0.040* | | | |
| | | (0.023) | | | |
| L.*diversity_minmax* | | | 0.027* | | |
| | | | (0.016) | | |
| L.*diversity_admedian* | | | | 0.041* | |
| | | | | (0.025) | |
| L.*diversity_admean* | | | | | 0.038 |
| | | | | | (0.024) |
| *speed* | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 |
| | (0.001) | (0.001) | (0.001) | (0.001) | (0.001) |
| *hhi_inter* | -0.888** | -0.925** | -0.913** | -0.875** | -0.861** |
| | (0.372) | (0.398) | (0.383) | (0.370) | (0.359) |
| *intra_hh* | -0.091 | -0.108 | -0.147 | -0.039 | -0.055 |
| | (0.149) | (0.145) | (0.155) | (0.150) | (0.148) |
| *fms* | 1.343 | 1.221 | 0.605 | 2.082 | 1.574 |
| | (1.784) | (1.834) | (1.991) | (1.971) | (1.697) |
| *fms_sq* | -2.403 | -3.328 | -1.661 | -3.700 | -2.813 |
| | (2.849) | (3.157) | (3.236) | (3.435) | (2.790) |
| *urban* | 0.042 | 0.027 | 0.025 | 0.039 | 0.038 |
| | (0.045) | (0.049) | (0.046) | (0.045) | (0.045) |
| *urban*cost_cons* | -0.000 | -0.000 | -0.000 | -0.000 | -0.000 |
| | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) |
| *cost_cons* | 0.006 | 0.006 | 0.007 | 0.005 | 0.006 |
| | (0.005) | (0.005) | (0.006) | (0.005) | (0.005) |
| *business_freedom* | 0.003** | 0.003* | 0.003** | 0.003* | 0.003** |
| | (0.001) | (0.001) | (0.001) | (0.001) | (0.001) |
| *investment_freedom* | 0.004 | 0.003 | 0.002 | 0.003 | 0.003 |
| | (0.002) | (0.002) | (0.002) | (0.002) | (0.002) |
| *gdp_percapita* | 0.130* | 0.122* | 0.130** | 0.142* | 0.134 |
| | (0.076) | (0.066) | (0.063) | (0.083) | (0.083) |
| *pc_hh* | 1.293*** | 1.387*** | 1.412*** | 1.184*** | 1.166*** |
| | (0.440) | (0.456) | (0.453) | (0.415) | (0.396) |
| *population* | 0.778 | 0.458 | 0.711 | 0.934 | 0.788 |
| | (1.198) | (1.040) | (1.263) | (1.077) | (1.140) |
| *telcom_rev* | 0.293* | 0.104 | 0.230 | 0.266 | 0.296* |
| | (0.169) | (0.130) | (0.143) | (0.179) | (0.173) |
| $N$ | 292 | 292 | 292 | 292 | 292 |
| Sargan Test $\chi^2$-stat | 56.04 | 47.06 | 54.71 | 55.75 | 58.50 |
| p-value | 0.83 | 0.97 | 0.86 | 0.83 | 0.76 |
| AR(4), Prob>$z$ | 0.21 | 0.28 | 0.25 | 0.20 | 0.22 |

Heteroscedasticity and autocorrelation robust standard errors in parentheses.
Significance levels: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.
All regressions include a constant as well as a linear and squared time trend which are not reported for brevity.

## Table A6: Trade-off competition and tariff diversity

| **Dependent variable:** *fbb_sub* | (1) | (2) | (3) | (4) | (5) |
|---|---|---|---|---|---|
| L.*fbb_sub* | 0.540*** | 0.579*** | 0.564*** | 0.534*** | 0.546*** |
| | (0.0852) | (0.0957) | (0.0878) | (0.0882) | (0.0840) |
| L.*fbb_price* | -0.0454* | -0.0286* | -0.0277* | -0.0391* | -0.0385* |
| | (0.0234) | (0.0154) | (0.0167) | (0.0208) | (0.0199) |
| L.*diversity_sd* | 0.0198 | | | | |
| | (0.0184) | | | | |
| L.*diversity_sd*comp_high* | 0.0211** | | | | |
| | (0.00961) | | | | |
| L.*diversity_minmean* | | 0.00953 | | | |
| | | (0.0133) | | | |
| L.*diversity_minmean*comp_high* | | 0.0230** | | | |
| | | (0.00934) | | | |
| L.*diversity_minmax* | | | 0.0144 | | |
| | | | (0.0151) | | |
| L.*diversity_minmax*comp_high* | | | 0.0144** | | |
| | | | (0.00688) | | |
| L.*diversity_admedian* | | | | 0.0127 | |
| | | | | (0.0165) | |
| L.*diversity_admedian*comp_high* | | | | 0.0260** | |
| | | | | (0.0116) | |
| L.*diversity_admean* | | | | | 0.0123 |
| | | | | | (0.0153) |
| L.*diversity_admean*comp_high* | | | | | 0.0232** |
| | | | | | (0.0102) |
| *speed* | -0.00124 | -0.00145 | -0.00103 | -0.00156 | -0.00146 |
| | (0.00132) | (0.00139) | (0.00111) | (0.00163) | (0.00153) |
| *comp_high* | -0.0192 | -0.0279* | -0.0164 | -0.0243 | -0.0204 |
| | (0.0229) | (0.0163) | (0.0214) | (0.0212) | (0.0222) |
| *intra_hh* | -0.00912 | -0.00308 | -0.0721 | 0.0357 | 0.0227 |
| | (0.140) | (0.147) | (0.135) | (0.158) | (0.150) |
| *urban* | 0.0406 | 0.0243 | 0.0244 | 0.0363 | 0.0407 |
| | (0.0500) | (0.0460) | (0.0434) | (0.0573) | (0.0532) |
| *business_freedom* | 0.00184** | 0.00147* | 0.00170** | 0.00167** | 0.00170** |
| | (0.000851) | (0.000837) | (0.000858) | (0.000814) | (0.000835) |
| *investment_freedom* | 0.00272 | 0.00198 | 0.00275 | 0.00269 | 0.00239 |
| | (0.00260) | (0.00222) | (0.00228) | (0.00253) | (0.00249) |
| *fms* | 1.704 | 0.437 | 1.256 | 1.296 | 1.470 |
| | (1.352) | (1.577) | (1.389) | (1.693) | (1.508) |
| *fms_sq* | -3.496 | -1.673 | -3.278 | -2.760 | -2.932 |
| | (2.411) | (2.892) | (2.594) | (2.982) | (2.625) |
| *gdp_percapita* | 0.264** | 0.224** | 0.252*** | 0.278** | 0.272** |
| | (0.107) | (0.0936) | (0.0971) | (0.111) | (0.109) |
| *pc_hh* | 0.858*** | 0.861*** | 0.830*** | 0.847*** | 0.829*** |
| | (0.321) | (0.298) | (0.309) | (0.309) | (0.321) |
| *population* | 1.476 | 0.609 | 1.268 | 1.263 | 1.327 |
| | (1.405) | (1.131) | (1.475) | (1.227) | (1.301) |
| *telco_rev* | 0.0645 | 0.0395 | 0.0593 | 0.0718 | 0.0764 |
| | (0.109) | (0.105) | (0.117) | (0.102) | (0.0989) |
| *N* | 301 | 301 | 301 | 301 | 301 |
| Sargan Test $\chi^2$-stat | 76.34 | 80.46 | 75.38 | 75.40 | 78.96 |
| p-value | 0.71 | 0.59 | 0.74 | 0.74 | 0.64 |
| AR(4), Prob>$z$ | 0.22 | 0.23 | 0.21 | 0.24 | 0.22 |

Heteroscedasticity and autocorrelation robust standard errors in parentheses.
Significance levels: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.
All regressions include a constant as well as a linear and squared time trend which are not reported for brevity.

Table A7: Mobile broadband subscription

| **Dependent variable**: *fbb_sub* | (1) | (2) | (3) | (4) | (5) |
|---|---|---|---|---|---|
| L.*mobile* | -0.149** | -0.129** | -0.134** | -0.140** | -0.146** |
| | (0.058) | (0.054) | (0.055) | (0.060) | (0.058) |
| L.*mobile_sq* | 0.005** | 0.004* | 0.004* | 0.004* | 0.004* |
| | (0.002) | (0.002) | (0.002) | (0.002) | (0.002) |
| L.*fbb_sub* | 0.661*** | 0.650*** | 0.652*** | 0.662*** | 0.666*** |
| | (0.066) | (0.063) | (0.062) | (0.066) | (0.067) |
| L.*fbb_price* | -0.023** | -0.030** | -0.024** | -0.024** | -0.020** |
| | (0.011) | (0.015) | (0.010) | (0.012) | (0.009) |
| L.*diversity_sd* | 0.015* | | | | |
| | (0.009) | | | | |
| L.*diversity_minmean* | | 0.020* | | | |
| | | (0.012) | | | |
| L.*diversity_minmax* | | | 0.016* | | |
| | | | (0.008) | | |
| L.*diversity_admedian* | | | | 0.016* | |
| | | | | (0.009) | |
| L.*diversity_admean* | | | | | 0.012* |
| | | | | | (0.007) |
| *inter_hh* | -0.125 | -0.204 | -0.147 | -0.146 | -0.107 |
| | (0.314) | (0.386) | (0.334) | (0.311) | (0.287) |
| *fms* | -0.090 | 0.634 | 0.598 | -0.070 | -0.141 |
| | (1.232) | (1.148) | (1.129) | (1.159) | (1.163) |
| *fms_sq* | -1.105 | -2.685 | -2.314 | -1.232 | -1.175 |
| | (2.154) | (2.000) | (1.945) | (1.950) | (2.032) |
| *business_freedom* | 0.001 | 0.001 | 0.001 | 0.000 | 0.000 |
| | (0.002) | (0.002) | (0.002) | (0.002) | (0.002) |
| *investment_freedom* | 0.000 | 0.000 | -0.000 | 0.000 | 0.000 |
| | (0.002) | (0.002) | (0.002) | (0.001) | (0.001) |
| *pop_density* | 0.000 | 0.000 | 0.000 | 0.001 | 0.000 |
| | (0.005) | (0.005) | (0.005) | (0.005) | (0.005) |
| *pc_hh* | 0.979*** | 1.061*** | 0.991*** | 0.975*** | 0.989*** |
| | (0.200) | (0.254) | (0.229) | (0.214) | (0.209) |
| *gdp_percapita* | 0.172*** | 0.143*** | 0.158*** | 0.166*** | 0.167*** |
| | (0.047) | (0.043) | (0.043) | (0.047) | (0.047) |
| *population* | 0.298 | 0.200 | 0.397 | 0.199 | 0.241 |
| | (0.631) | (0.636) | (0.651) | (0.617) | (0.619) |
| *N* | 230 | 230 | 230 | 230 | 230 |
| Sargan Test $\chi^2$-stat | 101.81 | 107.19 | 102.03 | 106.95 | 104.19 |
| p-value | 0.15 | 0.08 | 0.15 | 0.08 | 0.11 |
| AR(4), Prob>$z$ | 0.22 | 0.22 | 0.26 | 0.23 | 0.23 |

Heteroscedasticity and autocorrelation robust standard errors in parentheses.
Significance levels: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.
All regressions include a constant as well as a linear and squared time trend which are not reported for brevity.

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