How does spatial dependence affect cost pass-through? Evidence from the Hungarian retail gasoline market*

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A large part of market theory literature focuses on the cost pass-through behaviour of firms, as it is an essential instrument in the analytical toolkit of competition authorities when carrying out market structure-related examinations. Although spatial relations are well documented in many markets, cost pass-through analysis frameworks do not seem to incorporate these issues. Applying an error correction-based estimation strategy extended by a spatial econometric framework, the present paper provides evidence that spatial dependence appears significantly in the cost pass-through behaviour of firms. This suggests that, on the one hand, the detected symmetric cost pass-through may cover the properties of the competition. On the other hand, competition authorities should consider spatial dependencies when preparing court-case decisions to avoid verdicts arising from presumably spurious analysis results.

Keywords:
spatial dependence,
cost pass-through

Introduction

An essential part of the literature on industrial organization focuses on the cost pass-through behaviour of firms since their ability to pass on costs asymmetrically may signal their market power (Bulow–Pfleiderer 1983, Ten Kate–Niels 2005). In the retail gasoline market, first, Bacon (1991) demonstrated that prices typically rise faster when costs increase than they fall in the case of a cost decrease, calling this phenomenon "rockets and feathers".

* The research strategies presented in this paper are based on the doctoral dissertation of the author (Farkas 2019).

Empirical studies mark many reasons behind firms' abilities to pass on costs to consumers asymmetrically. One of the main motives is the assumed price-maker position of firms closely related to the intensity of competition in the markets. Deltas (2008) and Polemis–Fotis (2014) provide evidence that a higher market concentration may indicate higher market power, and thus, the price-maker position of some market-leader firms entails asymmetric cost pass-through. Verlinda (2008) provides evidence that branding strategies, the availability of rival stations, and the characteristics of the local markets contribute to the market leader position of firms that causes asymmetric price transmission, which appears in the form of product differentiation. Other arguments that may bring about asymmetric cost pass-through are consumer search costs (Borenstein et al. 1997, Yang–Ye 2008), production lags and finite inventories (Borenstein et al. 1997, Radchenko–Shapiro 2011), collusion of firms (Lewis 2011), menu costs (Meyer–von Cramon Taubadel 2004) and Edgeworth cycles (Noel 2009, Lewis 2011). Although most empirical evidence demonstrates asymmetric cost pass-through strategies, researchers often observe symmetric price transmission (Bachmeier–Griffin 2003, Clerides 2010, Farkas–Yontcheva 2019).

In line with the empirical findings, researchers started to agree that the ability to pass on costs asymmetrically may be a strong indicator of the price-maker position of firms, and its absence indicates higher concentration (Ritz 2015). Due to this relationship, cost pass-through analysis became a prominent strategy in the analytical toolkit of competition authorities when preparing court-case decisions (FTC 2011, Hungarian Competition Authority 2014, EC 2015).

Although the shreds of evidence and the existing theoretical framework support the application of price transmission analysis, the generally employed econometric models do not take into account the possible spatial dependencies among firms on the market. However, these relationships may change the pricing strategies of firms significantly in markets such as the retail markets for gasoline (Slade 1992, Pennerstorfer–Weiss 2013, Sen–Bera 2014). The present paper contributes to the literature at this point. Spatial econometric models emphasize that excluding the control for spatial dependencies in the presence of spatial relations harms the results of regression analyses and leads to spurious coefficient estimations (Anselin 1988, LeSage–Pace 2009, Maket et al. 2023).

Taking into account these considerations, the present research incorporates the most prominent applied methods of cost pass-through analysis into a spatial econometric framework. I examined the Hungarian retail gasoline market where similar to many other markets, the strong effect of spatial dependence on the pricing behaviour of firms is demonstrated (Farkas 2017), which assumes its effect also on their cost pass-through strategies.

Data and industry background[1]

Branded market leader chains, smaller chains, and independent stations characterize the Hungarian retail gasoline market. Vertical integration is typical in the case of the market leader chains, and MOL is the wholesale tier's main contributor, serving approximately 70% of the retail market (EC 2016). Other branded groups are at the upstream level, although they sell only to their respective stations. Moreover, in Hungary, only MOL has a refinery located in Százhalombatta.

Table 1

Relative frequencies of gasoline stations in the sample

	Brand	Market share
1	MOL	38.01
2	OMV	13.81
3	SHELL	15.24
5	Lukoil	5.87
6	Mobil Petrol	3.81
7	OIL!	3.17
8	Auchan automata	1.43
9	Independent	18.66

As Table 1 shows, there are branded chains with relatively large numbers of stations at the retail tier. However, it is less concentrated than the upstream level. The major brands (MOL, OMV, SHELL)[2] control more than 65% of the stations. Smaller chains or individual stations own the remaining 35%.

For the analysis, I used a unique dataset[3] that covers the entire country geographically. I included 934 stations in the study. The dataset comprises the time period starting with the January 8th, 2016 and ending with March 28th, 2018. The descriptive statistics of their data are presented in Table A1 in the Appendix.

Estimation strategy

Several techniques are available to assess the cost pass-through behaviour. I applied two error correction procedures following the Engle and Granger (1987) method. The time series are likely to cointegrate, and thus, the error correction routine can be

[1] The description presented in this section may show significant similarities to Erdős et al. (2022) since the same dataset is under investigation.

[2] The MOL group took over the AGIP chain on August 1, 2016. Before the acquisition, AGIP was regarded as the fourth major brand. In the present analysis, I do not deal with this issue, which is well documented in Erdős et al. (2022).

[3] Data are provided by a Hungarian firm named 3P Online Kft. They collect daily price data from the majority of Hungarian stations.

carried out [4]. First, I borrowed the approach introduced by Borenstein et al. (1997) and described it as follows[5]:

$$P_{it} = \phi_0 + \phi_1 C_t + \phi_{2i} S_i + \phi_{3t} T_t + \epsilon_{it}, \quad (1)$$

where P_{it} is the price level, C_t denotes the wholesale price (cost level), S_i is the individual, T_t is the time-fixed effect, and i and t are the station and time index in the long-run equilibrium equation, respectively. ϵ_{it} marks the error term supposed to be identically and independently distributed. Equation 2 describes the short-run adjustment path:

$$\Delta P_{it} = \beta_0 + \sum_{k=0}^{3} \beta_k^+ \Delta C_{t-k}^+ + \sum_{k=0}^{3} \beta_k^- \Delta C_{t-k}^- + \theta^+ \epsilon_{it}^+ + \theta^- \epsilon_{it}^- + \varphi_{it}, \quad (2)$$

where Δ reflects the changes in the variables among observation periods. The index ”+” denotes an increase in the variables, while ”−” indicates a decrease. As such, ΔC_{t-k-1}^+ is a rise in costs, while ΔC_{t-k-1}^- represents a cost decrease. Thus, based on the outcomes of Equation 2, cumulative response functions are defined to display the level of cost pass-through for both the case of cost decrease (Equation 3) and cost increase (Equation 4).

$$\begin{aligned} B0+ &= \beta 0+ \\ B1+ &= B0+ + \beta 1+ + \theta 1(B0+ - \varphi 1) \\ &\dots \qquad \dots \\ Bk+ &= Bk+-1 + \beta k+ + \theta 1(Bk+-1 - \varphi 1), \end{aligned} \quad (3)$$

$$\begin{aligned} B0- &= \beta 0- \\ B1- &= B0- + \beta 1- + \theta 1(B0- - \varphi 1) \\ &\dots \qquad \dots \\ Bk- &= Bk--1 + \beta k- + \theta 1(Bk--1 - \varphi 1). \end{aligned} \quad (4)$$

To extend the analysis, I also employed the short-run adjustment approach amended by Remer (2015)[6] that takes into consideration the autoregressive parts of the dependent variables as explanatory ones, described by Equation 5:

$$\Delta P_{it} = \beta_0 + \sum_{k=1}^{3} \beta_k^+ \Delta C_{t-k}^+ + \sum_{k=1}^{3} \beta_k^- \Delta C_{t-k}^- + \\ + \sum_{k=1}^{2} \gamma_k^+ \Delta P_{t-k}^+ + \sum_{k=1}^{2} \gamma_k^- \Delta P_{t-k}^- + \theta^+ \epsilon_{it}^+ + \theta^- \epsilon_{it}^- + \varphi_{it}, \quad (5)$$

with no change in the long-run equilibrium equation. The Remer approach requires a modification in the setup of the cumulative response functions. These changes are displayed in Equation 6 for the positive cost shocks.

$$B_k^+ = B_{k-1}^+ + \theta^+ max\{B_{k-1} - \phi_1, 0\} + \theta^- min\{0, B_{k-1} - \phi_1\} + \\ \sum_{i=1}^{k} (\gamma_i^+ \, max\{0, B_{k-i} - B_{k-i-1}\}) + \sum_{i=1}^{k} (\gamma_i^- \, min\{B_{k-1} - B_{k-i-1}, 0\}). \quad (6)$$

Analogous to Equation 6, a cumulative response function can also be derived for the negative cost shocks. I also calculated the 95% confidence intervals of the

[4] The testing procedure results are available from the author upon request since, based on the large number of firms and observations, their presentation may cause unnecessary difficulties.

[5] In the following: Borenstein–Cameron–Gilbert Group (BCG) approach.

[6] In the following: Remer approach.

cumulative response functions using a delta method-based error bootstrapping procedure, as introduced by Freedman (1984).

The above-described model frameworks are eligible to describe cost pass-through strategies when no spatial dependencies are detected. However, spatial interconnectedness between the actors should be incorporated into the estimations in the case of markets such as a market for retail gasoline.

One may use the spatial lag model illustrated by Anselin–Rey (2014) to estimate an equilibrium reaction level. Thus, I extend the short-run adjustment path equations as follows.

$$\Delta P_{it} = \beta_0 + \rho \sum_{j=1}^{n} W_{ij}\, \Delta P_{jt} + \sum_{k=0}^{3} \beta_k^{+}\, \Delta C_{t-k}^{+} + \sum_{k=0}^{3} \beta_k^{-}\, \Delta C_{t-k}^{-} + \theta^{+}\epsilon_{it}^{+} + \theta^{-}\epsilon_{it}^{-} + \varphi_{it}, \quad (7)$$

$$\Delta P_{it} = \beta_0 + \rho \sum_{j=1}^{n} W_{ij}\, \Delta P_{jt} + \sum_{k=1}^{3} \beta_k^{+}\, \Delta C_{t-k}^{+} + \sum_{k=1}^{3} \beta_k^{-}\, \Delta C_{t-k}^{-} +$$
$$+ \sum_{k=1}^{2} \gamma_k^{+}\, \Delta P_{t-k}^{+} + \sum_{k=1}^{2} \gamma_k^{-}\, \Delta P_{t-k}^{-} + \theta^{+}\epsilon_{it}^{+} + \theta^{-}\epsilon_{it}^{-} + \varphi_{it}, \quad (8)$$

In Equations 7 and 8, $\sum_{j=1}^{n} W_{ij}\, \Delta P_{jt}$ is the spatially lagged dependent variable, where W_{ij} is the row-standardized spatial weight matrix. In the latter cases, the cumulative response functions are built up similarly to the previous ones. Now, the spatial effects are supposed to be eliminated from the cost effect in the parameter estimations.

Results

This section is devoted to presenting the outcomes of the regression analyses described above. Tables 2 and 3 display the nonspatial cost pass-through analysis results according to the BCG and Remer approaches, respectively. Figures A1 and A2 in the Appendix show the corresponding cumulative response functions. The cost pass-through strategy of firms seems symmetric, and its elevation approximates unity in the first period, irrespective of the model type. This suggests that the level of competition might be intensive despite the market concentration reported in Table 1. These findings align with previous investigations on the Hungarian retail gasoline market (Csorba et al. 2011, Farkas–Yontcheva 2019). Interestingly, the accelerated effect of cost shocks tends to be negative, although the movement in the cumulative responses is infinitesimal.

To strengthen the examination results, I executed several robustness checks of the nonspatial estimations. These findings are reported in the appendices. As the first robustness analysis, I truncated the dataset according to station types that reflect the supposed market leader (Tables A2–A5 and Figures A3–A6 in the Appendix).

Table 2

Nonspatial cost pass-through analysis results according to the BCG approaches

Long-run equation		Short-run adjustment	
Dependent variable	P_t	Dependent variable	ΔP_t
C_t	0.862*** (0.005)	$\Delta Ct+$	0.896*** (0.003)
Constant	79.105*** (1.429)	$\Delta Ct-$	0.865*** (0.003)
Station fixed effect	Yes	ΔC^{+}_{t-1}	−0.015** (0.003)
Time fixed effect	Yes	ΔC^{-}_{t-1}	−0.014*** (0.003)
		ΔC^{+}_{t-2}	−0.009*** (0.006)
		ΔC^{-}_{t-2}	0.095*** (0.003)
		ΔC^{+}_{t-3}	−0.050*** (0.003)
		ΔC^{-}_{t-3}	0.017*** (0.009)
		$\vartheta+$	−0.066*** (0.004)
		$\vartheta-$	−0.066*** (0.004)
		Constant	0.138*** (0.010)
Observations	222,282	Observations	218,466
Adjusted R^2	0.956	Adjusted R^2	0.661

Notes: *p<0.1; **p<0.05; ***p<0.01. Standard errors are in parentheses and robust to heteroscedasticity and autocorrelation.

Second, since the geographical and structural characteristics are quite different in the capital city compared to the other areas of the nation, I separated the stations according to whether they are located in Budapest (Tables A6–A9 and Figures A7–A10 in the Appendix). The corresponding tables and cumulative response functions underpin the main findings of the nonspatial analyses. The results are not sensitive to the model types and the modifications in the robustness checks.

Table 3

Cost pass-through based on the Remer approach

Long-run equation		Short-run adjustment			
Dependent variable	P_t	Dependent variable		ΔP_t	
C_t	0.862*** (0.005)	$\Delta Ct+$	0.893*** (0.003)	ΔP^{+}_{t-1}	−0.050*** (0.006)
Constant	79.105*** (1.429)	$\Delta Ct-$	0.867*** (0.003)	ΔP^{-}_{t-1}	−0.102*** (0.007)
Station fixed effect	Yes	ΔC^{+}_{t-1}	0.043*** (0.007)	ΔP^{+}_{t-2}	−0.157*** (0.005)
Time fixed effect	Yes				
		ΔC^{-}_{t-1}	0.070*** (0.007)	ΔP^{-}_{t-2}	−0.018** (0.004)
		ΔC^{+}_{t-2}	0.128*** (0.005)	$\theta+$	−0.059*** (0.004)
		ΔC^{-}_{t-2}	0.108*** (0.005)	$\theta-$	−0,053*** (0.004)
		ΔC^{+}_{t-3}	−0.048*** (0.002)	Konstans	0.144*** (0.010)
		ΔC^{-}_{t-3}	0.024*** (0.002)		
Observations	222,282	Observations	218,466		
Adjusted R^2	0.956	Adjusted R^2	0.667		

Notes: *p<0.1; **p<0.05; ***p<0.01. Standard errors are in parentheses and robust to heteroscedasticity and autocorrelation.

After the above-presented examinations, I turned my attention to the spatial extensions of the models. Since there is no adequate econometric way to choose the proper spatial weight matrix, it is always up to the researcher and previous investigations in the economic literature. I employed three different matrices in each case to avoid the possible biases caused by inappropriate spatial weights. I selected those matrices that are commonly and reasonably usable when conducting spatial model building on the gasoline markets, taking into account the specialties of the Hungarian market. The first matrix regards those stations as neighbours of station "i" located in a 15 km radius of the station "i" neighbourhood, calculated with inverse distances. The second one is similar to the first one but calculates with inverse squared distances. The third matrix counts for neighbours of station "i" those stations that are the Voronoi-neighbours of the station "i" based on the Thiessen polygon method (Bowyer 1981). Tables 4 and 5 introduce the spatial regression results; meanwhile, Figures A11 and A12 in the Appendix show how the cumulative response functions are shaped under the spatial investigations. As my results suggest, spatial interactions play a prominent role in the cost pass-through behaviour of firms.

Table 4

Short-run adjustment according to the BCG approach in the spatial framework

Dependent variable: ΔP_t	Inv15	Invsquare15	Voronoi
ϱ	0.898*** (0.002)	0.501*** (0.002)	0.614*** (0.002)
$\Delta Ct+$	0.086*** (0.002)	0.443*** (0.002)	0.349*** (0.002)
$\Delta Ct-$	0.083*** (0.002)	0.427*** (0.002)	0.337*** (0.002)
ΔC^{+}_{t-1}	0.001 (0.001)	−0.004** (0.002)	−0.007*** (0.002)
ΔC^{-}_{t-1}	0.0002 (0.002)	−0.005** (0.002)	−0.006*** (0.002)
ΔC^{+}_{t-2}	−0.0003 (0.002)	−0.004* (0.002)	−0.004** (0.002)
ΔC^{-}_{t-2}	0.010*** (0.002)	0.047*** (0.002)	0.036*** (0.002)
ΔC^{+}_{t-3}	−0.003 (0.002)	−0.024*** (0.002)	−0.020*** (0.002)
ΔC^{-}_{t-3}	0.001 (0.002)	0.009*** (0.002)	0.007*** (0.002)
ϑ^{+}_{1}	−0.062*** (0.001)	−0.062*** (0.001)	−0.062*** (0.001)
ϑ^{-}_{1}	−0.065*** (0.001)	−0.063*** (0.001)	−0.065*** (0.001)
Constant	0.007 (0.006)	0.062*** (0.006)	0.052*** (0.006)
Observations	218,466	218,466	218,466
Pseudo R^2	0.125	0.493	0.414

Notes: *p<0.1; **p<0.05; ***p<0.01. Standard errors are in parentheses and robust to heteroscedasticity and autocorrelation.

First, the degree of cost pass-through indicated for the spatial models is much smaller than that of the nonspatial versions. Interestingly, in these cases, the outcomes of the Remer approach differ significantly from those of the BCG approach. It is also an important change in the results that after the elimination of the spatial effects, the cumulative responses start on an ever-increasing trajectory. These properties are more reasonable in pass-through strategies. Thus, the results indicate that competition among firms coerces a pricing strategy that is seemingly closer to competitive pricing at the marginal cost level.

I also conducted robustness analyses in the spatial framework to determine whether the model results are sensitive to the data structure changes. I examined the effect of a location (Tables A10–A13 and Figures A13–A16 in the Appendix) since truncating the dataset by brand type is pointless in this case. This differentiation did not significantly affect the main results of the spatial estimations. As such, the main conclusions of the spatial extensions remain the same.

Table 5

Short-run adjustment according to the Remer approach in the spatial framework

Dependent variable: ΔP_t	Inv15	Invsquare15	Voronoi
ϱ	0.892*** (0.002)	0.493*** (0.002)	0.606*** (0.002)
$\Delta Ct+$	0.090*** (0.002)	0.447*** (0.002)	0.354*** (0.002)
$\Delta Ct-$	0.088*** (0.002)	0.434*** (0.002)	0.345*** (0.002)
ΔC_{t-1}^{+}	0.009*** (0.003)	0.025*** (0.003)	0.019*** (0.003)
ΔC_{t-1}^{-}	0.056*** (0.003)	0.062*** (0.003)	0.060*** (0.003)
ΔC_{t-2}^{+}	0.023*** (0.003)	0.069*** (0.003)	0.057*** (0.003)
ΔC_{t-2}^{-}	0.019*** (0.003)	0.059*** (0.003)	0.046*** (0.003)
ΔC_{t-3}^{+}	−0.003 (0.002)	−0.023*** (0.002)	−0.019*** (0.002)
ΔC_{t-3}^{-}	0.004** (0.002)	0.013 (0.002)	0.011*** (0.002)
ΔP_{t-1}^{+}	−0.006*** (0.002)	−0.025*** (0.002)	−0.023*** (0.002)
ΔP_{t-1}^{-}	−0.065*** (0.003)	−0.080*** (0.003)	−0.078*** (0.003)
ΔP_{t-2}^{+}	−0.028*** (0.002)	−0.085*** (0.002)	−0.071*** (0.002)
ΔP_{t-2}^{-}	−0.010*** (0.003)	−0.014*** (0.002)	−0.012*** (0.002)
ϑ_1^{+}	−0.059*** (0.001)	−0.057*** (0.001)	−0.058*** (0.001)
ϑ_1^{-}	−0.061*** (0.001)	−0.055*** (0.001)	−0.058*** (0.001)
Constant	−0.007 (0.006)	0.065*** (0.007)	0.054* (0.006)
Observations	218,466	218,466	218,466
Pseudo R^2	0.133	0.503	0.427

Notes: *p<0.1; **p<0.05; ***p<0.01. Standard errors are in parentheses and robust to heteroscedasticity and autocorrelation.

Conclusions and policy implications

Analysing the cost pass-through behaviour of firms is an essential tool in the hands of competition authorities in addition to its scientific importance. Although there are many ways to detect the cost pass-through strategies of firms, a more commonly applied model framework is the error correction approach.

This paper conducts a comprehensive cost pass-through analysis of the Hungarian retail gasoline market. As a result of the investigation, the cost pass-through seems symmetric, suggesting intensive competition with firms in price-taking positions. However, the market concentration would have indicated another pricing strategy. Based on several robustness analyses, the results are robust to changes in the data structure.

However, many studies have documented the role of spatial interactions in such markets. Consequently, I extended the empirical application of the commonly used error correction technique, which allowed me to incorporate the spatial dependencies into the model. The research findings underpin that spatial interactions should be considered when analysing cost pass-through strategies.

These findings have several policy and related welfare consequences. On the one hand, detecting firms' price-maker and price-taker positions seems more difficult than the present methodologies suggest. On the other hand, my results underpin that excluding spatial relations from the models is likely to harm the effectiveness of the estimations. This suggests that competition authorities should reconsider the analytical toolkit they use when conducting court cases since they may lead to inaccurate results, which will likely result in detrimental decision-making processes.

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Appendix

Table A1

Descriptive statistics of the variables

Variable	Min.	Max.	Mean	sd	Median	IQR	Obs
P_{it}	280	434.9	364.4	19.628	346.9	26	222,282
C_{it}	262.4	333.4	307.9	16.065	310.4	21	222,282
ΔP_{it}	–56.00	45.00	0.22	3.016	0	0	218,466
ΔC_{it}	–9.00	9.00	0.24	2.75	0	2	218,466

Figure A1

Cumulative reactions according to the BCG approach

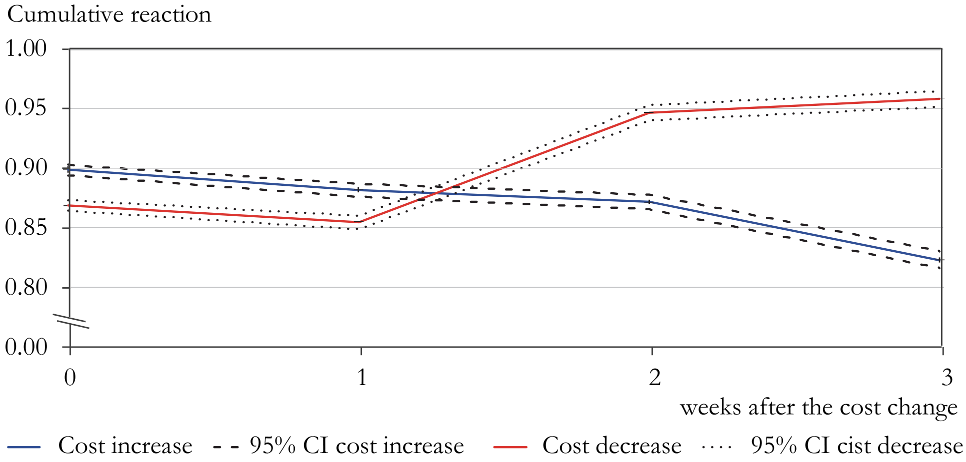


Figure A2

Cumulative reactions according to the Remer approach

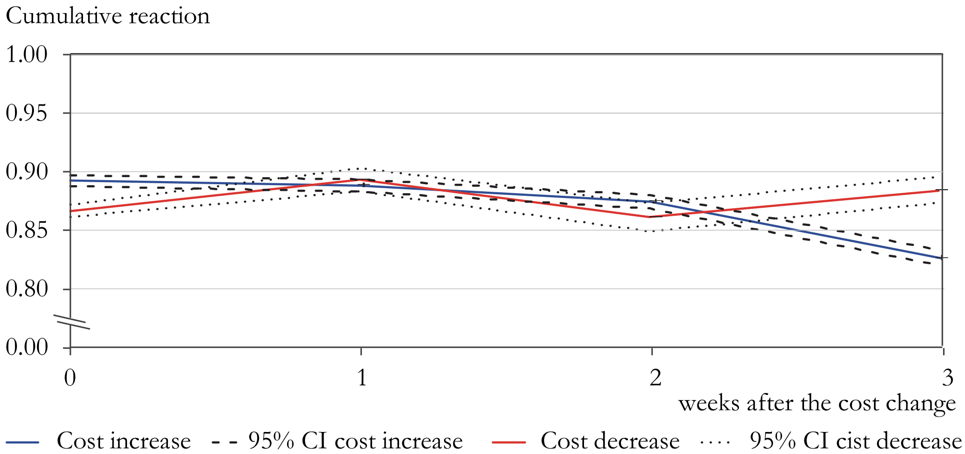


Table A2

Cost pass-through of MOL stations based on the BCG approach

Long-run equation		*Short-run adjustment*	
Dependent variable	P_t	Dependent variable	ΔP_t
C_t	0.934*** (0.012)	$\Delta Ct+$	0.932*** (0.003)
Constant	56.272*** (3.842)	$\Delta Ct-$	0.915*** (0.004)
Station fixed effect	Yes	ΔC^{+}_{t-1}	–0.033** (0.003)
Time fixed effect	Yes	ΔC^{-}_{t-1}	–0.033** (0.003)
		ΔC^{+}_{t-2}	−0.005*** (0.003)
		ΔC^{-}_{t-2}	0.101*** (0.004)
		ΔC^{+}_{t-3}	−0.062*** (0.003)
		ΔC^{-}_{t-3}	0.016*** (0.003)
		$\vartheta+$	−0.054*** (0.003)
		$\vartheta-$	−0.043*** (0.002)
		Constant	0.175*** (0.011)
Observations	89,472	Observations	87,936
Adjusted R^2	0.968	Adjusted R^2	0.723

Notes: *p<0.1; **p<0.05; ***p<0.01. Standard errors are in parentheses and robust to heteroscedasticity and autocorrelation.

Table A3

Cost pass-through of MOL stations based on the Remer approach

Long-run equation		*Short-run adjustment*			
Dependent variable: P_t		Dependent variable: ΔP_t			
C_t	0.934*** (0.012)	$\Delta Ct+$	0.926*** (0.004)	ΔP^{+}_{t-1}	−0.060*** (0.005)
Constant	56.272*** (3.482)	$\Delta Ct-$	0.919*** (0.004)	ΔP^{-}_{t-1}	−0.068*** (0.009)
Station fixed effect	Yes	ΔC^{+}_{t-1}	0.039*** (0.006)	ΔP^{+}_{t-2}	−0.197*** (0.008)
Time fixed effect	Yes	ΔC^{-}_{t-1}	0.023** (0.009)	ΔP^{-}_{t-2}	−0.0001** (0.004)
		ΔC^{+}_{t-2}	0.174*** (0.009)	$\vartheta+$	−0.046 (0.007)
		ΔC^{-}_{t-2}	0.097*** (0.008)	$\vartheta-$	−0.035*** (0.007)
		ΔC^{+}_{t-3}	−0.063*** (0.003)	Constant	0.177*** (0.015)
		ΔC^{-}_{t-3}	0.021*** (0.003)		
Observations	89,472	Observations	87,936		
Adjusted R^2	0.956	Adjusted R^2	0.730		

Notes: *p<0.1; **p<0.05; ***p<0.01. Standard errors are in parentheses and robust to heteroscedasticity and autocorrelation.

Figure A3

Cumulative reactions of MOL stations according to the BCG-approach

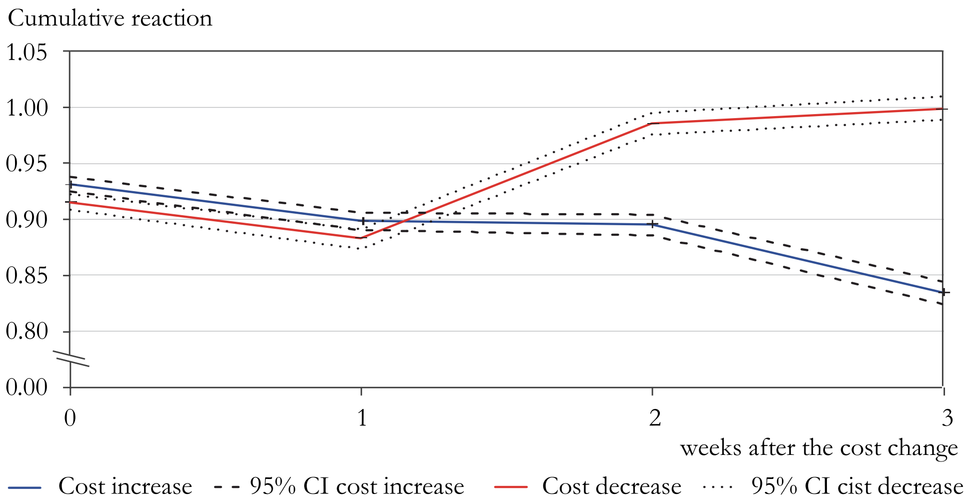


Figure A4

Cumulative reactions of MOL stations according to the Remer-approach

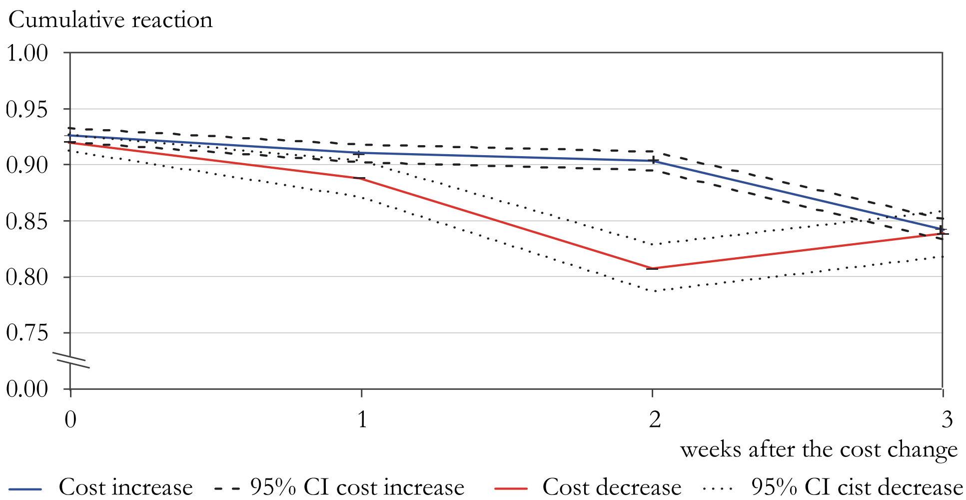


Table A4

Cost pass-through of non-MOL stations based on the BCG-approach

Long-run equation		*Short-run adjustment*	
Dependent variable	P_t	Dependent variable	ΔP_t
C_t	0.814*** (0.018)	$\Delta Ct+$	0.873*** (0.004)
Constant	56.272*** (3.842)	$\Delta Ct-$	0.832*** (0.005)
Station fixed effect	Yes	ΔC^{+}_{t-1}	−0.003 (0.004)
Time fixed effect	Yes	ΔC^{-}_{t-1}	−0.001 (0.004)
		ΔC^{+}_{t-2}	−0.012*** (0.004)
		ΔC^{-}_{t-2}	0.090*** (0.004)
		ΔC^{+}_{t-3}	−0.042*** (0.003)
		ΔC^{-}_{t-3}	0.018*** (0.003)
		$\vartheta+$	−0.071*** (0.005)
		$\vartheta-$	−0.078*** (0.005)
		Constant	0.113*** (0.013)
Observations	132,810	Observations	130,530
Adjusted R^2	0.950	Adjusted R^2	0.613

Notes: *p<0.1; **p<0.05; ***p<0.01. Standard errors are in parentheses and robust to heteroscedasticity and autocorrelation.

Table A5

Cost pass-through of non-MOL stations based on the Remer-approach

Long-run equation		*Short-run adjustment*			
Dependent variable: P_t		Dependent variable: ΔP_t			
C_t	0.814*** (0.018)	$\Delta Ct+$	0.869*** (0.004)	ΔP^{+}_{t-1}	−0.045*** (0.009)
Constant	95.833*** (5.778)	$\Delta Ct-$	0.832*** (0.004)	ΔP^{-}_{t-1}	−0.117*** (0.009)
Station fixed effect	Yes	ΔC^{+}_{t-1}	0.047*** (0.009)	ΔP^{+}_{t-2}	−0.137*** (0.006)
Time fixed effect	Yes	ΔC^{-}_{t-1}	0.094** (0.009)	ΔP^{-}_{t-2}	−0.024*** (0.004)
		ΔC^{+}_{t-2}	0.104*** (0.007)	$\vartheta+$	−0.063*** (0.005)
		ΔC^{-}_{t-2}	0.110*** (0.006)	$\vartheta-$	−0.064*** (0.005)
		ΔC^{+}_{t-3}	−0.039*** (0.003)	Constant	0.117*** (0.013)
		ΔC^{-}_{t-3}	0.025*** (0.003)		
Observations	132,810	Observations	130,530		
Adjusted R^2	0.950	Adjusted R^2	0.628		

Notes: *p<0.1; **p<0.05; ***p<0.01. Standard errors are in parentheses and robust to heteroscedasticity and autocorrelation.

Figure A5

Cumulative reactions of non-MOL stations according to the BCG-approach

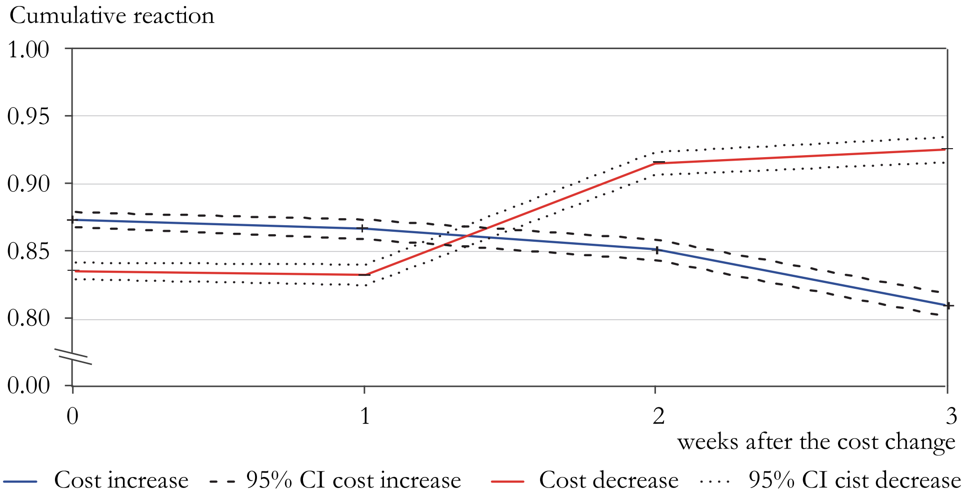


Figure A6

Cumulative reactions of non-MOL stations according to the Remer-approach

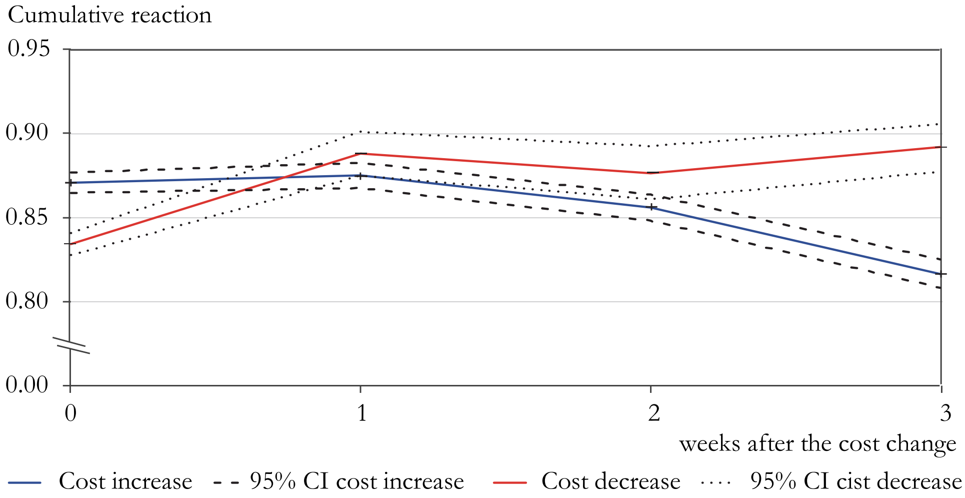


Table A6

Cost pass-through of stations in Budapest based on the BCG-approach

Long-run equation		*Short-run adjustment*	
Dependent variable	P_t	Dependent variable	ΔP_t
C_t	0.865*** (0.021)	$\Delta Ct+$	0.929*** (0.007)
Constant	77.908*** (6.777)	$\Delta Ct-$	0.901*** (0.006)
Station fixed effect	Yes	ΔC_{t-1}^{+}	−0.026*** (0.006)
Time fixed effect	Yes	ΔC_{t-1}^{-}	−0.028*** (0.005)
		ΔC_{t-2}^{+}	−0.009 (0.006)
		ΔC_{t-2}^{-}	0.097*** (0.006)
		ΔC_{t-3}^{+}	−0.058*** (0.005)
		ΔC_{t-3}^{-}	0.019*** (0.005)
		$\vartheta+$	−0.094*** (0.018)
		$\vartheta-$	−0.089*** (0.013)
		Constant	0.146*** (0.029)
Observations	37,979	Observations	37,327
Adjusted R^2	0.967	Adjusted R^2	0.701

Notes: *p<0.1; **p<0.05; ***p<0.01. Standard errors are in parentheses and robust to heteroscedasticity and autocorrelation.

Table A7

Cost pass-through stations in Budapest based on the Remer-approach

Long-run equation		*Short-run adjustment*			
Dependent variable: P_t		Dependent variable: ΔP_t			
C_t	0.865*** (0.021)	$\Delta Ct+$	0.925*** (0.007)	ΔP_{t-1}^{+}	−0.075*** (0.009)
Constant	77.908*** (6.777)	$\Delta Ct-$	0.904*** (0.006)	ΔP_{t-1}^{-}	−0.144*** (0.018)
Station fixed effect	Yes	ΔC_{t-1}^{+}	0.057*** (0.011)	ΔP_{t-2}^{+}	−0.177*** (0.012)
Time fixed effect	Yes	ΔC_{t-1}^{-}	0.098** (0.017)	ΔP_{t-2}^{-}	−0.022*** (0.008)
		ΔC_{t-2}^{+}	0.148*** (0.013)	$\vartheta+$	−0.079*** (0.018)
		ΔC_{t-2}^{-}	0.113*** (0.010)	$\vartheta-$	−0.069*** (0.013)
		ΔC_{t-3}^{+}	−0.057*** (0.005)	Constant	0.151*** (0.029)
		ΔC_{t-3}^{-}	0.028*** (0.005)		
Observations	37,979	Observations	37,327		
Adjusted R^2	0.967	Adjusted R^2	0.709		

Notes: *p<0.1; **p<0.05; ***p<0.01. Standard errors are in parentheses and robust to heteroscedasticity and autocorrelation.

Figure A7

Cumulative reactions of stations in Budapest according to the BCG-approach

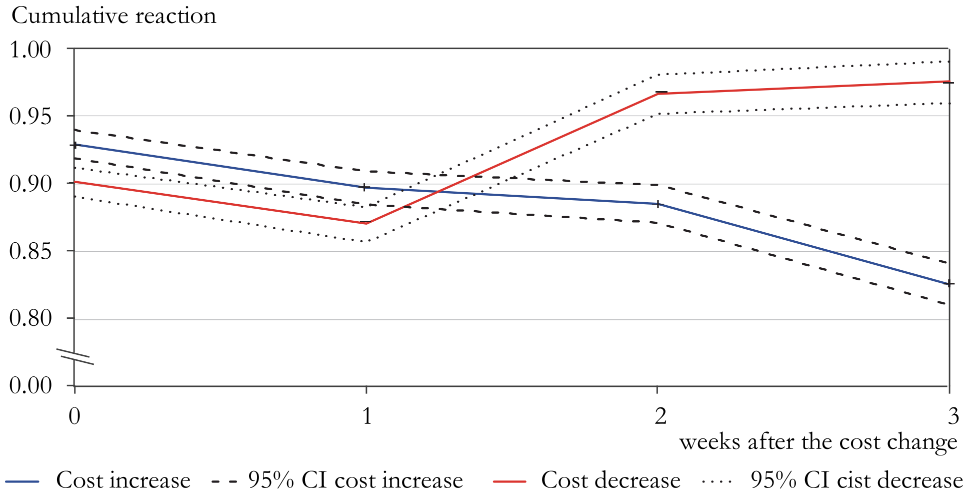


Figure A8

Cumulative reactions stations in Budapest according to the Remer-approach

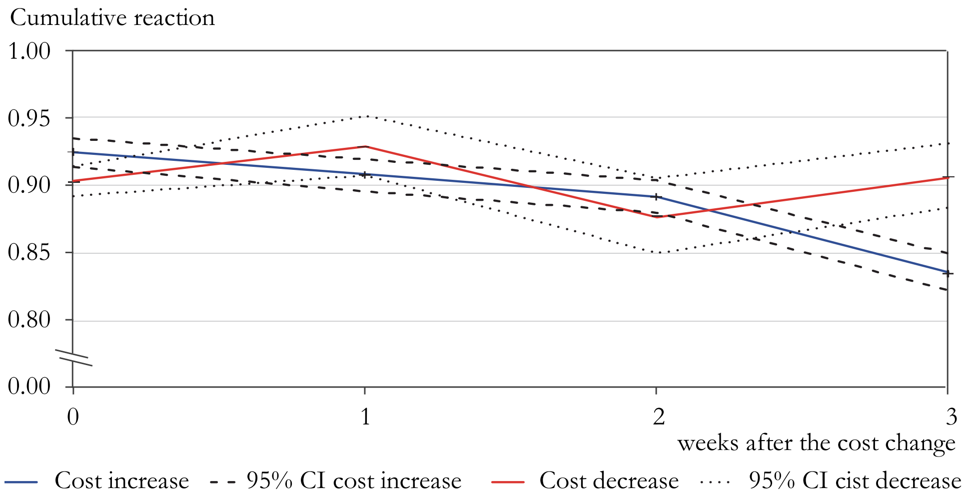


Table A8

Cost pass-through of stations out of Budapest based on the BCG-approach

Long-run equation		*Short-run adjustment*	
Dependent variable	P_t	Dependent variable	ΔP_t
C_t	0.862*** (0.005)	$\Delta Ct+$	0.890*** (0.003)
Constant	77.316*** (1.629)	$\Delta Ct-$	0.858*** (0.004)
Station fixed effect	Yes	ΔC^{+}_{t-1}	−0.013*** (0.003)
Time fixed effect	Yes	ΔC^{-}_{t-1}	−0.011*** (0.003)
		ΔC^{+}_{t-2}	−0.009*** (0.003)
		ΔC^{-}_{t-2}	0.094*** (0.003)
		ΔC^{+}_{t-3}	−0.049*** (0.003)
		ΔC^{-}_{t-3}	0.017*** (0.002)
		$\vartheta+$	−0.064*** (0.004)
		$\vartheta-$	−0.063*** (0.004)
		Constant	0.138*** (0.010)
Observations	184,303	Observations	181,139
Adjusted R^2	0.956	Adjusted R^2	0.653

Notes: *p<0.1; **p<0.05; ***p<0.01. Standard errors are in parentheses and robust to heteroscedasticity and autocorrelation.

Table A9

Cost pass-through of stations out of Budapest based on the Remer-approach

Long-run equation		*Short-run adjustment*			
Dependent variable: P_t		Dependent variable: ΔP_t			
C_t	0.862*** (0.005)	$\Delta Ct+$	0.886*** (0.003)	ΔP^{+}_{t-1}	−0.046*** (0.007)
Constant	77.316*** (1.629)	$\Delta Ct-$	0.860*** (0.003)	ΔP^{-}_{t-1}	−0.095*** (0.008)
Station fixed effect	Yes	ΔC^{+}_{t-1}	0.041*** (0.008)	ΔP^{+}_{t-2}	−0.154*** (0.005)
Time fixed effect	Yes	ΔC^{-}_{t-1}	0.066** (0.008)	ΔP^{-}_{t-2}	−0.017*** (0.004)
		ΔC^{+}_{t-2}	0.124*** (0.006)	$\vartheta+$	−0.058*** (0.004)
		ΔC^{-}_{t-2}	0.107*** (0.005)	$\vartheta-$	−0.051*** (0.004)
		ΔC^{+}_{t-3}	−0.046*** (0.007)	Constant	0.143*** (0.010)
		ΔC^{-}_{t-3}	0.023*** (0.002)		
Observations	184,303	Observations	181,139		
Adjusted R^2	0.956	Adjusted R^2	0.659		

Notes: *p<0.1; **p<0.05; ***p<0.01. Standard errors are in parentheses and robust to heteroscedasticity and autocorrelation.

Figure A9

Cumulative reactions of stations out of Budapest according to the BCG-approach

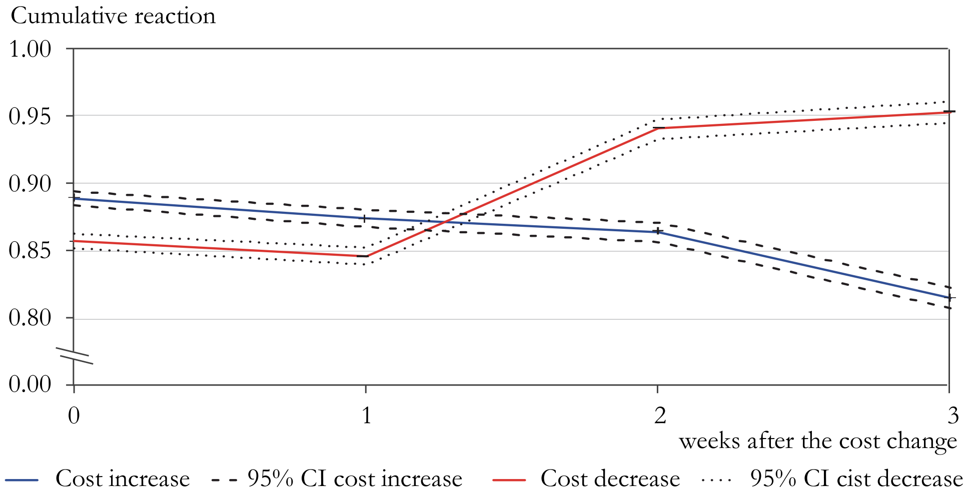


Figure A10

Cumulative reactions of stations out of Budapest according to the Remer-approach

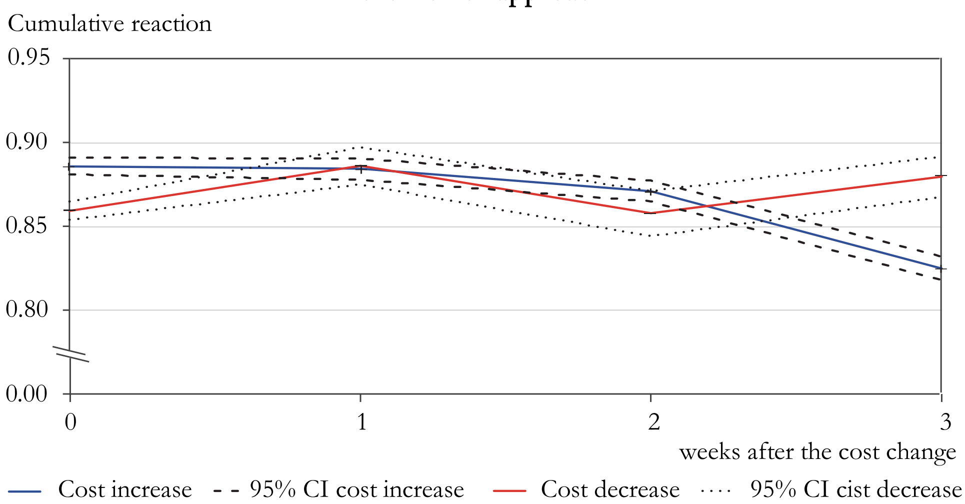


Figure A11

Cumulative reactions according to the BCG approach in the spatial framework

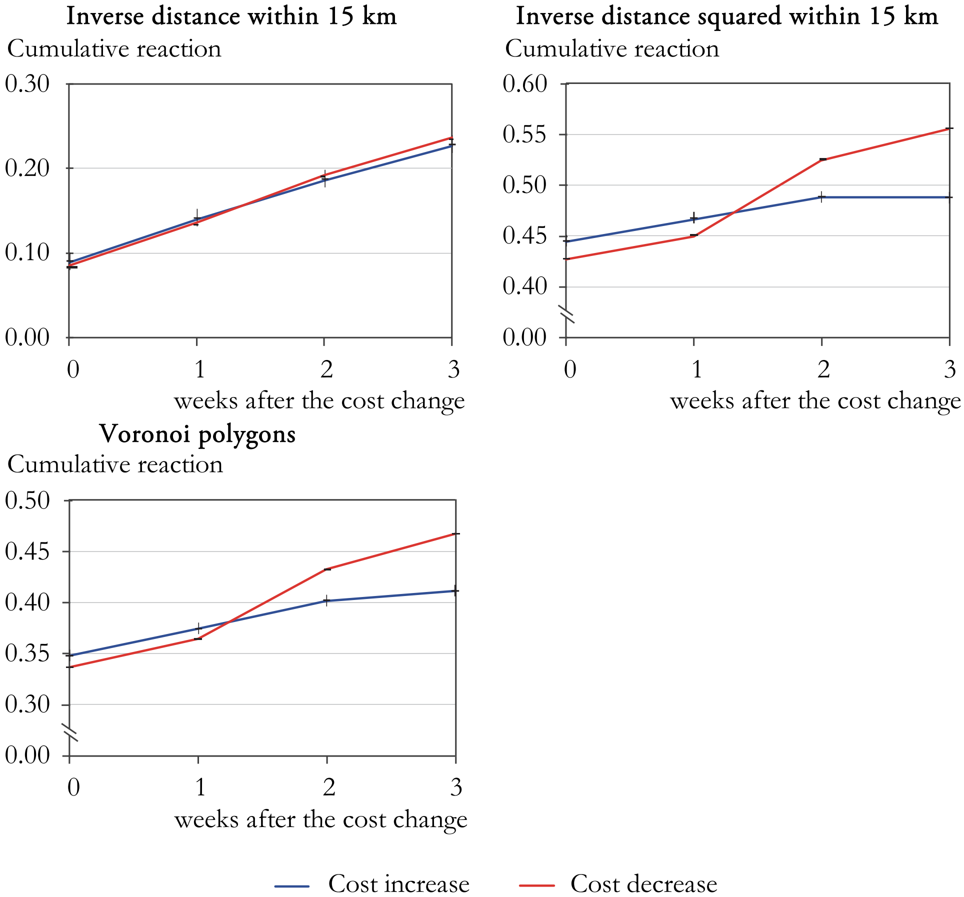


Figure A12

Cumulative reactions according to the Remer approach in the spatial framework

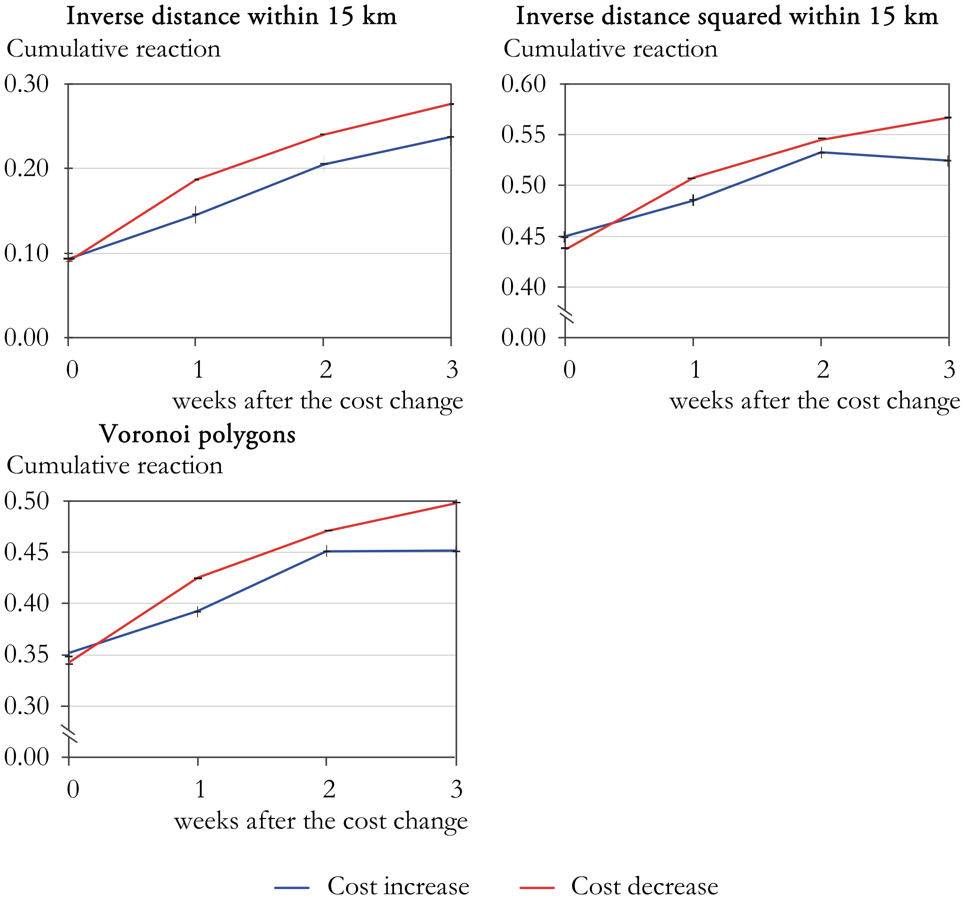


Table A10

Short-run adjustment of stations in Budapest according to the BCG-approach in spatial framework

Dependent variable: ΔP_t	Inv15	Invsquare15	Voronoi
ϱ	0.897*** (0.004)	0.581*** (0.004)	0.669*** (0.004)
$\Delta Ct+$	0.098*** (0.004)	0.394*** (0.004)	0.304*** (0.004)
$\Delta Ct-$	0.093*** (0.004)	0.377*** (0.005)	0.298*** (0.004)
ΔC^{+}_{t-1}	−0.002 (0.004)	−0.012*** (0.004)	−0.008** (0.004)
ΔC^{-}_{t-1}	−0.005 (0.004)	−0.014*** (0.005)	−0.008* (0.004)
ΔC^{+}_{t-2}	−0.0002 (0.004)	−0.003 (0.004)	−0.005 (0.004)
ΔC^{-}_{t-2}	0.011** (0.004)	0.041*** (0.005)	0.032*** (0.004)
ΔC^{+}_{t-3}	−0.006 (0.004)	−0.024*** (0.004)	−0.019*** (0.004)
ΔC^{-}_{t-3}	0.003 (0.004)	0.009** (0.004)	0.006 (0.004)
ϑ^{+}_{1}	−0.090*** (0.004)	−0.088*** (0.004)	−0.087*** (0.004)
ϑ^{-}_{1}	−0.091*** (0.004)	−0.089*** (0.004)	−0.089*** (0.004)
Constant	0.010 (0.013)	0.051*** (0.015)	0.049*** (0.014)
Observations	37,327	37,327	37,327
Pseudo R^2	0.140	0.467	0.387

Notes: *p<0.1; **p<0.05; ***p<0.01. Standard errors are in parentheses and robust to heteroscedasticity and autocorrelation.

Figure A13

Cumulative reactions of station in Budapest according to the BCG-approach in spatial framework

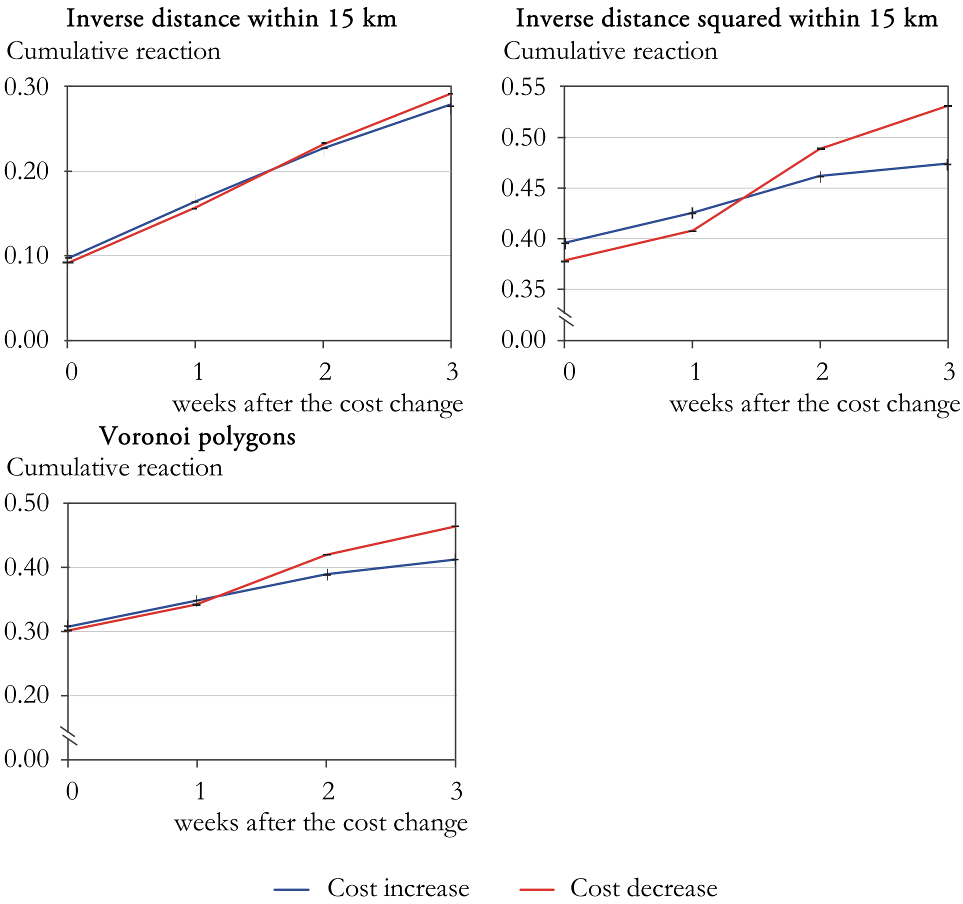


Table A11

Short-run adjustment of stations in Budapest according to the Remer-approach in spatial framework

Dependent variable: ΔP_t	Inv15	Invsquare15	Voronoi
ϱ	0.891*** (0.004)	0.572*** (0.004)	0.660*** (0.004)
$\Delta Ct+$	0.101*** (0.004)	0.400*** (0.004)	0.311*** (0.004)
$\Delta Ct-$	0.099*** (0.004)	0.387*** (0.004)	0.308*** (0.004)
ΔC^{+}_{t-1}	−0.0004 (0.006)	0.020*** (0.007)	0.016** (0.006)
ΔC^{-}_{t-1}	0.072*** (0.007)	0.079*** (0.008)	0.079*** (0.007)
ΔC^{+}_{t-2}	0.028*** (0.006)	0.072*** (0.007)	0.055*** (0.006)
ΔC^{-}_{t-2}	0.019*** (0.006)	0.053*** (0.007)	0.045*** (0.007)
ΔC^{+}_{t-3}	−0.006 (0.004)	−0.024*** (0.004)	−0.019*** (0.004)
ΔC^{-}_{t-3}	0.006 (0.004)	0.014*** (0.004)	0.011** (0.004)
ΔP^{+}_{t-1}	0.002 (0.005)	−0.026*** (0.006)	−0.020*** (0.005)
ΔP^{-}_{t-1}	−0.085*** (0.006)	−0.105*** (0.006)	−0.098*** (0.006)
ΔP^{+}_{t-2}	−0.034*** (0.005)	−0.085*** (0.005)	−0.068*** (0.005)
ΔP^{-}_{t-2}	−0.010** (0.005)	−0.014*** (0.005)	−0.015*** (0.005)
ϑ^{+}_{1}	−0.087*** (0.004)	−0.081*** (0.004)	−0.081*** (0.004)
ϑ^{-}_{1}	−0.083*** (0.003)	−0.077*** (0.004)	−0.078*** (0.004)
Constant	0.013 (0.013)	0.056*** (0.015)	0.053*** (0.014)
Observations	37,327	37,327	37,327
Pseudo R^2	0.151	0.481	0.402

Notes: *p<0.1; **p<0.05; ***p<0.01. Standard errors are in parentheses and robust to heteroscedasticity and autocorrelation.

Figure A14

Cumulative reactions of stations in Budapest according to the Remer-approach in spatial framework

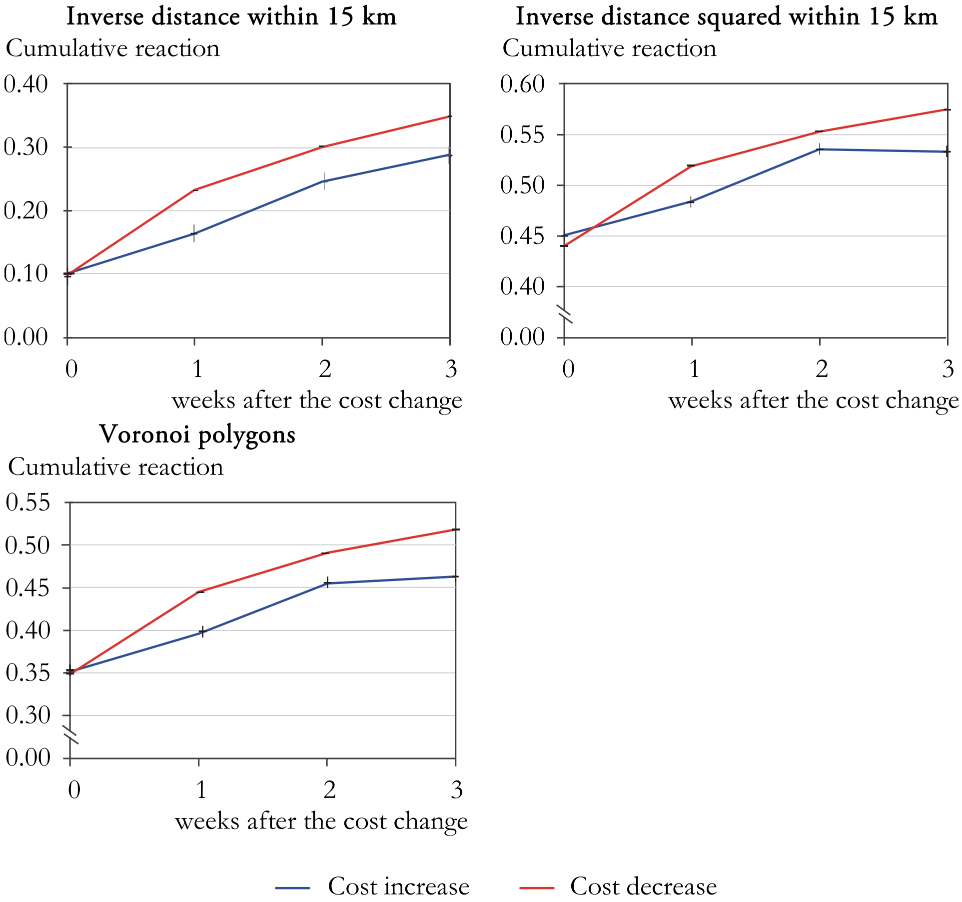


Table A12

Short-run adjustment of stations out of Budapest according to the BCG-approach in spatial framework

Dependent variable: ΔP_t	Inv15	Invsquare15	Voronoi
ϱ	0.867*** (0.002)	0.476*** (0.002)	0.604*** (0.002)
$\Delta Ct+$	0.114*** (0.002)	0.461*** (0.002)	0.357*** (0.002)
$\Delta Ct-$	0.110*** (0.002)	0.444*** (0.002)	0.343*** (0.002)
ΔC_{t-1}^{+}	0.0007 (0.002)	−0.003 (0.002)	−0.007*** (0.002)
ΔC_{t-1}^{-}	−0.0002 (0.002)	−0.004* (0.002)	−0.005** (0.002)
ΔC_{t-2}^{+}	−0.0007 (0.002)	−0.004* (0.002)	−0.004 (0.002)*
ΔC_{t-2}^{-}	0.012*** (0.002)	0.049*** (0.002)	0.037*** (0.002)
ΔC_{t-3}^{+}	−0.004** (0.002)	−0.023*** (0.002)	−0.020*** (0.002)
ΔC_{t-3}^{-}	0.002 (0.002)	0.009*** (0.002)	0.007*** (0.002)
ϑ_1^{+}	−0.060*** (0.001)	−0.059*** (0.001)	−0.060*** (0.001)
ϑ_1^{-}	−0.062*** (0.001)	−0.060*** (0.001)	−0.062*** (0.001)
Constant	0.011* (0.007)	0.066*** (0.007)	0.053*** (0.007)
Observations	181,139	181,139	181,139
Pseudo R^2	0.159	0.503	0.418

Notes: *p<0.1; **p<0.05; ***p<0.01. Standard errors are in parentheses and robust to heteroscedasticity and autocorrelation.

Figure A15

Cumulative reactions of station out of Budapest according to the BCG-approach in spatial framework

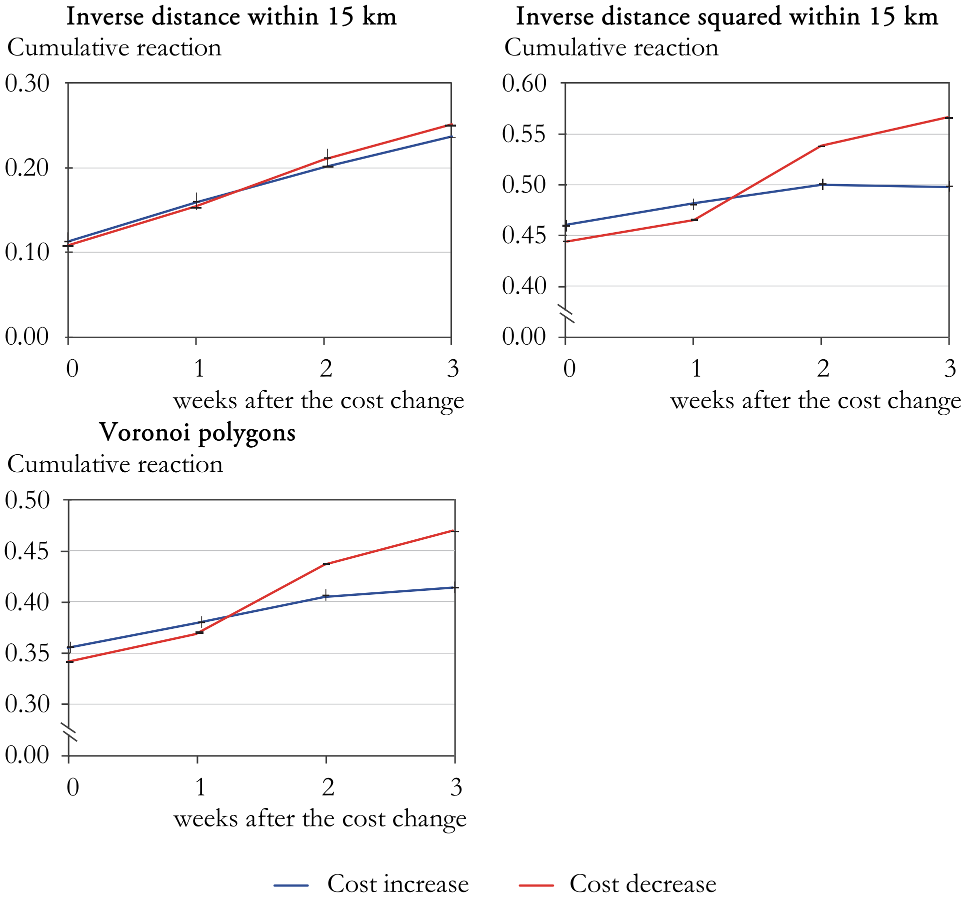


Table A13

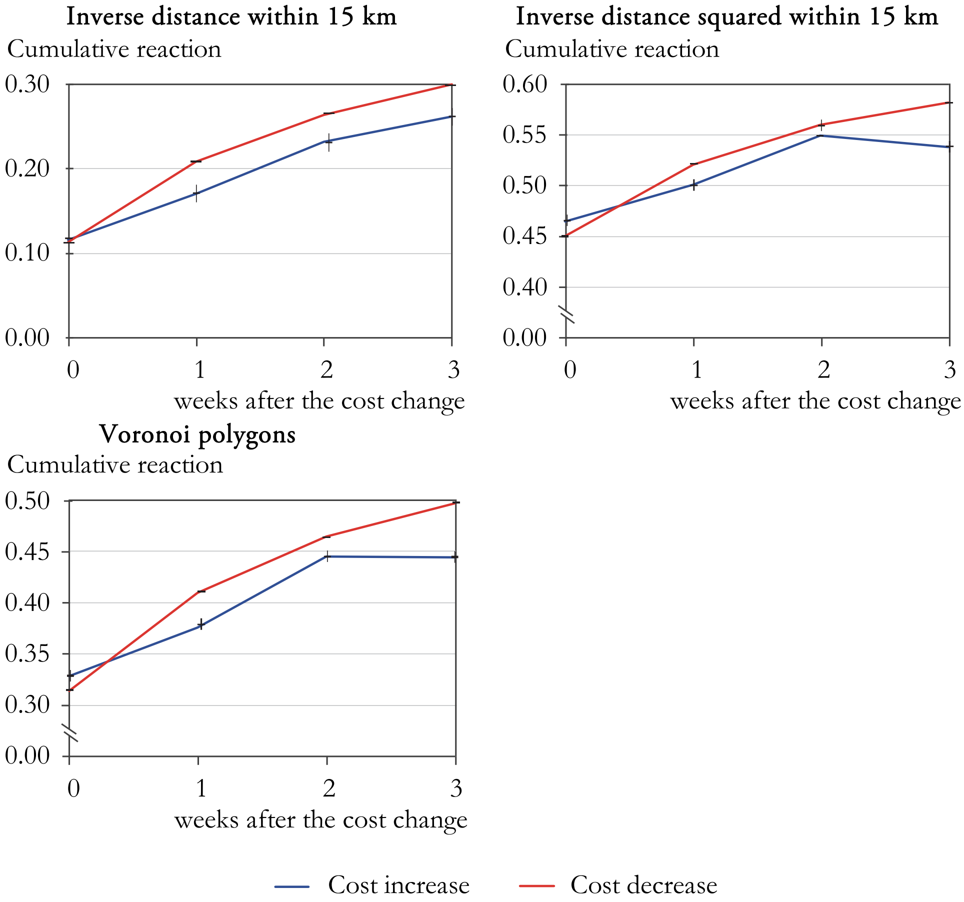
Short-run adjustment of stations out of Budapest according to the Remer-approach in spatial framework

Dependent variable: ΔP_t	Inv15	Invsquare15	Voronoi
ϱ	0.861*** (0.002)	0.469*** (0.002)	0.596*** (0.002)
$\Delta Ct+$	0.118*** (0.002)	0.465*** (0.002)	0.362*** (0.002)
$\Delta Ct-$	0.115*** (0.002)	0.451*** (0.002)	0.351*** (0.002)
ΔC_{t-1}^{+}	0.013*** (0.003)	0.026*** (0.003)	0.019*** (0.003)
ΔC_{t-1}^{-}	0.053*** (0.003)	0.059*** (0.004)	0.056*** (0.004)
ΔC_{t-2}^{+}	0.025*** (0.003)	0.070*** (0.003)	0.057*** (0.003)
ΔC_{t-2}^{-}	0.022*** (0.003)	0.061*** (0.003)	0.047*** (0.003)
ΔC_{t-3}^{+}	−0.004** (0.002)	−0.023*** (0.002)	−0.019*** (0.002)
ΔC_{t-3}^{-}	0.005** (0.002)	0.013*** (0.002)	0.011** (0.002)
ΔP_{t-1}^{+}	−0.010 (0.002)	−0.025*** (0.003)	−0.022*** (0.003)
ΔP_{t-1}^{-}	−0.063*** (0.003)	−0.076*** (0.003)	−0.073*** (0.003)
ΔP_{t-2}^{+}	−0.031*** (0.002)	−0.085*** (0.003)	−0.071*** (0.003)
ΔP_{t-2}^{-}	−0.010*** (0.002)	−0.014*** (0.003)	−0.012*** (0.003)
ϑ_1^{+}	−0.057*** (0.001)	−0.055*** (0.001)	−0.056*** (0.001)
ϑ_1^{-}	−0.058*** (0.001)	−0.053*** (0.001)	−0.056*** (0.001)
Constant	0.011* (0.007)	0.069*** (0.007)	0.056*** (0.007)
Observations	181,139	181,139	181,139
Pseudo R^2	0.169	0.512	0.429

Notes: *p<0.1; **p<0.05; ***p<0.01. Standard errors are in parentheses and robust to heteroscedasticity and autocorrelation.

Figure A16

Cumulative reactions of stations out of Budapest according to the Remer-approach in spatial framework



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