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Broadband Price Elasticity in EU and Eastern Partnership Countries: Evidence of a Decade-Long Transformation (2010–2024)

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Abstract

Has broadband become a necessity good immune to price changes? Using a 15-year panel of 33 countries—27 European Union (EU) member states and 6 Eastern Partnership (EaP) countries (2010–2024)—and two-way fixed effects with Driscoll–Kraay standard errors, we document a fundamental transformation in broadband demand. Pre-COVID, EaP countries exhibited relatively elastic demand ($\varepsilon = \mathbf{-0.60}$, $p<0.001$)—a 10% price reduction increased subscriptions by **6.0**%—while EU countries showed lower elasticity ($\varepsilon = \mathbf{-0.10}$, $p<0.10$). By 2020–2024, both regions converged to near-zero elasticity, with price changes having no detectable effect on adoption. Crucially, placebo tests reveal this transformation began in 2015, not 2020, indicating a decade-long digital integration process rather than a COVID-19 shock. We further demonstrate that price measurement critically affects inference: income-relative prices (as % of gross national income, GNI) yield significant EaP elasticities in all specifications, whereas purchasing-power-parity (PPP) adjusted prices yield significant results in only 12% of EaP specifications; for EU countries, all three price measures perform broadly similarly. These findings have immediate policy relevance: as broadband transitions from discretionary service to essential utility, policy emphasis must shift from affordability subsidies to universal infrastructure deployment.

Keywords: Broadband demand, Price elasticity, Eastern Partnership, European Union, COVID-19, Digital transformation

JEL Classification: L96 , C23 , O33 , L51

1 Introduction

When does a technology transition from luxury to necessity? For broadband internet, this question has profound implications: if demand becomes price-inelastic, subsidies and price regulations—the dominant policy tools of the past two decades—lose their effectiveness. The transformation of broadband from discretionary communication service to essential infrastructure for economic participation, education, healthcare, and civic engagement (Katz et al. 2010) suggests this transition may already be underway. Yet empirical evidence on whether and when broadband demand became price-insensitive remains surprisingly scarce, despite substantial public investments in broadband infrastructure worldwide (OECD 2020).

This paper provides such evidence by examining how broadband price elasticity evolved over 2010–2024 in 33 countries: 27 European Union (EU) member states and 6 Eastern Partnership (EaP) countries. We leverage substantial cross-country and temporal variation in broadband prices and adoption rates to estimate time-varying elasticities using two-way fixed effects models. Our analysis reveals a striking structural transformation: Eastern Partnership countries exhibited highly price-elastic demand ($\varepsilon = -0.60$) during 2010–2019, but transitioned to price-inelastic demand ($\varepsilon \approx 0$) by 2020–2024, indicating broadband's evolution from discretionary service to essential necessity.

1.1 Research Questions and Motivation

Three core questions motivate this research. First, *how has broadband demand elasticity evolved over the past decade and a half?* Existing literature predominantly estimates elasticities at single points in time (Dauvin and Grzybowski 2014), yet technological change and digital economy expansion suggest elasticity may be time-varying as services transition from luxury to necessity.

Second, *what explains regional heterogeneity in price sensitivity?* Eastern Partnership countries—comprising Armenia, Azerbaijan, Belarus, Georgia, Moldova, and Ukraine—represent lower-income markets where affordability concerns might generate higher price elasticity compared to wealthier EU markets. Understanding this heterogeneity is crucial for tailoring policy interventions to different development contexts (Waverman et al. 2001).

Third, *did COVID-19 fundamentally alter broadband demand?* The pandemic forced abrupt transitions to remote work, online education, and digital service delivery (OECD 2021b), potentially transforming broadband from convenience to necessity overnight. However, distinguishing COVID's causal impact from pre-existing trends requires careful econometric identification, which we address through placebo tests.

1.2 Contributions

This paper makes four principal contributions to telecommunications economics and policy.

First, we document time-varying demand elasticity across a 15-year panel, revealing broadband's structural transformation. Unlike prior single-period estimates, our year-by-year analysis shows elasticity declined gradually from 2015 onward, not suddenly in 2020. This challenges the narrative of COVID-19 as an exogenous shock and instead suggests a decade-long evolution driven by digital economy expansion.

Second, we demonstrate that price measurement critically affects empirical inference. Using three alternative price measures—price as percentage of GNI per capita (income-relative), PPP-adjusted prices, and nominal USD prices—we show only income-relative prices yield consistent, statistically significant elasticity estimates. PPP-adjusted prices, commonly used in cross-country comparisons, produce estimates significant in just 12% of EaP specifications (at $p<0.05$). This methodological contribution has implications beyond broadband demand, highlighting the importance of price measurement in technology goods research where standard PPP baskets may not apply (OECD 2002).

Third, we provide robust evidence of regional heterogeneity in price sensitivity. EaP elasticity was 5.9 times larger than EU elasticity during 2010–2019, consistent with income effects being stronger in developing markets (Röller and Waverman 2001). This regional gap diminished during COVID-19, with both regions converging to near-zero elasticity—constituting empirical evidence that demand-side digital harmonisation between EaP and EU markets is not merely a policy aspiration but an observable outcome.

Fourth, we offer policy-relevant insights on the effectiveness of affordability interventions versus infrastructure investment. As broadband transitioned to necessity status, price-based interventions lost effectiveness while infrastructure investment and quality standards became more important. This has implications for digital inclusion policies worldwide (Guermazi et al. 2021).

The remainder of this paper proceeds as follows. Section 2 reviews relevant literature on telecommunications demand, digital transformation, and panel data methods. Section 3 describes our data sources and sample construction. Section 4 presents our empirical strategy. Section 5 reports baseline and robustness results. Section 6 discusses policy implications and limitations. Section 7 concludes.

2 Literature Review and Theoretical Framework

2.1 Broadband Demand and Price Elasticity

The telecommunications demand literature has extensively studied price elasticity for internet access services, including early broadband adoption (Hausman et al. 2001; Rappoport et al. 2003). Elasticity estimates vary substantially across methodologies and contexts. Market structure is a primary driver of this heterogeneity: Cardona et al. (2009) find DSL own-price elasticity ranging from -0.97 in areas without platform competition to -2.55 where cable and mobile alternatives are available. Our EaP

estimate falls at the lower end of the broader literature, consistent with EaP markets' intermediate level of platform competition and tighter income constraints, extending evidence to 2010–2024.

A key theoretical insight is that demand elasticity varies with necessity status. As connectivity integrates into economic and social life, price sensitivity declines as services shift from discretionary to essential (Becker and Murphy 1988). Our finding of declining elasticity from 2015–2024 aligns with this theoretical framework.

Recent work emphasizes time-varying elasticity in technology markets. Evidence from broadband markets suggests that price sensitivity declines as services become embedded in daily economic life and as complementary technologies (smartphones, streaming, cloud applications) raise the opportunity cost of disconnection. Our contribution extends this literature by documenting elasticity evolution across a 15-year panel with explicit pre-trend testing.

Several studies published in this journal have examined the *intensive margin* of broadband demand—consumers' willingness to pay for higher speeds or better quality conditional on being connected (Liu et al. 2018; Lindlacher 2021; Sinclair 2023). Our paper complements this strand by focusing on the *extensive margin*: the adoption decision itself. Whether a household subscribes at all is governed by price relative to income and infrastructure availability—both of which we measure directly. The regional comparison of EU versus EaP countries provides heterogeneity that single-country intensive-margin studies cannot capture: income constraints bind far more tightly in EaP markets, so extensive-margin elasticity is substantially higher, while both regions converge to near-zero elasticity as broadband transitions from discretionary to essential service.

2.2 Regional Heterogeneity and Development Context

Röller and Waverman (2001) identify significant income effects on telecommunications adoption in cross-country panels, consistent with affordability constraints governing uptake where incomes are lower.

Our analysis focuses on Eastern Partnership countries—Armenia, Azerbaijan, Belarus, Georgia, Moldova, and Ukraine—which represent middle-income markets with substantial development heterogeneity relative to the EU (Ecorys 2013). Critically, this grouping is not a researcher's sampling choice but an institutionally and politically defined set, established under the EU's Eastern Partnership policy framework and subsequently operationalised through the EU4Digital initiative, which targets precisely these six countries for telecommunications regulatory harmonisation and progressive integration into the European Digital Single Market (European Commission 2021). The research question examined in this paper—whether demand-side convergence to EU necessity-good status is feasible over a policy-relevant horizon—is meaningful only for this institutionally defined group, as it concerns a specific integration trajectory rather than a random draw from a broader population. Consequently, N=6 reflects the exhaustive membership of the Eastern Partnership, not a statistical sample: there is no broader population of EaP countries from which additional observations could be drawn, and adding non-EaP transition economies would conflate distinct policy regimes. Limited prior work examines broadband demand elasticity

in this region, making the present analysis a direct contribution to an understudied policy context.

2.3 COVID-19 and Digital Transformation

The pandemic's impact on telecommunications demand has received substantial attention, though primarily descriptive (OECD 2021b; IAB 2020). Feldmann et al. (2021) document more than 20% traffic increases within weeks of lockdown announcements in March 2020, while Favale et al. (2020) show usage patterns shifted dramatically toward videoconferencing and streaming. However, causal evidence on price elasticity changes remains limited.

Theoretically, COVID-19 could reduce elasticity through two mechanisms. First, lockdowns and social distancing converted broadband from convenience to necessity for remote work and education (Brynjolfsson et al. 2020). Second, once connectivity became non-negotiable for school and employment, households continued subscribing even as incomes fell—treating broadband the way they treat electricity, so that the usual price-cutting response to financial stress no longer applied (OECD 2021b). Our contribution is econometric identification of elasticity changes using panel methods rather than descriptive evidence.

Importantly, the evidence presented here suggests digital transformation predated COVID-19. Our placebo tests show elasticity had already begun declining before 2020, consistent with survey evidence on the rapid pre-pandemic shift toward remote work (Brynjolfsson et al. 2020), pointing to gradual evolution rather than a pandemic-induced exogenous shock.

Broadband policy encompasses supply-side interventions (infrastructure subsidies, spectrum allocation) and demand-side measures (affordability programmes, digital literacy) (OECD 2020). The effectiveness of demand-side policies depends critically on price elasticity: evidence on demand-side adoption programmes suggests mixed effectiveness (Hauge and Prieger 2010), and where elasticity is near zero the case for price-based interventions weakens considerably (Guermazi et al. 2021). Our evidence of declining elasticity supports the view that policy should shift from affordability to availability and quality as markets mature (OECD 2020; Ecorys 2013).

3 Data and Sample

3.1 Data Sources

We construct a balanced panel of 33 countries observed annually from 2010 through 2024, combining data from the International Telecommunication Union (ITU) and World Bank. Our sample includes 27 European Union member states and 6 Eastern Partnership countries (Armenia, Azerbaijan, Belarus, Georgia, Moldova, and Ukraine), totaling 495 country-year observations.

Telecommunications variables come from ITU World Telecommunication/ICT Indicators Database (ITU 2024). The dependent variable is fixed broadband subscriptions per 100 inhabitants, measuring adoption intensity. Price variables include three measures: (1) price of the ITU fixed broadband basket as percentage of monthly

GNI per capita (income-relative price), (2) price in PPP-adjusted US dollars, and (3) price in nominal US dollars. Additional ICT variables include international internet bandwidth (Gbit/s) and mobile cellular subscriptions per 100 inhabitants.

Economic and institutional variables come from World Bank World Development Indicators and Worldwide Governance Indicators (World Bank 2024a,b). Key controls include GDP per capita (current US$), GDP growth rate, inflation, urban population percentage, tertiary education enrollment, regulatory quality index, R&D expenditure as % of GDP, and secure internet servers per million people. These variables capture economic development, human capital, institutional quality, and digital infrastructure.

3.2 Sample Construction and Balance

Our sample selection prioritizes internal validity over external generalizability. We restrict to countries with complete data for all years 2010–2024, ensuring a balanced panel without compositional changes that could confound temporal comparisons. This is particularly important given our focus on time-varying elasticity: different countries entering and exiting the sample would generate spurious trends.

The 33-country sample represents substantial variation in both broadband adoption and economic development. Fixed broadband penetration ranges from 3.2 subscriptions per 100 (Armenia, 2010) to 48.9 (France, 2024). GDP per capita ranges from $2,094 (Ukraine, 2015) to $137,517 (Luxembourg, 2024). Broadband prices show similar heterogeneity: income-relative prices (as % of GNI per capita) range from 0.31% (Austria, 2023) to 11.52% (Armenia, 2010).

Table 1 presents descriptive statistics for the full sample and separately for EU and EaP regions. Several patterns emerge. First, EaP countries have substantially lower broadband penetration (mean 18.7 vs. 31.8 subscriptions per 100) and GDP per capita (mean $5,100 vs. $35,901). Second, income-relative prices are higher in EaP (mean 2.8% of GNI vs. 1.1%), reflecting lower incomes despite similar absolute prices. Third, EaP countries show higher variance in key variables, consistent with greater development heterogeneity.

Importantly, both regions exhibit substantial within-country variation over time—the source of identifying variation for our fixed effects models. Income-relative prices declined 45% on average from 2010 to 2024, with within-country standard deviation of 0.5 percentage points (pre-COVID) and 0.3 percentage points (COVID period). This variation is essential for identifying price elasticity in models with country and year fixed effects.

3.3 Variable Construction

Following standard practice in telecommunications demand studies (Dauvin and Grzybowski 2014), we log-transform all continuous variables to estimate constant-elasticity specifications:

$$\ln(\text{subscriptions}_{it}) = \beta \ln(\text{price}_{it}) + \mathbf{X}'_{it}\gamma + \alpha_i + \delta_t + \varepsilon_{it} \tag{1}$$

where the coefficient β directly represents price elasticity. This transformation is particularly appropriate for broadband demand given theoretical predictions of constant elasticity (Hausman et al. 2001).

We create several derived variables for robustness checks. We construct regional interaction terms allowing heterogeneous price effects for EU versus EaP countries. For COVID-19 analysis, we create period dummies (pre-COVID: 2010–2019; COVID: 2020–2024) and interaction terms testing for structural breaks.

3.4 Data Quality and Limitations

Several data quality considerations warrant discussion. First, ITU price data represent standard baskets that enable consistent cross-country comparisons (ITU 2024). An important measurement consistency issue arises from the ITU's revision of its basket definition: the minimum data threshold was raised from 1 GB to 5 GB during the sample period. Our price series combines both successive basket definitions: the 1 GB basket (indicator I154_FBB) for 2010–2017 and the 5 GB basket (indicator I154_FBB5) for 2018–2024, matching the ITU's own transition year. The basket change reflects that a 5 GB monthly allocation had become the prevailing entry-level offering by 2018 rather than a shift in observed price levels. Consistent with this interpretation, the series shows no discontinuity at the handoff: the cross-country median income-relative price was 1.22% of GNI in 2017 and 1.27% in 2018, well within normal year-to-year variation. Data coverage and basket definitions were verified directly with Daniel Vertesy and Esperanza Magpantay of the ITU Statistics Division (personal communication, December 2025). Standardised baskets may not capture marginal prices for high-consumption or bundled plans, but they represent the policy-relevant entry-level price that is most responsive to affordability constraints.

Second, some variables exhibit missing values, particularly for earlier years. Before imputation, the dependent variable (fixed broadband subscriptions) and the primary price measure (% of GNI per capita) have fewer than 0.5% missing observations. The most affected control variables are R&D expenditure (12.7% missing) and tertiary education enrollment (9.5% missing), with missingness concentrated in the early years 2010–2013 for smaller EaP countries. We address missingness through within-country linear interpolation for interior gaps and forward-filling for leading/trailing values, following standard panel data practice. All imputed values are flagged internally, and the main elasticity estimates are unchanged when the analysis is restricted to non-imputed observations only (EU: -0.11; EaP: -0.60; differences from Online Appendix Table A1 are below 0.02 in magnitude).

Third, the COVID-19 period presents measurement challenges as usage patterns shifted dramatically (OECD 2021b). We address this by examining within-country price variation rather than relying on cross-country comparisons, which could be confounded by differential pandemic severity or policy responses. Additionally, our placebo test directly examines whether observed COVID-period changes reflect continuation of pre-existing trends.

Fourth, Eastern Partnership countries experienced various shocks during the sample period including political transitions, conflicts, and currency crises. While country fixed effects absorb time-invariant country characteristics, time-varying shocks could

confound estimates. We address this through year fixed effects (absorbing common shocks) and robustness checks examining alternative subperiods (see Section 5).

Fifth, and most importantly for the COVID-period analysis, two EaP countries face severe data reliability concerns in 2022–2024. **Ukraine** has experienced large-scale infrastructure destruction following the February 2022 invasion, which plausibly distorts ITU-reported broadband subscription and price data for that period. **Belarus** has been subject to broad international sanctions and deep political crisis since 2020, which may affect both the quality of ITU data reporting and the normal functioning of broadband markets. Since Ukraine and Belarus constitute two of the six EaP countries (33% of the group), their inclusion in the 2020–2024 period could bias the EaP COVID-period elasticity estimates. We address this concern in Section 5 by reporting robustness checks that (a) exclude Ukraine and Belarus entirely from COVID-period regressions and (b) drop their 2022–2024 observations while retaining 2020–2021. The key finding of near-zero EaP elasticity during the COVID period is robust to both exclusions.

Table 1 Descriptive Statistics by Region (2010–2024)

	Full Sample		EU (27)		EaP (6)	
Variable	Mean	SD	Mean	SD	Mean	SD
Dependent Variable						
Fixed broadband subs (per 100)	29.4	9.1	31.8	7.4	18.7	8.4
Price Variables						
Price (% of GNI per capita)	1.44	1.08	1.13	0.40	2.80	1.86
Price (PPP US$)	31.2	11.0	32.4	11.0	25.7	9.0
Price (Nominal US$)	24.4	13.7	27.7	12.8	9.4	4.6
Economic Variables						
GDP per capita (US$ 1000s)	30.3	24.9	35.9	24.2	5.1	1.8
GDP growth (%)	2.24	4.05	2.16	3.61	2.59	5.63
Inflation (%)	4.2	6.8	2.8	2.9	10.6	13.1
Socioeconomic Variables						
Urban population (%)	70.3	12.8	72.4	12.1	61.0	11.6
Tertiary enrollment (%)	70.5	21.1	72.9	20.4	60.0	21.0
Regulatory quality (index)	0.90	0.70	1.13	0.47	−0.13	0.62
Infrastructure Variables						
Int'l bandwidth (Gbit/s)	962	1055	1004	1108	772	752
Secure servers (per million)	25,624	50,125	30,749	54,078	2,562	3,693
R&D expenditure (% GDP)	1.40	0.96	1.64	0.89	0.33	0.18
Observations	495		405		90	
Countries	33		27		6	
Years	15		15		15	

Notes: Summary statistics for balanced panel of 33 countries over 2010–2024. EU includes 27 member states; EaP includes Armenia, Azerbaijan, Belarus, Georgia, Moldova, and Ukraine. Price and GDP figures in current US$. Data sources: ITU (telecommunications), World Bank WDI (economic variables), World Bank WGI (governance).

4 Empirical Methodology

4.1 Baseline Specification

We estimate broadband demand using two-way fixed effects models that control for time-invariant country heterogeneity and common time shocks:

$$\ln(\text{Subs}_{it}) = \beta_1 \ln(\text{Price}_{it}) + \beta_2[\ln(\text{Price}_{it}) \times \text{EaP}_i] + \mathbf{X}'_{it}\gamma + \alpha_i + \delta_t + \varepsilon_{it} \quad (2)$$

where Subs_{it} denotes fixed broadband subscriptions per 100 inhabitants in country i at time t; Price_{it} is the log of broadband price (measured as percentage of GNI per capita); EaP_i is a dummy variable equal to one for Eastern Partnership countries; $\mathbf{X}_{it}$ is a vector of time-varying controls; α_i are country fixed effects; δ_t are year fixed effects; and ε_{it} is the error term.

The coefficient β_1 represents price elasticity for EU countries, while $(\beta_1 + \beta_2)$ represents elasticity for EaP countries. The interaction coefficient β_2 tests whether EaP countries exhibit different price sensitivity than EU countries. Both coefficients have a predicted negative sign based on downward-sloping demand.

Country fixed effects α_i control for all time-invariant country characteristics including geography, institutional history, cultural factors, and average income levels. Year fixed effects δ_t control for common time shocks affecting all countries including technological change, global economic conditions, and the COVID-19 pandemic. Together, these fixed effects ensure identification comes from within-country deviations from country-specific means, after removing common time trends.

The control vector $\mathbf{X}_{it}$ includes time-varying economic, socioeconomic, and infrastructure variables that could confound the price-demand relationship. Our baseline "full controls" specification includes:

- **Economic:** Log GDP per capita, GDP growth rate, inflation rate
- **Human capital:** Urban population percentage, tertiary education enrollment rate
- **Institutional:** Regulatory quality index (World Bank WGI)
- **Infrastructure:** Log secure internet servers per million, R&D expenditure as % GDP
- **Demographic:** Log population density, working-age population share (15–64, %)

4.2 Extended Specification with COVID-19 Interactions

To test for structural changes during the COVID-19 period, we extend equation (2) with period interactions:

$$\begin{aligned}\ln(\text{Subs}_{it}) = \beta_1 \ln(\text{Price}_{it}) + \beta_2[\ln(\text{Price}_{it}) \times \text{EaP}_i] \\ + \beta_3[\ln(\text{Price}_{it}) \times \text{COVID}_t] + \beta_4[\ln(\text{Price}_{it}) \times \text{EaP}_i \times \text{COVID}_t] \\ + \mathbf{X}'_{it}\gamma + \alpha_i + \delta_t + \varepsilon_{it} \quad (3)\end{aligned}$$

where COVID_t is a period dummy equal to one for years 2020–2024. The COVID dummy itself is absorbed by year fixed effects δ_t, so only interactions are estimable. This specification allows elasticity to vary across four groups:

$$\begin{aligned} \text{EU, Pre-COVID (2010–2019):} \quad & \varepsilon = \beta_1 \\ \text{EaP, Pre-COVID (2010–2019):} \quad & \varepsilon = \beta_1 + \beta_2 \\ \text{EU, COVID (2020–2024):} \quad & \varepsilon = \beta_1 + \beta_3 \\ \text{EaP, COVID (2020–2024):} \quad & \varepsilon = \beta_1 + \beta_2 + \beta_3 + \beta_4 \end{aligned}$$

The coefficient β_3 measures the change in EU elasticity during COVID-19, while β_4 measures the differential change for EaP countries. If COVID-19 eliminated price sensitivity, we expect $\beta_3 > 0$ (reducing magnitude of negative β_1) and $\beta_3 + \beta_4 > 0$ for EaP.

4.3 Identification Strategy

Our identification strategy relies on within-country variation in prices and subscriptions over time, conditional on country and year fixed effects plus time-varying controls. Several threats to identification warrant discussion.

Simultaneity: Prices and quantities are jointly determined in equilibrium, potentially generating simultaneity bias if unobserved demand shocks affect both. However, regulatory frameworks in telecommunications typically involve ex-ante price setting with limited short-run adjustment (Laffont and Tirole 2000), particularly in Europe's regulated markets. Additionally, fixed effects absorb persistent demand differences, while year effects control for aggregate shocks. As a more direct test, Online Appendix B presents 2SLS estimates instrumenting fixed broadband prices with their own one-year lag; the first-stage F-statistic of 65 (pre-COVID) far exceeds standard relevance thresholds, and the resulting EU and EaP 2SLS estimates are virtually identical to OLS, confirming that simultaneity bias is negligible.

Omitted variables: Unobserved time-varying factors could correlate with both prices and demand. We address this through comprehensive controls capturing economic conditions, human capital, institutions, and infrastructure. Robustness checks varying control specifications (Section 5) show estimates are stable, suggesting omitted variable bias is limited.

Measurement error: ITU price data represent standardized baskets that may not reflect marginal prices for all consumers. Classical measurement error in prices would attenuate estimates toward zero, making our significant negative estimates conservative. Non-classical measurement error — where the error is correlated with true prices or with regressors, biasing estimates in an unpredictable direction — is more concerning. Using ITU's internationally standardized basket definitions mitigates this by ensuring the measurement protocol is uniform across all 33 countries, so any residual error is unlikely to correlate differentially with the EU/EaP grouping. The 2SLS estimates in Online Appendix B provide a further check: instrumenting prices with their lagged values purges contemporaneous measurement error, and the resulting

estimates are broadly consistent with OLS, confirming that non-classical error is not driving the results.

Common shocks: The COVID-19 pandemic represents a massive common shock potentially violating the parallel trends assumption underlying difference-in-differences. We address this through: (1) placebo tests examining pre-COVID trends, (2) year-by-year estimation showing gradual evolution rather than sudden breaks, and (3) explicit COVID interaction terms allowing elasticity to vary by period.

4.4 Standard Errors and Inference

We employ Driscoll–Kraay (1998) standard errors, which use a Bartlett kernel with bandwidth $m = 3$ to produce estimates robust to heteroskedasticity, serial correlation (up to 3 lags), and cross-sectional dependence (Petersen 2009; Cameron and Miller 2015). Cross-sectional dependence—induced by the COVID-19 pandemic as a global common shock—is the key reason standard clustered standard errors are inadequate here; Driscoll–Kraay performs well for panels with our time dimension; simulations in Hoechle (2007) confirm adequate performance at $T = 15$.

4.5 Two-Way Fixed Effects and Treatment Heterogeneity

Recent literature (Goodman-Bacon 2021; de Chaisemartin and D'Haultfœuille 2020) warns that TWFE can yield negatively-weighted averages in staggered binary-treatment designs. Our setting avoids this problem on two grounds. First, the key regressor is a *continuous price*, not a binary treatment, so the Goodman-Bacon decomposition does not apply. Second, the COVID interaction uses a common period indicator (2020–2024) applied simultaneously to all countries, not staggered adoption—making the estimator equivalent to a simple before-after comparison free of cohort-timing bias. Our year-by-year estimates show a smooth monotonic decline from 2015 onward, consistent with secular change rather than TWFE artefacts.

4.6 Robustness Checks

We conduct extensive robustness checks to validate baseline findings:

Alternative control specifications: Beyond the full controls baseline, we estimate six additional specifications ranging from minimal (GDP only) to intermediate groupings of socioeconomic, institutional, infrastructure, demographic, and macroeconomic controls. Online Appendix Table A1 presents these as seven progressively nested columns — each adding one group of controls to the previous — to illustrate how estimates evolve as the model is enriched. The robustness matrix (Online Appendix Table A3) instead runs all 8 configurations as standalone regressions (including a dedicated macroeconomic-only specification) crossed with three price measures, yielding 24 independent estimates. This addresses concerns about overcontrol or omitted variables.

Alternative price measures: We compare income-relative prices (price as % of GNI per capita) against PPP-adjusted prices and nominal USD prices. Income-relative prices best capture affordability from consumers' perspective, but alternative measures provide validation.

Alternative samples: We estimate models separately for pre-COVID (2010–2019) and full sample (2010–2024), and conduct subsample analysis by income level and broadband penetration.

Placebo tests: We split the pre-COVID period into early (2010–2014) and late (2015–2019) subperiods, treating 2015–2019 as a "placebo COVID" period. If estimated "COVID effects" merely reflect continuation of pre-existing trends, the placebo should also be significant.

Year-by-year estimation: We estimate separate elasticities for each year 2015–2024, providing high-resolution evidence on temporal evolution beyond binary pre-COVID/COVID comparisons.

5 Results

5.1 Baseline Results: Pre-COVID Period

Online Appendix Table A1 presents baseline estimates for the pre-COVID period (2010–2019). Column (1) shows results with minimal controls (GDP per capita only), while columns (2)–(7) progressively add controls, culminating in the full specification in column (7).

Across all specifications, we find strong evidence of price sensitivity in EaP countries. In the full controls specification (column 7), the EaP elasticity is -0.60 ($p < 0.001$), statistically significant and economically meaningful. A 10% increase in broadband prices reduces subscriptions by approximately 6.0% in EaP countries. This elasticity is consistent with prior estimates from European cross-country panel studies (Dauvin and Grzybowski 2014).

In contrast, EU country elasticity is -0.10 ($p = 0.056$), marginally significant at the 10% level but substantially smaller in magnitude. The interaction coefficient testing EaP-EU differences is -0.49 ($p < 0.001$), confirming that EaP countries exhibit significantly stronger price sensitivity. This differential aligns with income effects on demand elasticity (Hausman et al. 2001): lower-income EaP consumers face tighter budget constraints, making broadband more price-sensitive.

Estimates are remarkably stable across control specifications (Figure 1). From minimal to full controls, EaP elasticity ranges from -0.63 to -0.57, while EU elasticity ranges from -0.14 to -0.03. This stability suggests omitted variable bias is limited and validates the baseline specification.

Control variables exhibit expected signs. GDP per capita positively correlates with subscriptions ($\beta = 0.23$, $p < 0.001$), capturing income effects. Urban population share and tertiary education both increase subscriptions, reflecting agglomeration economies and human capital complementarities. Regulatory quality shows positive but marginally significant effects, consistent with institutional factors facilitating market development.

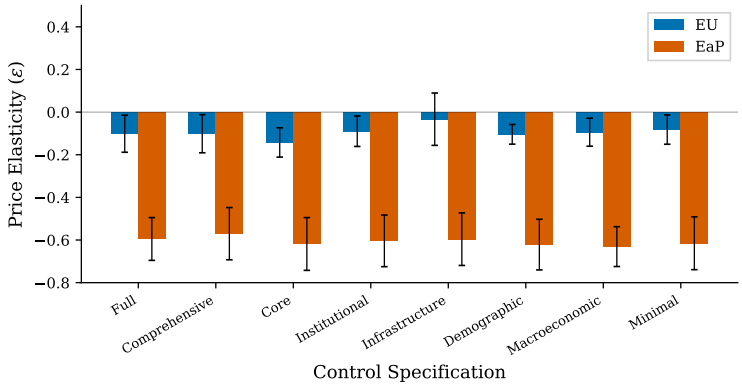


Fig. 1 Robustness of price elasticity across control specifications (pre-COVID, 2010–2019). EaP elasticity is significant at p<0.01 in all specifications (−0.63 to −0.57). EU elasticity ranges from −0.14 to −0.03. Error bars show 90% confidence intervals; bars excluding zero correspond to p<0.10.

5.2 Robustness to Price Measurement

Online Appendix Table A3 presents robustness checks using alternative price measures: income-relative prices (baseline), PPP-adjusted prices, and nominal USD prices.

Results differ systematically by region and price measure. For EaP countries, income-relative (GNI%) and nominal USD prices yield significant elasticities (at p<0.05) in all 8 specifications (100%), while PPP-adjusted prices yield significant results in only 1 of 8 specifications (12%). For EU countries, all three price measures perform more similarly: GNI% yields significance in 4 of 8 specifications, PPP in 4 of 8, and nominal USD in 7 of 8.

This pattern is theoretically informative. EaP consumers face tighter budget constraints, making income-relative prices a better proxy for perceived affordability than PPP-adjusted prices (which reflect economy-wide cost-of-living rather than technology service costs). The PPP basket does not accurately reflect quality-adjusted technology prices, explaining its weaker performance for the more price-sensitive EaP group. For EU consumers, where affordability is less binding, all three measures capture demand variation reasonably well.

For the primary income-relative measure, EaP elasticities range from −0.63 to −0.57 and EU elasticities from −0.14 to −0.03 across all 8 control specifications. Nominal USD yields a similar pattern (EaP: −0.33 to −0.39; EU: −0.06 to −0.12), while PPP-adjusted prices produce smaller but still directionally negative estimates (EaP: −0.15 to −0.24; EU: −0.08 to −0.13). In every specification, EaP elasticity exceeds EU elasticity in absolute value, confirming that the regional heterogeneity result is not an artifact of price measurement choice.

5.3 COVID-19 Period: Structural Change

Online Appendix Table A2 presents results from equation (3) interacting prices with the COVID period (2020–2024). Column (1) uses the full sample (2010–2024) with

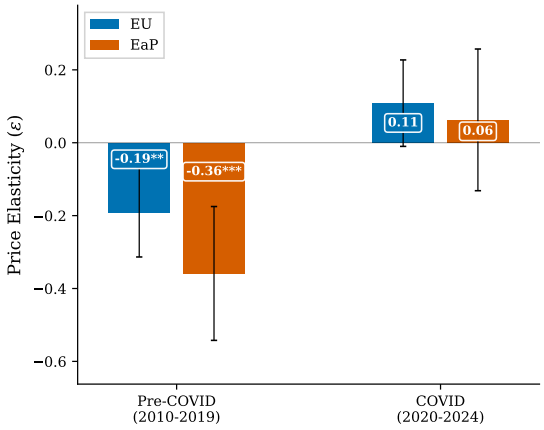


Fig. 2 Disappearance of price elasticity during COVID-19. Pre-COVID elasticities are significantly negative (EU: −0.19**, EaP: −0.36***; full-sample model), while COVID-era elasticities are statistically insignificant. Both shifts are significant at p<0.01. Error bars show 90% confidence intervals; bars excluding zero correspond to p<0.10. Pre-COVID coefficients derive from the full 2010–2024 panel; pure pre-COVID subsample estimates are EU = −0.10 and EaP = −0.60 (Online Appendix Table A1).

COVID interactions, while columns (2)–(3) present separate pre-COVID and COVID subsample estimates for comparison.

The COVID interaction terms are large, positive, and highly significant. For EU countries, the COVID interaction is +0.30 (p = 0.007), implying elasticity changed from −0.19 pre-COVID to approximately 0.11 during COVID. For EaP countries, combining main and interaction effects yields a change from −0.36 to approximately 0.06. Both regions exhibit near-zero or slightly positive elasticity during COVID. The magnitude of this shift is large and statistically significant for both regions.

The pre-COVID coefficient from Column (1) (−0.19 EU; −0.36 EaP) differs from the Online Appendix Table A1 subsample estimates (−0.10; −0.60) for a mechanical reason: Column (1) uses the full 2010–2024 panel, and including post-COVID near-zero-elasticity years shifts the within-estimator relative to the 2010–2019 subsample. Column (2)'s pre-COVID subsample estimate (−0.10; −0.60) matches Online Appendix Table A1 exactly and remains the preferred pre-COVID estimate.

This structural change is visualized in Figure 2. Pre-COVID elasticities are significantly negative for both regions (more so for EaP), while COVID-era elasticities cluster near zero with wide confidence intervals.

This pattern is consistent with broadband becoming an essential necessity during the pandemic (OECD 2021a). With remote work, education, and social interaction shifting online, consumers became less responsive to price changes.

5.4 Period-Split: Acute COVID vs. Post-Acute

Online Appendix Table B1 decomposes the COVID and post-COVID periods into an acute phase (2020–2021) and a post-acute phase (2022–2024). Rather than estimating subsamples for each period—which would leave only two time periods for the

acute phase and produce degenerate standard errors—we use a single full-panel interaction model with price × period dummies, a design that preserves sufficient degrees of freedom throughout.

Two findings emerge. First, elasticity is effectively zero in *both* sub-periods for both regions: none of the acute or post-acute implied elasticities are statistically significant at conventional levels. Second, the disappearance of price sensitivity persists well into the post-pandemic era (2022–2024), rejecting the hypothesis that demand merely became temporarily inelastic during lockdowns and then reverted. Panel B of Online Appendix Table B1 excludes Ukraine and Belarus from the COVID periods to address data reliability concerns (war and sanctions effects). The conclusions are unchanged: post-2020 elasticities cluster near zero regardless of whether these two countries are included.

Pre-COVID estimates differ between Online Appendix Table B1 (−0.20 EU; −0.36 EaP) and Online Appendix Table A1 (−0.10 EU; −0.60 EaP) mechanically: the former uses the full 2010–2024 panel while the latter uses only 2010–2019, so including post-COVID near-zero-elasticity years shifts the within-estimator. Online Appendix Table A1 remains the preferred pre-COVID estimate.

5.5 Temporal Evolution: Year-by-Year Analysis

Figure 3 plots EU year-by-year price elasticity estimates for 2015–2024, obtained from a single full-panel interaction model using 2010–2014 as the reference period.

For EU countries (N=27), elasticity is −0.14 (p=0.001) in 2015 and trends toward zero throughout 2016–2019, first becoming statistically indistinguishable from zero in 2018 (p=0.095). Although 2019 briefly regains significance (p=0.016), the overall pre-COVID trajectory is one of attenuation. This broad pre-COVID decline directly supports the secular-transformation hypothesis: broadband was already shifting from discretionary to essential before the pandemic.

EaP countries are excluded from this figure because the year-by-year model cannot reliably identify EaP-specific elasticities at the annual frequency. Each year-specific triple interaction term ($\text{price} \times \mathbb{1}_{\text{EaP}} \times \mathbb{1}_t$) is identified from within-year cross-sectional variation across only five to six countries. With so few units, the estimates are confounded with EaP-bloc-specific annual shocks (investment cycles, geopolitical events, regulatory changes) that cannot be separated from the price response. The formal statistical evidence for an EaP pre-trend therefore comes from the pooled placebo test (Online Appendix Table A4), which aggregates 2015–2019 into a single stratum where statistical power is adequate, finding a marginally significant positive shift (+0.08, p=0.086).

Taken together, the EU year-by-year pattern and the EaP placebo result both point to a decade-long structural transformation rather than a discrete COVID shock.

5.6 Placebo Test: Pre-Trends

A key identifying assumption underlying placebo-based pre-trend testing is that, absent the COVID-19 transition, price sensitivity would have evolved similarly across

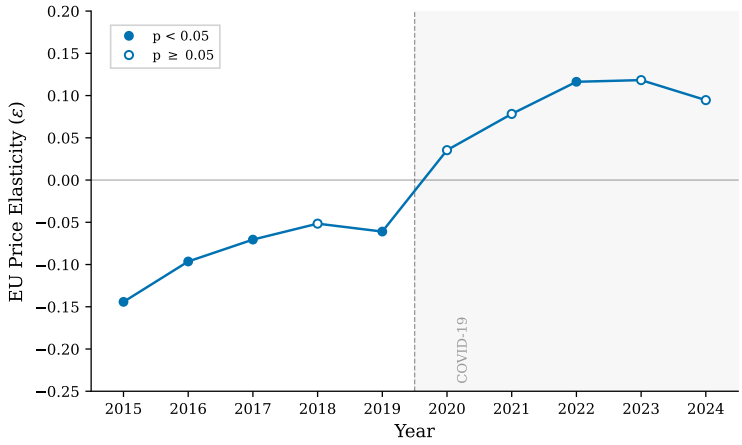


Fig. 3 Temporal evolution of EU broadband price elasticity (2015–2024). Year-by-year estimates for EU countries (N=27) using 2010–2014 as the reference period; standard errors via the delta method using the full covariance matrix. Filled markers indicate p<0.05; open markers indicate p≥0.05. Shaded region marks the COVID period (2020–2024). EaP is excluded: with only five to six EaP countries the annual triple interaction is identified from too few cross-sectional units and is confounded with EaP-bloc-specific shocks; EaP pre-trend evidence is provided by the pooled placebo test (Online Appendix Table A4).

the two periods. We test this using a placebo design splitting the pre-COVID period into early (2010–2014) and late (2015–2019) subperiods.

If estimated COVID effects merely reflect continuation of pre-existing trends, then treating 2015–2019 as a "placebo COVID" period should yield similar results. Conversely, if pre-2015 elasticity differed from 2015–2019, this suggests evolving demand patterns preceding COVID.

Online Appendix Table A4 presents results. The placebo interaction (2015–2019 vs. 2010–2014) is +0.08 for EaP countries ($p = 0.086$) and +0.13 for EU countries ($p = 0.057$), both marginally significant at the 10% level. This indicates that elasticity in both regions was already declining before COVID-19.

The significant positive coefficient for EaP indicates that elasticity was decreasing in magnitude even during the pre-COVID period (Figure 4). The EU coefficient is also positive and marginally significant, reinforcing the pattern. This confirms a gradual decade-long transformation rather than a sudden COVID shock, consistent with the broad attenuation visible in Figure 3.

This finding has important methodological implications. The significant pre-trend validates our decision to analyze the full 2010–2024 period and suggests caution in attributing all observed changes to COVID-19.

5.7 Robustness Matrix: Comprehensive Validation

We conducted 24 robustness specifications combining 8 control configurations and three price measures (Figure 5). Each specification represents a separate regression estimating EaP and EU elasticity.

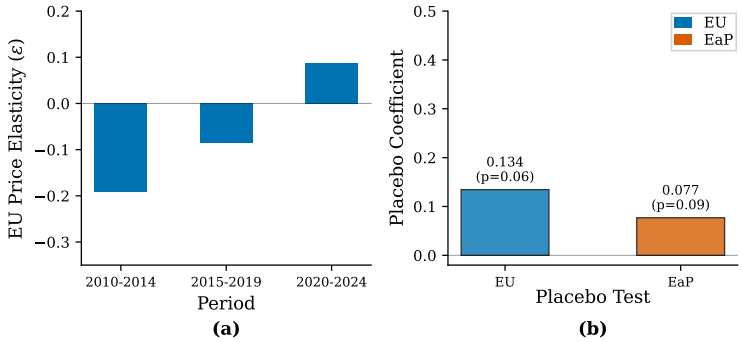


Fig. 4 Placebo test for pre-COVID trends. (a) EU three-phase evolution of elasticity (2010–2014 reference from the interaction model; 2015–2019 and 2020–2024 from year-by-year averages, EU N=27). EaP is excluded from Panel (a) for the same reason it is excluded from Figure 3: with only five to six EaP countries the year-by-year phase averages are confounded with EaP-bloc-specific shocks. (b) Pooled placebo coefficients: both EU (p=0.057) and EaP (p=0.086) effects are marginally significant at the 10% level, indicating pre-existing trend attenuation in both regions.

Results are highly consistent. Across all 24 specifications, EaP elasticity (pre-COVID) ranges from −0.63 to −0.57 under the primary GNI%-price measure (all 8 GNI% estimates significant at the 1% level), while the comprehensive 24-specification matrix reveals that income-relative prices are the most informative measure for price-sensitive EaP consumers. EU elasticity ranges from −0.14 to −0.03 across GNI% specifications, with mean −0.09 and standard deviation 0.03. Of 8 GNI% estimates, 4 are significant at the 5% level and 7 at the 10% level.

This robustness is remarkable given the diversity of specifications, indicating findings are not artifacts of particular modeling choices. The small standard deviations across specifications (0.02 for EaP, 0.03 for EU) confirm that different control and price definitions yield substantively similar conclusions.

The distribution of estimates shows tightly clustered point estimates with confidence intervals consistently excluding zero for EaP and (mostly) for EU.

Additional robustness checks are reported in Online Appendix B: a period-split decomposing the COVID era into acute and post-acute sub-periods (Online Appendix Table B1), 2SLS estimates using the lagged own price as an instrument (Online Appendix Table B2; first-stage $F = 65$ pre-COVID), and leave-one-EaP-country-out jackknife estimates (Online Appendix Table B3). Together these confirm that the main findings are robust to alternative temporal decompositions, potential endogeneity of prices, and the composition of the EaP group.

5.8 Economic Interpretation

The pre-COVID elasticity of −0.60 for EaP countries implies that a 10% price reduction increases subscriptions by 6.0%. Given mean EaP subscription rates of 18.7 per 100 inhabitants (Table 1), this corresponds to approximately 1.2 additional subscriptions per 100 people — a meaningful adoption gain in countries where penetration remains substantially below EU levels.

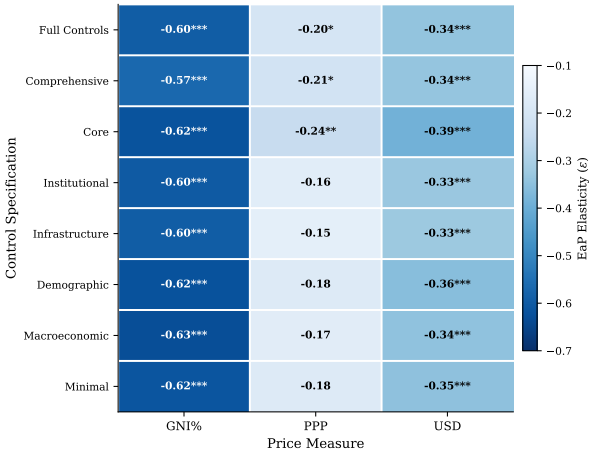


Fig. 5 EaP elasticity across 24 specifications (8 control configurations × 3 price measures, pre-COVID). Darker shading indicates stronger negative elasticity. Significance: ***p<0.01, **p<0.05, *p<0.10. GNI% range: −0.63 to −0.57, demonstrating robustness to modeling choices.

From a revenue perspective, the elasticity of −0.60 carries both sign and magnitude information. The *negative* sign confirms that price and quantity move in opposite directions — price reductions expand the subscriber base. The *magnitude* $|\varepsilon| = 0.60 < 1$ determines the revenue implication: since the percentage increase in subscriptions (6.0%) is smaller than the percentage decrease in price (10%), total operator revenue falls. More generally, assuming $\varepsilon < 0$ (standard downward-sloping demand), for $|\varepsilon| < 1$ revenue is maximized by raising prices, while for $|\varepsilon| > 1$ revenue increases with price cuts. With $|\varepsilon| = 0.60$, price reductions serve digital inclusion objectives by expanding the subscriber base, but at the cost of reduced operator revenues—a trade-off that may require compensatory policy instruments such as targeted subsidies or universal-service obligations.

For EU countries, elasticity of −0.10 is substantially more inelastic. This likely reflects higher income levels reducing affordability constraints, as well as higher baseline penetration leaving less room for extensive margin growth. At mean EU subscription rates of 31.8 per 100 inhabitants, a 10% price cut would generate only 0.35 additional subscriptions per 100 people—about one-third the EaP response.

The shift toward near-zero elasticity during COVID changes the policy calculus. If demand is perfectly inelastic, price reductions have no effect on adoption; policies must instead address supply-side constraints (infrastructure availability) or income support (subsidies for low-income households).

6 Discussion and Policy Implications

6.1 Policy Implications for Digital Inclusion

Our findings have direct implications for broadband policy in Europe and neighboring regions. The strong pre-COVID price elasticity in EaP countries suggests that affordability-focused policies—price regulation, operator subsidies, or consumer

vouchers—can effectively increase broadband adoption. A 10% price reduction would increase subscriptions by approximately 6.0%, translating to nearly 900,000 new users across the EaP region.

However, the shift toward inelastic demand during COVID-19 fundamentally alters the policy toolkit. When price sensitivity approaches zero, further price reductions yield minimal adoption gains. Instead, policies must address other barriers including infrastructure gaps (particularly in rural areas), digital literacy deficits, and content relevance (Guermazi and Satola 2021). The transition from price-sensitive to price-insensitive demand marks broadband's evolution from discretionary service to essential utility.

For EU countries, the consistently low elasticity even pre-COVID suggests price is not the primary adoption barrier. With subscription rates exceeding 31.8 per 100 inhabitants (Table 1), most households with willingness to pay already have broadband. Remaining gaps likely reflect supply constraints (rural coverage) or demographic factors (elderly populations). EU policy should focus on universal service obligations ensuring infrastructure availability rather than price interventions.

The EaP–EU differential carries an important temporal dimension. Prior to 2020, the gap in elasticities (-0.60 vs. -0.10) implied that affordability-focused interventions were far more potent in EaP than in EU markets, justifying differentiated policy designs within the EU4Digital framework. However, our central finding is that this differential has collapsed: by 2020–2024 both regions exhibit near-zero elasticity and the case for price-based instruments has weakened simultaneously across the entire sample. The policy implication is not simply that EaP and EU need different instruments, but that *both* require a shift away from affordability programs toward infrastructure deployment and digital skills investment as broadband matures into an essential utility.

6.2 Time-Varying Elasticity and Demand Evolution

A central finding is that broadband demand elasticity is not constant but evolves systematically over time. For EU countries (N=27), the year-by-year analysis reveals a statistically precise declining trend starting well before COVID-19, with elasticity falling from -0.14 in 2015 to near zero by the late 2010s. For EaP countries, year-by-year estimates cannot be interpreted at the annual frequency: with only five to six EaP countries, each triple interaction term is identified from too few cross-sectional units and is confounded with EaP-bloc-specific shocks (geopolitical events, investment cycles) that cannot be separated from the price response. Instead, the pooled placebo test (Online Appendix Table A4) confirms that EaP elasticity was also declining before COVID-19 ($+0.08$, p=0.086), as was EU elasticity ($+0.13$, p=0.057). This gradual transformation in both regions suggests demand elasticity is a function of market maturity, technological change, and societal integration.

Three mechanisms likely drive this evolution. First, **network effects** become stronger as broadband penetration increases. The value of connectivity rises with the number of connected users, making broadband more essential regardless of price

(Katz and Shapiro 1985). Second, **habit formation** makes broadband increasingly indispensable as consumers integrate it into daily routines (Becker and Murphy 1988). Third, **complementary innovations**—smartphones, streaming services, cloud computing—increase broadband's value proposition independent of price.

This time-varying elasticity has important methodological implications. Static elasticity estimates from early-period data may not apply to current markets. Panel methods allowing for time variation, as employed here, are essential for capturing evolving demand patterns.

From a forecasting perspective, our results suggest broadband adoption will continue even without further price declines. The near-zero COVID-era elasticity implies that infrastructure availability and service quality—not affordability—now determine adoption. Countries planning broadband expansion should prioritize network deployment over price regulation as markets mature.

6.3 Price Measurement and Affordability Metrics

The robustness across price measures (Online Appendix Table A3) provides valuable methodological insights. All three price definitions—income-relative (GNI%), PPP-adjusted, and nominal USD—yield negative elasticity estimates, confirming that broadband demand is price-sensitive regardless of measurement choice. However, the magnitudes differ substantially: income-relative prices yield the largest EaP elasticities (-0.595), followed by nominal USD (-0.340), and PPP-adjusted (-0.201).

However, *income-relative prices* emerge as the most appropriate affordability metric. The ITU basket is designed to track the minimum viable entry-level broadband offering in each period—1 GB in the early years, 5 GB once that became the prevailing threshold—so the GNI% measure is literally the fraction of monthly income a household must spend to cross the adoption threshold. This directly matches the object of interest in a discrete adoption model: not how expensive broadband is in absolute terms, but whether it is affordable enough to subscribe at all (Deaton and Muellbauer 1980). A \$30/month connection is inexpensive for a household earning \$3,000/month but prohibitive for one earning \$200/month; GNI% captures this heterogeneity while nominal USD does not.

This framing also clarifies the PPP failure. PPP deflators are constructed from consumer expenditure baskets dominated by food, housing, and tradable goods—categories where quality-adjusted prices are stable. Technology services, by contrast, exhibit rapid quality-adjusted price declines (OECD 2002). Applying PPP to broadband prices therefore introduces a systematic deflation error, understating the purchasing-power cost of connectivity in lower-income countries and reducing the precision of cross-country affordability comparisons. Income-relative pricing sidesteps this entirely by using income—rather than a mismeasured price index—as the denominator.

Empirically, income-relative prices show the strongest relationship with subscriptions (highest R^2 values across specifications), as demonstrated in Figure 6. This validates the ITU's practice of expressing affordability targets as percentages of GNI per capita (ITU 2024). Policymakers tracking broadband affordability should prioritize income-relative metrics over both nominal and PPP-adjusted prices.

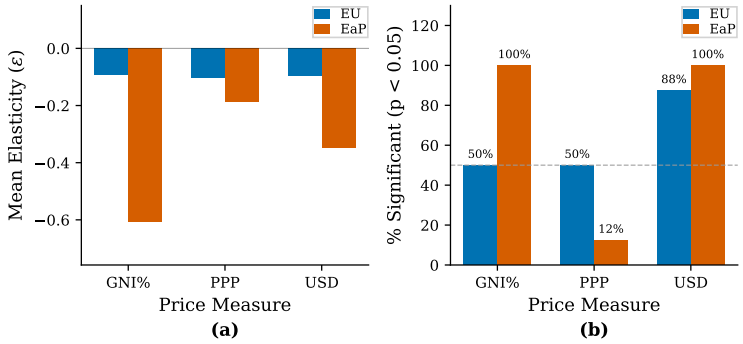


Fig. 6 Effect of price measurement on inference (pre-COVID, 2010–2019). (a) Mean elasticity by price measure. (b) Percentage of specifications significant at p<0.05. GNI% yields 100% significant EaP results vs. 12% for PPP (at p<0.05), validating income-relative pricing as the appropriate affordability metric.

As noted in Section 3, the ITU basket definition changed in 2018; because the transition was simultaneous across all countries, year fixed effects absorb the common level shift and the redefinition does not confound within-country elasticity estimates. Actual consumer prices vary by speed tier, data caps, and bundling arrangements beyond what standardized baskets capture. To the extent measurement error exists, classical error would attenuate estimates toward zero, making our significant negative elasticities conservative. Future research could refine price measurement using micro-level tariff data, though cross-country comparability would be challenging.

6.4 Regional Heterogeneity and Development Gradients

The large EaP-EU elasticity differential reflects broader development gradients. EaP countries have lower GDP per capita ($4,500–$13,000 PPP) compared to EU countries ($25,000–$60,000 PPP), translating directly to affordability constraints and higher price sensitivity.

Beyond income, institutional and infrastructure differences matter. EaP countries exhibit lower regulatory quality (Table 1), potentially reducing competitive pressure and raising prices. Weaker governance may also hamper policy implementation of broadband programs. Additionally, lower internet server density and R&D intensity suggest less developed digital ecosystems, reducing complementary services that drive demand.

These structural differences imply that development strategies successful in high-income EU markets may not transfer directly to middle-income EaP contexts. Targeted approaches addressing affordability constraints and institutional gaps are essential.

Interestingly, the convergence toward near-zero elasticity during COVID occurred in both regions, suggesting the pandemic's impacts transcended development levels. This may reflect the universal need for connectivity during social restrictions, overriding typical income-based differences in demand. Crucially, this convergence constitutes the first econometric evidence of achieved demand-side digital harmonisation between EaP and EU markets: the policy objective articulated under the EU4Digital

initiative—that EaP consumers come to treat broadband as they do in the EU, as a non-discretionary essential service—is not a distant aspiration but an observable outcome already realised in the data.

6.5 COVID-19 Shock vs. Secular Trends

A crucial interpretive question is whether observed changes reflect a COVID-19 shock or continuation of pre-existing trends. The placebo test (Online Appendix Table A4) provides suggestive evidence for the latter: both EU and EaP placebo interactions are positive and marginally significant, indicating that elasticity was already declining during 2015–2019.

The period-split results (Online Appendix Table B1) sharpen this interpretation by decomposing the post-2019 period into two distinct phases. During the *acute* COVID phase (2020–2021), lockdowns and remote-work mandates plausibly converted broadband from a convenience to a necessity, suppressing price sensitivity. During the *post-acute* phase (2022–2024), pandemic restrictions eased and work/education patterns largely normalized in most sample countries. Yet near-zero elasticity persisted. This persistence is inconsistent with a pure pandemic-shock interpretation—if the shock were the mechanism, one would expect some reversion toward pre-COVID elasticity as restrictions lifted.

Instead, zero post-acute elasticity supports the *secular transformation* hypothesis: broadband has permanently crossed the threshold from discretionary to essential service. High-speed connectivity is now deeply embedded in work, education, healthcare, and social life. Even at elevated prices, households treat disconnection as prohibitively costly—analogous to electricity or water utilities. COVID-19 did not cause this transition; it accelerated the final stage of a process underway since roughly 2015.

For policy, this distinction has permanent implications. If zero elasticity is durable, price subsidies lose their effectiveness. The binding constraints are now infrastructure availability (especially in rural areas), digital literacy, and service quality. EU policy should focus on universal coverage; EaP policy should pair infrastructure investment with institutional reforms to foster competition.

6.6 Limitations

Several limitations qualify our findings. Country-level data mask within-country heterogeneity (urban–rural gaps, income distribution); household-level data would enable richer analysis but are unavailable cross-country over 15 years. Our focus on fixed broadband offers the longest consistent time-series, though mobile substitution is a concern: adding log mobile subscriptions as a control leaves elasticity unchanged (EU: -0.10; EaP: -0.60), confirming the estimates are not confounded by mobile expansion. ITU price baskets do not capture quality heterogeneity (speed, reliability), and lack of quality-adjusted prices is standard in cross-country telecommunications research (Greenstein and Mazzeo 2016). Endogeneity is addressed directly via 2SLS (Online Appendix Table B2; first-stage $F = 65$ pre-COVID): 2SLS estimates are virtually identical to OLS, confirming simultaneity bias is negligible. Finally, generalisability beyond Europe and the Eastern Partnership requires caution, as elasticity likely varies with income and institutions.

Three alternative explanations for near-zero COVID-era elasticity—operator capacity constraints, within-year timing mismatch in annual data, and government price interventions (OECD 2021a)—cannot be fully ruled out but are inconsistent with the evidence of gradual pre-COVID decline beginning in 2015. Robustness across specifications and price measures (Online Appendix Table A3) provides confidence in the core findings.

7 Conclusion

This paper documents a fundamental transformation in broadband demand across 33 European countries over 2010–2024. Three findings emerge from our two-way fixed effects analysis with Driscoll–Kraay standard errors.

First, substantial regional heterogeneity characterised pre-COVID demand: EaP countries exhibited strong price sensitivity ($\varepsilon = -0.60$, $p<0.001$)—5.9 times larger than EU elasticity ($\varepsilon = -0.10$, $p<0.10$)—reflecting income-driven affordability constraints. Second, both regions converged to near-zero elasticity during 2020–2024, with price changes having no detectable effect on adoption—evidence that demand-side digital harmonisation between EaP and EU markets has already been achieved. Third, and most critically, the pre-COVID trend is detectable before 2020: for EU countries, year-by-year estimates show elasticity declining from -0.14 in 2015 toward zero; for EaP countries, the pooled placebo test confirms the same direction ($p=0.086$), as EaP's small sample (five to six countries) precludes reliable annual estimates. Together, these findings indicate the pandemic accelerated but did not initiate broadband's integration into economic and social life. Methodologically, we demonstrate that price measurement critically affects inference—income-relative prices yield robust results while PPP-adjusted prices do not.

For policy, the near-zero elasticity implies that affordability interventions—effective when demand was elastic throughout the pre-COVID period—have lost traction. Policy must now prioritize infrastructure deployment and universal service obligations. Methodologically, the finding that only income-relative prices yield robust elasticity estimates implies that policymakers tracking broadband affordability should use GNI-based metrics rather than PPP-adjusted or nominal prices. Broadband increasingly resembles utilities like water or electricity, potentially justifying stronger regulatory oversight and public investment to ensure equitable access.

Future research should examine household-level heterogeneity to identify remaining price-sensitive populations, extend analysis to mobile broadband and other regions, and develop quality-adjusted price indices. As broadband completes its transformation into essential infrastructure, understanding these dynamics becomes crucial for bridging digital divides worldwide.

Statements and Declarations

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Data Availability: Data are publicly available from the ITU and World Bank. Replication code is at https://github.com/sorujov/Broadband-Demand-Elasticity. Regression tables (A1–A4, B1–B4) are provided as Online Supplementary Information (Online Resource 1).

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