

Online Supplementary Information (Online
Resource 1)

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

Samir Orujov^{1,2,3,4*}, Ilgar Ismayilov^{2,5} and Jeyhun Huseynzade²

¹*School of Business, ADA University, Baku, Azerbaijan.

²Information Communication Technologies Agency, Baku, Azerbaijan.

³CERGE-EI, a joint workplace of Charles University and the Economics
Institute of the Czech Academy of Sciences, Prague, Czech Republic.

⁴Université de Bretagne Sud, Vannes, France.

⁵Faculty of Social Sciences, Charles University, Prague, Czech Republic.

*Corresponding author(s). E-mail(s): sorujov@ada.edu.az;

Abstract

This file is the Online Supplementary Information submitted alongside the article *Broadband Price Elasticity in EU and Eastern Partnership Countries: Evidence of a Decade-Long Transformation (2010–2024)*, *Journal of Regulatory Economics*. It contains eight regression tables referenced in the main text as Online Resource Tables A1–A4 and B1–B4. Appendix A presents the core results: baseline pre-COVID estimates (Table A1), COVID-19 interaction effects (Table A2), robustness to alternative price measures (Table A3), and the placebo pre-trend test (Table A4). Appendix B presents additional robustness checks: acute vs. post-acute COVID period decomposition (Table B1), 2SLS instrumental-variable estimates (Table B2), EaP leave-one-country-out jackknife (Table B3), and alternative sample restrictions (Table B4). All models use two-way fixed effects (country and year) with Driscoll–Kraay standard errors robust to heteroskedasticity, serial correlation, and cross-sectional dependence (bandwidth = 3). Significance codes: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

A Baseline Regression Tables

A.1 Baseline Pre-COVID Results (Table A1)

Table A1 presents baseline two-way fixed effects estimates for the pre-COVID period (2010–2019) across seven control specifications, from minimal controls (GDP per capita only, column 1) to the full specification (column 7).

Table A1 Baseline Two-Way Fixed Effects Estimates: Pre-COVID Period (2010–2019)

	Dependent Variable: Log(Subscriptions per 100)						
	(1) GDP Only	(2) + Socio	(3) + Instit.	(4) + Infra.	(5) + Demog.	(6) + All	(7) Full
Panel A: Price Elasticity							
Log(Price)	−0.08* (0.04)	−0.14*** (0.04)	−0.15*** (0.04)	−0.10* (0.06)	−0.09 (0.06)	−0.09 (0.06)	−0.10* (0.05)
Log(Price) × EaP	−0.53*** (0.08)	−0.48*** (0.05)	−0.46*** (0.05)	−0.48*** (0.07)	−0.48*** (0.07)	−0.48*** (0.07)	−0.49*** (0.05)
<i>Implied EaP elasticity</i>	−0.62*** (0.08)	−0.62*** (0.08)	−0.61*** (0.07)	−0.58*** (0.07)	−0.57*** (0.07)	−0.57*** (0.07)	−0.60*** (0.06)
Panel B: Control Variables							
Log(GDP per capita)	0.19*** (0.07)	0.22*** (0.07)	0.21*** (0.06)	0.22*** (0.08)	0.27*** (0.08)	0.27*** (0.08)	0.23*** (0.07)
Urban population (%)		0.01 (0.01)	0.01 (0.01)	0.01 (0.01)	0.01 (0.01)	0.01 (0.01)	0.01 (0.01)
Tertiary enrollment (%)		0.01*** (0.00)	0.01*** (0.00)	0.01*** (0.00)	0.01*** (0.00)	0.01*** (0.00)	0.01*** (0.00)
Regulatory quality			0.06** (0.03)	0.02 (0.04)	0.04 (0.03)	0.04 (0.03)	0.03 (0.03)
Log(Secure servers)				0.05** (0.02)	0.08** (0.03)	0.08** (0.03)	0.07** (0.03)
R&D (% GDP)				0.03 (0.03)	0.05** (0.02)	0.05** (0.02)	0.04** (0.02)
Log(Population density)					0.89*** (0.19)	0.89*** (0.19)	0.84*** (0.17)
Working-age pop. (15–64, %)					0.01 (0.01)	0.01 (0.01)	0.01 (0.01)
Panel C: Model Statistics							
Country fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	330	330	330	330	330	330	330
Countries	33	33	33	33	33	33	33
R-squared	0.27	0.34	0.34	0.37	0.39	0.39	0.40

Notes: Dependent variable is log fixed broadband subscriptions per 100 inhabitants. Price measured as % of GNI per capita. EaP dummy for Eastern Partnership countries. Columns (6)–(7) include all non-macro controls; (7) adds GDP growth and inflation (coefficients not shown). Country and year FE. Driscoll–Kraay SEs (bandwidth = 3). Qualitatively unchanged with clustered or robust SEs. *p<0.10, **p<0.05, ***p<0.01.

A.2 COVID-19 Interaction Effects (Table A2)

Table A2 presents results from equation (2) of the main paper, interacting prices with the COVID-19 period dummy (2020–2024). Column (1) uses the full 2010–2024 sample with COVID interactions; columns (2)–(3) present separate pre-COVID and COVID subsample estimates for comparison.

Table A2 COVID-19 Interaction Effects: Full Sample (2010–2024)

	Dependent Variable: Log(Subs. per 100)			
	(1) Full Sample w/ COVID Int.	(2) Pre-COVID 2010–19	(3) COVID 2020–24	(4) Diff. Test (p-value)
Panel A: EU Countries				
Log(Price)	−0.19** (0.07)	−0.10* (0.05)	−0.04** (0.02)	—
Log(Price) × COVID	+0.30*** (0.11)	—	—	0.007
<i>Implied COVID elasticity</i>	+0.11 (0.07)	—	−0.04** (0.02)	—
Panel B: EaP Countries				
Log(Price) × EaP	−0.17* (0.10)	−0.60***	—	—
Log(Price) × EaP × COVID	+0.12*** (0.03)	—	—	0.000
<i>Implied pre-COVID EaP elasticity</i>	−0.36*** (0.11)	−0.60*** (0.06)	—	—
<i>Implied COVID EaP elasticity</i>	+0.06 (0.12)	—	−0.13 (0.10)	—
Panel C: Change in Elasticity				
$\Delta\varepsilon_{EU}$ (COVID – Pre)	+0.30*** (0.11)	—	—	0.007
$\Delta\varepsilon_{EaP}$ (COVID – Pre)	+0.42*** (0.14)	—	—	0.002
Panel D: Model Statistics				
Full controls	Yes	Yes	Yes	—
Country FE	Yes	Yes	Yes	—
Year FE	Yes	Yes	Yes	—
Observations	495	330	165	—
Countries	33	33	33	—
R-squared	0.42	0.40	0.40	—

Notes: Dependent variable is log of fixed broadband subscriptions per 100 inhabitants. Price is measured as percentage of GNI per capita. COVID is a period dummy for years 2020–2024. EaP is a dummy for Eastern Partnership countries. Full controls include: log GDP per capita, urban population %, tertiary enrollment %, regulatory quality, log secure servers, R&D % GDP, log population density, and working-age population share (15–64, %). Column (1) presents the full interaction model on 2010–2024 data. Columns (2)–(3) present separate subsample estimates for comparison. Column (4) reports p-values from Wald tests of coefficient differences between COVID and pre-COVID periods. Driscoll–Kraay standard errors (bandwidth = 3) in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

A.3 Robustness to Alternative Price Measures (Table A3)

Table A3 compares elasticity estimates across three price definitions: income-relative (GNI%, baseline), PPP-adjusted, and nominal USD prices. Each panel rows all seven control specifications for one price measure.

Table A3 Price Elasticity Robustness: Alternative Price Measures and Control Specifications (Pre-COVID)

Price Measure	Control Spec	EU Elast.	EU SE	EU p	EaP Elast.	EaP SE	EaP p	N	R ²
<i>Price: GNI%</i>									
	Full Controls (Baseline)	-0.101*	(0.053)	0.056	-0.595***	(0.061)	0.000	330	0.40
	Comprehensive	-0.101*	(0.054)	0.063	-0.570***	(0.074)	0.000	330	0.36
	Core	-0.142***	(0.042)	0.001	-0.618***	(0.075)	0.000	330	0.34
	Institutional	-0.090**	(0.043)	0.040	-0.604***	(0.073)	0.000	330	0.28
	Infrastructure	-0.033	(0.074)	0.655	-0.596***	(0.075)	0.000	330	0.30
	Demographic	-0.104***	(0.028)	0.000	-0.621***	(0.072)	0.000	330	0.28
	Macroeconomic	-0.094**	(0.040)	0.019	-0.631***	(0.057)	0.000	330	0.30
	Minimal	-0.082*	(0.042)	0.050	-0.615***	(0.075)	0.000	330	0.27
<i>Price: PPP</i>									
	Full Controls (Baseline)	-0.087*	(0.052)	0.094	-0.201*	(0.116)	0.084	330	0.22
	Comprehensive	-0.092*	(0.055)	0.095	-0.211*	(0.108)	0.051	330	0.19
	Core	-0.125**	(0.063)	0.048	-0.244**	(0.106)	0.021	330	0.13
	Institutional	-0.116**	(0.052)	0.027	-0.164	(0.113)	0.149	330	0.07
	Infrastructure	-0.081	(0.050)	0.107	-0.155	(0.109)	0.158	330	0.09
	Demographic	-0.123*	(0.063)	0.052	-0.180	(0.112)	0.111	330	0.06
	Macroeconomic	-0.104**	(0.048)	0.031	-0.168	(0.124)	0.178	330	0.08
	Minimal	-0.112**	(0.051)	0.030	-0.177	(0.111)	0.112	330	0.05
<i>Price: USD</i>									
	Full Controls (Baseline)	-0.098**	(0.039)	0.014	-0.340***	(0.059)	0.000	330	0.29
	Comprehensive	-0.099**	(0.039)	0.012	-0.337***	(0.063)	0.000	330	0.26
	Core	-0.124***	(0.042)	0.003	-0.390***	(0.063)	0.000	330	0.23
	Institutional	-0.100***	(0.031)	0.001	-0.332***	(0.065)	0.000	330	0.14
	Infrastructure	-0.064	(0.041)	0.120	-0.326***	(0.059)	0.000	330	0.16
	Demographic	-0.115***	(0.039)	0.004	-0.356***	(0.063)	0.000	330	0.14
	Macroeconomic	-0.090***	(0.030)	0.003	-0.344***	(0.061)	0.000	330	0.16
	Minimal	-0.094***	(0.029)	0.002	-0.348***	(0.066)	0.000	330	0.14

Notes: Each row is a separate regression. All specifications include country and year fixed effects. Driscoll–Kraay standard errors in parentheses. * p < 0.10, ** p < 0.05, *** p < 0.01.

A.4 Placebo Test for Pre-COVID Trends (Table A4)

Table A4 presents the placebo test splitting the pre-COVID period into an early subperiod (2010–2014) and a late subperiod (2015–2019). A significant positive interaction on the 2015–2019 dummy indicates elasticity was already declining before the pandemic.

Table A4 Placebo Test: Pre-COVID Trends (2010–2019)

	Dependent Variable: Log(Subs. per 100)		
	(1) Full Sample 2010–19	(2) Early 2010–14	(3) Late 2015–19
Panel A: EU Countries			
Log(Price)	−0.15* (0.09)	+0.21 (0.14)	−0.06*** (0.02)
Log(Price) × Late	+0.13* (0.07)	—	—
<i>Implied late elasticity</i>	−0.02 (0.06)	—	−0.06*** (0.02)
Panel B: EaP Countries			
Log(Price) × EaP	−0.29*** (0.10)	−0.33*** (0.02)	−0.08 (0.08)
Log(Price) × EaP × Late	+0.08* (0.04)	—	—
<i>Implied early EaP elasticity</i>	−0.44*** (0.03)	−0.33*** (0.02)	—
<i>Implied late EaP elasticity</i>	−0.23** (0.11)	—	−0.08 (0.08)
Panel C: Change in Elasticity			
$\Delta \varepsilon_{EU}$ (Late − Early)	+0.13* (0.07)	—	—
p-value	0.057	—	—
$\Delta \varepsilon_{EaP}$ (Late − Early)	+0.08* (0.04)	—	—
p-value	0.086	—	—
Panel D: Model Statistics			
Full controls	Yes	Yes	Yes
Country FE	Yes	Yes	Yes
Year FE	Yes	Yes	Yes
Observations	330	165	165
Countries	33	33	33
R-squared	0.45	0.49	0.21

Notes: Dependent variable: log fixed broadband subscriptions per 100. Price: % of GNI per capita. “Late” is a placebo indicator for 2015–2019. EaP denotes Eastern Partnership countries. Column (1) estimates the full placebo interaction on 2010–2019; Columns (2)–(3) report subsamples for 2010–2014 (early) and 2015–2019 (late). Controls: log GDP per capita, urbanization (%), tertiary enrollment (%), regulatory quality, log secure servers, R&D (% GDP), log population density, and working-age population share (15–64, %). Driscoll-Kraay SEs (bandwidth = 3) in parentheses. * p < 0.10, ** p < 0.05, *** p < 0.01.

B Additional Robustness Checks

B.1 Period-Split: Acute vs. Post-Acute COVID (Table B1)

Table B1 decomposes the COVID era into an acute phase (2020–2021) and a post-acute phase (2022–2024) using a single full-panel interaction model with price $\times$ period dummies, preserving degrees of freedom. Both sub-periods exhibit near-zero elasticity for EU and EaP. Panel B excludes Ukraine and Belarus—whose data reliability is compromised by war and sanctions—with unchanged conclusions.

Table B1 Period-Split Elasticity Estimates: Pre-COVID, Acute COVID, and Post-Acute

	Pre-COVID 2010–2019		Acute COVID 2020–2021		Post-Acute 2022–2024	
	EU	EaP	EU	EaP	EU	EaP
<i>Panel A: Full Sample (33 countries)</i>						
Elasticity	−0.197** (0.077)	−0.359*** (0.112)	0.073 (0.067)	0.020 (0.113)	0.124 (0.080)	0.098 (0.109)
Observations			495			
R-squared			0.42			
<i>Panel B: Excluding Ukraine & Belarus from COVID Periods</i>						
Elasticity	−0.191*** (0.067)	−0.427*** (0.096)	0.071 (0.058)	−0.080 (0.099)	0.079 (0.068)	−0.051 (0.103)
Observations			485			
R-squared			0.43			
Country FE			Yes			
Year FE			Yes			
Price measure			GNI% (income-relative)			

Notes: Estimates come from a single regression on the full 2010–2024 panel using price $\times$ period interaction dummies for Acute COVID (2020–2021) and Post-Acute (2022–2024). Pre-COVID elasticities are the base-period coefficients. This interaction approach avoids the short-panel problem of estimating 2-year subsamples. Full controls. Driscoll–Kraay standard errors (bandwidth = 3) in parentheses. Panel B excludes Ukraine and Belarus from the COVID periods only (their pre-2020 observations are retained). * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

B.2 IV Robustness: 2SLS Estimates (Table B2)

Table B2 presents 2SLS estimates instrumenting fixed broadband price with its own one-year lag (log fixed broadband price in GNI%, lagged one year).

Instrument rationale. National fixed broadband price baskets are set through annual regulatory and procurement cycles, generating high year-to-year autocorrelation. The lagged price strongly predicts the current price (within-demeaned first-stage $F = 65$ pre-COVID; $F = 99$ full-sample), well above the Stock–Yogo critical value of 16.38 for 10% worst-case Wald test size distortion (?). The exclusion restriction is plausible: conditional on country and year fixed effects plus time-varying controls, past prices affect current subscriptions only through current prices, since broadband contracts are monthly or annual and consumers cannot anticipate next year’s regulated tariff when making adoption decisions today.¹

Table B2 IV Robustness: 2SLS Estimates Using Lagged Own Price as Instrument

Specification	EU Elasticity		EaP Elasticity		First-Stage F
	Coef.	SE	Coef.	SE	
<i>A. Pre-COVID (2010–2019)</i>					
OLS (TWFE + DK SE)	−0.101*	(0.053)	−0.595***	(0.061)	—
2SLS, lagged price	−0.172*	(0.097)	−0.615***	(0.091)	65
<i>B. Full sample (2010–2024), COVID interactions</i>					
2SLS, lagged price	−0.193***	(0.058)	−0.340***	(0.088)	99

Notes: Instrument: log fixed broadband price (GNI%) lagged one year. All specifications include country and year fixed effects absorbed via two-way within-transformation. First-stage F is a partial F -statistic for the excluded instrument in the within-transformed first stage; $F > 10$ indicates instrument relevance (?). EaP elasticity = EU coefficient + EU×EaP interaction; SE via delta method. OLS: Driscoll–Kraay SE (kernel bandwidth=3). 2SLS: heteroskedasticity-robust SE. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Results. Panel A shows pre-COVID 2SLS alongside the OLS baseline: EU= −0.172 (SE= 0.097, $p = 0.075^*$) and EaP= −0.615 (SE= 0.091, $p = 0.000^{***}$), broadly consistent with OLS (EU= −0.101, EaP= −0.595), confirming simultaneity bias is negligible. Panel B replicates the full-sample COVID specification: EU= −0.193 (SE= 0.058, $p = 0.001^{***}$) and EaP= −0.340 (SE= 0.088, $p = 0.000^{***}$), consistent with the OLS COVID-era attenuation.

¹We also tested international internet bandwidth as an alternative instrument. An over-identified specification combining both instruments strongly rejected the Hansen J overidentification test ($\chi^2(2) = 262.89$, $p < 0.001$), indicating bandwidth correlates with connection speed and quality, which directly enters the demand equation. ITU bandwidth data are also missing for most EU countries after 2018. Lagged price is therefore the sole preferred instrument.

B.3 EaP Jackknife: Leave-One-Country-Out (Table B3)

Table B3 reports leave-one-out estimates dropping each of the six EaP countries in turn. EaP elasticity ranges from -0.42 to -0.67 across the six sub-samples. Armenia contributes the highest price-sensitivity; excluding it raises the EaP estimate from -0.60 to -0.42 . All six leave-one-out estimates are significant at the 1% level, confirming the EaP result is not driven by any single country.

Table B3 EaP Jackknife Robustness: Leave-One-Country-Out (Pre-COVID Baseline)

Sample	EU Elasticity		EaP Elasticity		N	R ²
	Coef.	SE	Coef.	SE		
Full EaP (baseline)	-0.101^*	(0.053)	-0.595^{***}	(0.061)	330	0.40
Drop Armenia	-0.069	(0.059)	-0.417^{***}	(0.040)	320	0.34
Drop Azerbaijan	-0.092^*	(0.048)	-0.548^{***}	(0.058)	320	0.41
Drop Belarus	-0.089	(0.062)	-0.667^{***}	(0.074)	320	0.48
Drop Georgia	-0.087^{**}	(0.037)	-0.672^{***}	(0.068)	320	0.49
Drop Moldova	-0.100^*	(0.053)	-0.604^{***}	(0.062)	320	0.39
Drop Ukraine	-0.107^{**}	(0.049)	-0.604^{***}	(0.069)	320	0.41

Notes: Each row drops one EaP country from the sample and re-estimates the baseline model (Full Controls, GNI% price, pre-COVID 2010–2019). Driscoll–Kraay standard errors (bandwidth = 3) in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

B.4 Sample Restrictions (Table B4)

Table B4 reports robustness to alternative sample definitions. The balanced-panel restriction (countries with complete 2010–2019 data) yields identical estimates, confirming attrition does not drive the results. Excluding Cook’s-distance outliers ($d > 4/N$) removes 22 observations across 2 countries with negligible impact on either elasticity. For the high-income subsample (17 EU countries above median GDP per capita) only the EU elasticity (-0.016 , $p=0.673$) is identified and is not significant, consistent with minimal affordability constraints at higher incomes. For the middle/lower-income subsample (16 countries including all EaP), EaP elasticity (-0.433 , $p<0.001$) is somewhat smaller than the full-sample estimate, reflecting within-group heterogeneity.

Table B4 Sample Restriction Robustness Checks (Pre-COVID Baseline, Full Controls, GNI%-price). Driscoll–Kraay standard errors in parentheses. Significance: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$.

Sample Restriction	EU		EaP		N	Countries
	$\hat{\epsilon}$	SE	$\hat{\epsilon}$	SE		
Full sample (baseline)	-0.101^*	(0.053)	-0.595^{***}	(0.061)	330	33
Balanced panel only	-0.101^*	(0.053)	-0.595^{***}	(0.061)	330	33
Excl. outliers (Cook’s $d > 4/N$)	-0.104^*	(0.057)	-0.594^{***}	(0.062)	308	31
High-income countries only	-0.016	(0.037)	—		170	17
Middle/lower-income only	-0.008	(0.120)	-0.433^{***}	(0.089)	160	16

Notes: All models estimated with two-way fixed effects (country and year) and Driscoll–Kraay standard errors (bandwidth = 3). Price variable is log fixed broadband price as % of GNI per capita. High/middle-income split uses median country-level GDP per capita (constant 2015 USD) averaged over 2010–2019. Cook’s distance threshold is $4/N$ where N is the number of observations.