

Online Appendix:

Policy Spillover Effects on Student Achievement – Evidence from PISA*

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1 GMM Estimation and Inference

Spatial econometric models are typically estimated using maximum likelihood (MLE) (e.g., Anselin (1988) and Elhorst (2005)), quasi-maximum likelihood (QMLE) (e.g., Lee and Yu (2010)), two-stage least squares (2SLS) (e.g., Kelejian and Prucha (1998)), and generalised method of moments (GMM) (e.g., Lee (2007) and Lee and Liu (2010)). GMM is our preferred estimator because of its robustness to violations of distributional assumptions. Also, the GMM tends to be asymptotically more efficient than 2SLS, and it allows us to verify model specification using over-identifying restrictions tests (J-tests). The GMM estimator is given by

$$(1.1) \quad \hat{\theta}_n = \arg \min_{\theta \in \Theta} Q_n(\theta) = (\tilde{\mathbf{x}}' \mathbf{z}_n \mathbf{M} \mathbf{z}_n' \tilde{\mathbf{x}})^{-1} \tilde{\mathbf{x}}' \mathbf{z}_n \mathbf{M} \mathbf{z}_n' \mathbf{y}_n$$

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where $Q_n(\boldsymbol{\theta}) = \frac{1}{n}g_n(\boldsymbol{\theta})'\mathbf{M}g_n(\boldsymbol{\theta})$, $g_n(\boldsymbol{\theta}) = \mathbf{z}'_n\boldsymbol{\varepsilon}_n(\boldsymbol{\theta})$, the $n \times p_p$ matrix of instruments \mathbf{z}_n denotes the linearly independent columns of $[\mathbf{x}_n, \mathbf{w}_n\mathbf{x}_n]$, $\boldsymbol{\varepsilon}_n(\boldsymbol{\theta}) = \mathbf{y}_n - \check{\mathbf{x}}\boldsymbol{\theta}$, $\check{\mathbf{x}} \equiv [\mathbf{w}_n\mathbf{y}_n, \mathbf{x}_n]$, Θ is a compact parameter space, and \mathbf{M} is a $p_p \times p_p$ positive definite matrix. The subscript n is used to emphasise dependence on data and also denote the total number of country-year observations $N \times T$.

Following the GMM literature (e.g., Hansen (1982) and Lee (2007)), the optimal weighting matrix is $\mathbf{M} = \boldsymbol{\Omega}_n^{-1}$ where $\boldsymbol{\Omega}_n \equiv \text{var}(g_n(\boldsymbol{\theta}_o))$. Since disturbances may be heteroskedastic and arbitrarily correlated over time for each country, they are clustered at the country level, i.e., $\boldsymbol{\Omega}_n(\boldsymbol{\theta}_o) \equiv \text{var}(g_n(\boldsymbol{\theta}_o)) = \text{var}(\sum_{i=1}^N \sum_{t=1}^T \mathbf{z}_{it}\varepsilon_{it}) = \sum_{i=1}^N \text{var}(\sum_{t=1}^T \mathbf{z}_{it}\varepsilon_{it}) = \sum_{i=1}^N \sum_{t=1}^T \sum_{t'=1}^T \mathbb{E}(\mathbf{z}_{it}\varepsilon_{it}\varepsilon_{it'}\mathbf{z}_{it'}')$.

Following standard arguments (e.g., Hansen (1982) and Lee (2007)), $\sqrt{n}(\hat{\boldsymbol{\theta}}_n - \boldsymbol{\theta}_o) \xrightarrow{d} \mathcal{N}(\mathbf{0}, \mathbf{V}_o)$ and $\mathbf{V}_o = \left[\lim_{n \rightarrow \infty} \check{\mathbf{x}}'\mathbf{z}_n\boldsymbol{\Omega}_n^{-1}\mathbf{z}_n'\check{\mathbf{x}}/n \right]^{-1}$. The covariance matrix is estimated using $\hat{\mathbf{V}}_n = \left[\check{\mathbf{x}}'\mathbf{z}_n\hat{\boldsymbol{\Omega}}_n^{-1}\mathbf{z}_n'\check{\mathbf{x}}/n \right]^{-1}$, where $\hat{\boldsymbol{\Omega}}_n = \sum_{i=1}^N \sum_{t=1}^T \sum_{t'=1}^T \mathbf{z}_{it}\hat{\varepsilon}_{it}\hat{\varepsilon}_{it'}\mathbf{z}_{it'}'$, $\hat{\varepsilon}_{it}$ is the residual corresponding to country i in year t , and $\text{var}(\hat{\boldsymbol{\theta}}_n) = \hat{\mathbf{V}}_n/n$ is the covariance matrix of $\hat{\boldsymbol{\theta}}_n$. Recall p_p is the total number of moments. Let p_θ denote the length of the parameter vector $\boldsymbol{\theta}$. The test statistic for the over-identifying restrictions test is $J\text{-stat} = g_n(\hat{\boldsymbol{\theta}}_n)'\hat{\boldsymbol{\Omega}}_n^{-1}g_n(\hat{\boldsymbol{\theta}}_n) \xrightarrow{d} \chi^2(p_p - p_\theta)$ where $p_p - p_\theta$ is the degrees of freedom.

2 Descriptive Statistics

This section provides additional descriptive statistics at the country level and over time. Table 2.1 shows summary statistics by country for outcome variables viz. test scores in Reading, Mathematics, and Science, and covariates viz. school autonomy, private school share, external monitoring, shortage (none and large), GDP per capita, and OECD membership. As reading test scores and school autonomy are, respectively, the outcome variable and main covariate of interest, Table 2.2 provides their summary statistics by country and year.¹

Trends of both reading scores and autonomy by country can be visualised in Figures 2.1 and 2.2. Both plots show that on average (see the thick black line) neither school autonomy or reading scores dramatically increase over time. Generally, there is no discernible pattern or trend. This alleviates concerns about the existence of trends that may lead to spurious correlations or co-integration. Moreover, such concerns are further alleviated by the inclusion of year dummies and other controls in the specifications. Taking this argument up a notch further, two considerations come to mind. One is diagnostic and the other is robust estimation. On diagnostics, the number of waves is insufficient to conduct any informative test of co-integration in panels as such tests often require $T \rightarrow \infty$. On robust estimation, we face two challenges in using an ARDL specification and its SAR extension, for example. First, we only have three waves of data thus at least one wave is lost due to time lagging. Second, an SAR-ARDL(1,1), for example, doubles the number of covariates, i.e., from \mathbf{x}_{it} to $[\mathbf{x}_{it}, \mathbf{x}_{i(t-1)}]$ with a loss of N country observations due to lagging by one period. This, in our case, leads to a non-invertible covariance matrix of the GMM moment conditions.

¹Table 2.2 is not replicated for other variables due to concerns of space.

Table 2.1: Summary Statistics by Country (averaged over all three waves)

	Test scores			School Autonomy	Private School Share	External Monitoring	No Shortage	Large Shortage	GDP Per Capita	OECD Member
	Reading	Math	Science							
ALB	394.68	394.98	405.10	0.62	0.11	0.81	0.48	0.09	4,462	0
ARE	435.55	427.55	440.97	0.49	0.57	0.91	0.60	0.08	42,482	0
ARG	423.19	410.93	427.22	0.69	0.42	0.66	0.36	0.14	12,047	0
AUS	509.87	504.13	519.58	0.93	0.47	0.87	0.59	0.01	41,485	1
AUT	481.59	499.40	498.38	0.81	0.14	0.45	0.47	0.05	55,198	1
BEL	504.36	512.26	504.48	0.86	0.58	0.49	0.50	0.04	49,058	1
BGR	432.31	436.00	443.84	0.50	0.03	0.84	0.40	0.06	20,925	0
BRA	408.54	383.80	402.57	0.59	0.19	0.84	0.40	0.08	9,985	0
CAN	524.68	520.18	527.28	0.79	0.13	0.88	0.49	0.02	36,931	1
CHE	500.58	528.71	512.46	0.73	0.15	0.39	0.61	0.01	70,599	0
CHL	449.78	422.12	446.45	0.69	0.51	0.79	0.31	0.09	37,331	1
COL	413.83	382.33	405.39	0.66	0.28	0.79	0.17	0.26	9,160	1
CRI	436.87	405.55	426.48	0.58	0.22	0.90	0.22	0.33	8,032	0
CZE	486.11	494.70	500.54	0.99	0.09	0.52	0.24	0.04	18,408	1
DEU	504.70	510.76	517.89	0.81	0.07	0.31	0.40	0.03	37,321	1
DNK	496.95	504.80	499.92	0.87	0.29	0.64	0.42	0.02	58,012	1
ESP	488.72	484.68	493.14	0.72	0.43	0.74	0.53	0.04	50,287	1
EST	512.13	517.39	534.47	0.97	0.07	0.76	0.21	0.06	32,799	1
FIN	528.77	523.44	543.39	0.89	0.05	0.41	0.35	0.01	44,699	1
GBR	497.16	492.94	512.35	0.99	0.43	0.84	0.53	0.02	46,529	1
GRC	475.67	457.57	463.89	0.16	0.04	0.62	0.39	0.12	33,642	1
HKG	534.81	554.57	542.42	0.99	0.93	0.70	0.54	0.01	38,028	0
HRV	482.39	465.04	484.37	0.62	0.09	0.83	0.23	0.11	17,556	1
HUN	484.05	481.35	491.23	0.77	0.16	0.49	0.36	0.06	23,428	0
IDN	398.36	377.51	389.19	0.90	0.61	0.76	0.13	0.27	6,470	0
IRL	513.21	497.45	510.85	0.90	0.56	0.54	0.44	0.06	42,459	1
ISL	488.11	495.83	482.33	0.95	0.02	0.75	0.38	0.01	35,806	1
ISR	479.58	461.00	463.82	0.93	0.16	0.80	0.30	0.08	39,577	1
ITA	486.85	485.99	487.64	0.86	0.16	0.26	0.34	0.03	44,540	1
JOR	404.05	384.17	411.14	0.15	0.20	0.85	0.46	0.19	14,996	0
JPN	524.62	532.61	541.52	0.96	0.25	0.09	0.57	0.07	41,009	1
KOR	530.83	541.37	530.53	0.92	0.30	0.84	0.31	0.02	16,859	1
LTU	472.72	477.93	487.51	0.86	0.02	0.69	0.36	0.07	22,482	1
LUX	480.47	488.23	485.99	0.73	0.22	0.61	0.34	0.00	86,435	1
LVA	486.80	484.94	495.43	0.83	0.04	0.54	0.23	0.02	15,627	1
MAC	501.43	535.74	520.06	0.89	0.92	0.45	0.39	0.07	75,355	0
MEX	424.03	413.27	415.51	0.35	0.20	0.87	0.17	0.22	11,978	1
MNE	418.85	410.03	407.56	0.49	0.02	0.92	0.12	0.04	36,158	0
NLD	507.53	520.35	517.62	0.99	0.64	0.71	0.56	0.03	40,911	1
NOR	506.79	496.35	497.63	0.79	0.06	0.75	0.23	0.02	68,308	1
NZL	514.11	504.76	520.32	0.98	0.15	0.91	0.43	0.02	40,853	1
PER	383.80	373.26	379.71	0.77	0.34	0.60	0.13	0.31	35,703	0
POL	508.12	505.59	511.78	0.92	0.07	0.79	0.48	0.01	24,143	1
PRT	491.74	488.53	494.44	0.56	0.17	0.81	0.45	0.02	18,236	1
QAT	387.04	382.32	393.57	0.45	0.41	0.91	0.79	0.03	61,573	0
ROU	431.89	438.53	433.94	0.67	0.01	0.68	0.24	0.03	9,859	0
RUS	476.39	481.35	483.74	0.71	0.01	0.99	0.28	0.13	13,347	0
SGP	534.41	566.56	549.59	0.78	0.13	0.97	0.86	0.00	50,487	0
SVK	464.24	484.52	474.08	0.95	0.12	0.80	0.13	0.12	18,571	1
SVN	489.87	504.17	512.92	0.86	0.01	0.65	0.41	0.02	25,598	1
SWE	493.65	488.81	491.11	0.89	0.27	0.84	0.53	0.00	58,976	1
THA	423.91	420.26	430.21	0.95	0.13	0.90	0.18	0.13	5,275	0
TUN	389.59	375.37	395.04	0.23	0.16	0.82	0.19	0.21	4,292	0
TUR	456.01	437.96	447.60	0.20	0.02	0.89	0.15	0.32	11,506	1
URY	424.58	418.00	426.14	0.51	0.23	0.68	0.46	0.05	13,387	0
USA	498.12	479.47	498.55	0.77	0.23	0.91	0.40	0.04	51,111	1

Table 2.2: Summary Statistics by Country by Year

	Reading test scores			School autonomy		
	2009	2012	2015	2009	2012	2015
ALB	384.82	393.96	405.26	0.63	0.61	0.61
ARE	431.42	441.70	433.54	0.47	0.49	0.50
ARG	398.26	395.98	475.33	0.73	0.60	0.74
AUS	514.90	511.80	502.90	0.95	0.93	0.92
AUT	470.28	489.61	484.87	0.83	0.76	0.83
BEL	505.95	508.62	498.52	0.86	0.86	0.86
BGR	429.08	436.13	431.72	0.52	0.49	0.48
BRA	411.75	406.53	407.35	0.60	0.56	0.59
CAN	524.24	523.12	526.67	0.82	0.75	0.80
CHE	500.5	509.04	492.20	0.76	0.71	0.71
CHL	449.37	441.40	458.57	0.73	0.65	0.69
COL	413.18	403.40	424.91	0.66	0.61	0.70
CRI	442.58	440.55	427.49	0.71	0.52	0.52
CZE	478.19	492.89	487.25	0.99	1.00	0.99
DEU	497.31	507.68	509.10	0.79	0.80	0.83
DNK	494.92	496.13	499.81	0.87	0.84	0.90
ESP	481.04	487.94	497.19	0.76	0.68	0.71
EST	500.96	516.29	519.14	0.96	0.96	0.99
FIN	535.88	524.02	526.42	0.94	0.84	0.90
GBR	494.18	499.32	497.97	0.99	0.99	0.99
GRC	482.78	477.20	467.04	0.13	0.16	0.17
HKG	533.15	544.60	526.68	0.99	1.00	0.99
HRV	475.75	484.57	486.86	0.65	0.59	0.64
HUN	494.18	488.46	469.52	0.80	0.81	0.69
IDN	401.71	396.12	397.26	0.86	0.93	0.90
IRL	495.64	523.17	520.81	0.89	0.90	0.91
ISL	500.28	482.52	481.53	0.94	0.95	0.95
ISR	473.99	485.80	478.96	0.94	0.92	0.93
ITA	486.05	489.75	484.76	0.86	0.87	0.85
JOR	405.01	399.03	408.10	0.14	0.16	0.16
JPN	519.86	538.05	515.96	0.98	0.95	0.95
KOR	539.27	535.79	517.44	0.91	0.92	0.94
LTU	468.44	477.31	472.41	0.84	0.88	0.87
LUX	472.17	487.81	481.44	0.70	0.71	0.77
LVA	483.96	488.69	487.76	0.80	0.83	0.85
MAC	486.64	508.95	508.69	0.90	0.87	0.92
MEX	425.27	423.55	423.28	0.36	0.36	0.32
MNE	407.55	422.11	426.88	0.57	0.35	0.54
NLD	508.40	511.23	502.96	0.99	0.98	0.99
NOR	503.23	503.94	513.19	0.77	0.7	0.88
NZL	520.88	512.19	509.27	0.98	0.97	0.98
PER	369.70	384.15	397.54	0.77	0.76	0.76
POL	500.48	518.19	505.70	0.93	0.92	0.92
PRT	489.33	487.76	498.13	0.48	0.59	0.62
QAT	371.72	387.50	401.89	0.44	0.47	0.44
ROU	424.46	437.60	433.62	0.69	0.58	0.75
RUS	459.40	475.15	494.63	0.73	0.71	0.69
SGP	525.90	542.22	535.10	0.84	0.82	0.68
SVK	477.44	462.77	452.51	0.95	0.95	0.95
SVN	483.08	481.32	505.22	0.92	0.86	0.79
SWE	497.45	483.34	500.16	0.92	0.86	0.89
THA	421.37	441.22	409.13	0.92	0.96	0.96
TUN	403.63	404.08	361.06	0.18	0.39	0.13
TUR	464.19	475.49	428.34	0.30	0.16	0.13
URY	425.81	411.35	436.57	0.47	0.51	0.54
USA	499.83	497.58	496.94	0.80	0.71	0.80

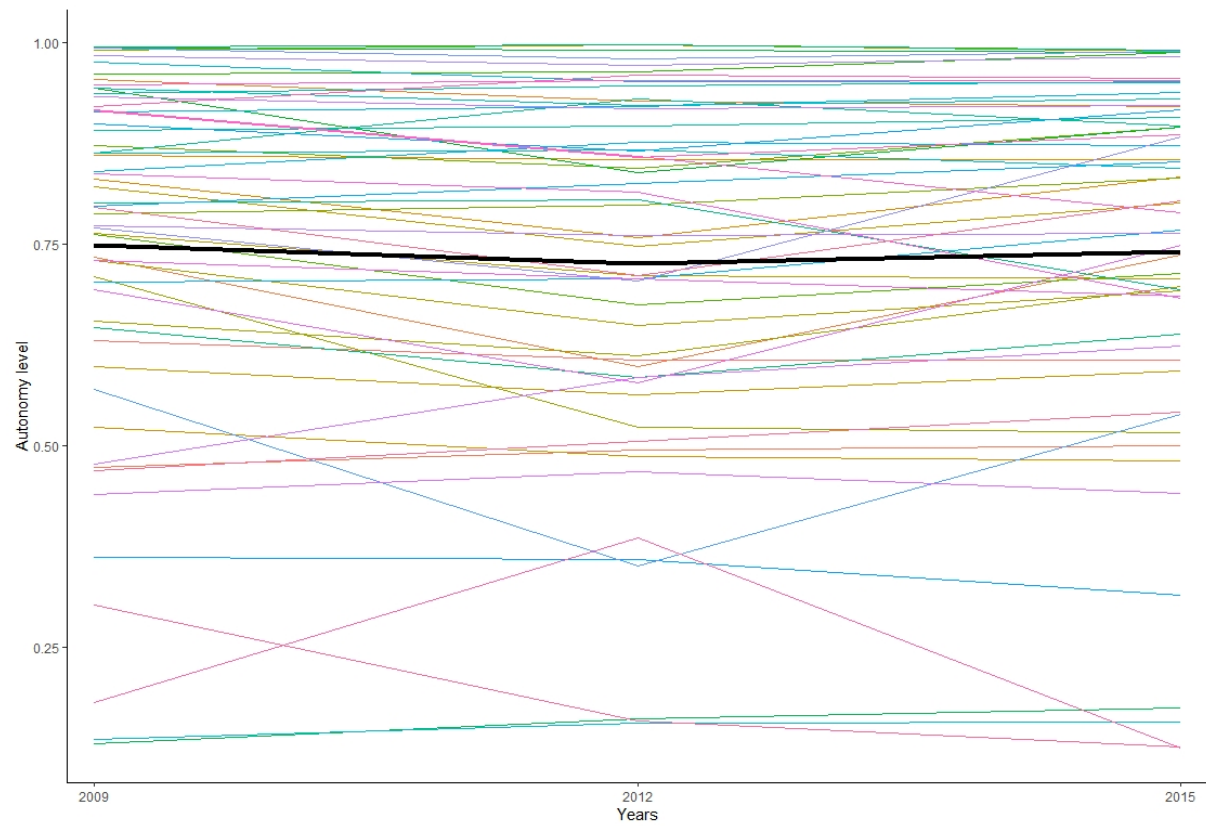


Figure 2.1: Trend in School Autonomy by Year

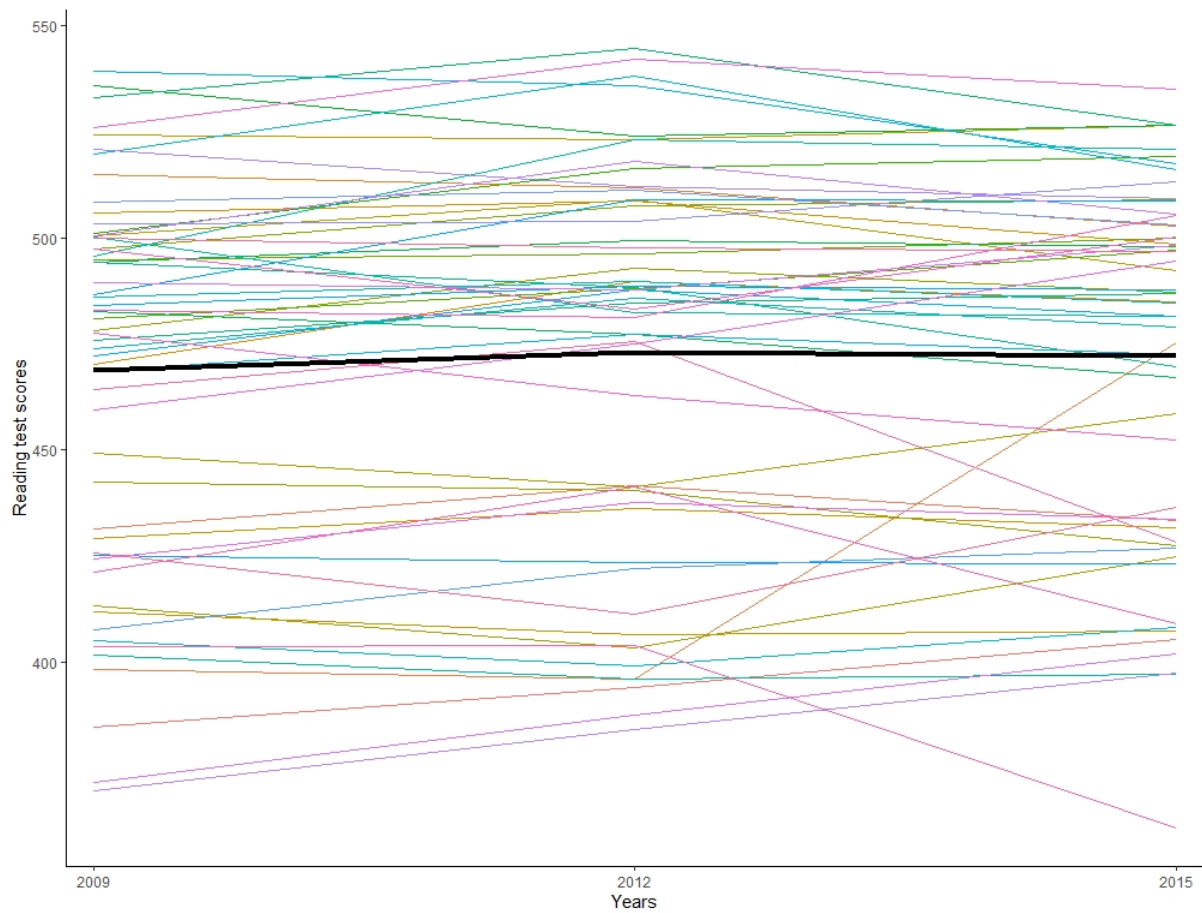


Figure 2.2: Trend in Reading Test Scores by Year

3 Additional Empirical Results

Additional empirical results are shown and discussed in this section. We replicate the results by subdomain (Table 4.3 in the main text) and the robustness analyses (Table 4.4 in the main text) for Mathematics and Science here. For Tables 3.1 and 3.2, we see that all specifications have significant spatial coefficients and spillover effects, albeit larger than the effects reported in the main text for Reading. For Tables 3.3 and 3.4, we again show that dropping imputed values does not alter our results, that the spatial coefficient for OECD countries only is insignificant and that there are large spillover effects for the European sample. Including country-fixed effects for Mathematics reduces the size of the spillover effects but they are still positive and significant. For Science, this specification could not be computed due to challenges in inverting the covariance matrix of moments.

Finally, Table 3.5 displays three specifications with alternative spatial matrices all related to economic distance or similarity between countries, namely, closeness in GDP per capita, OECD membership, and World Bank income categories.² The spillover effect with the spatial matrix based on GDP per capita (column (1) of Table 3.5) is not interpreted as the spatial coefficient is unreasonably large; it falls outside the natural bound $\rho \in (-1, 1)$ for a row-normalised spatial matrix. Moreover, the J-statistic suggests the model is not supported by the data at the 5% level. For the other two specifications, the spillover effects are, respectively, larger and smaller than the comparable spillover effect reported in the main text. Although the spillover effects in Table 3.5 (columns (2) and (3)) appear different from the one reported in the main text (see Table 4.2 column (1) of the main text), the respective confidence intervals, however, do not exclude the estimate in the main text. The local effects are, however, very similar to those reported in the main text. Thus, these findings suggest that the choice of the spatial matrix does not significantly (in the statistical sense) alter the spillover effects. In addition, the local effect does not vary in any meaningful way across

²A spatial matrix based on common language or linguistic similarity could not be considered as it led to the isolation and thus loss of several countries.

Table 3.1: SAR Results by Subdomains for Mathematics

	School				Personnel	Budget
	Assessments	Textbooks	Content	Course choice		
	(1)	(2)	(3)	(4)		
Panel A	Coefficients					
Autonomy	79.588*** (16.249)	56.951*** (13.496)	47.650*** (12.524)	65.669*** (11.560)	42.679*** (14.330)	67.446*** (14.061)
ρ	0.653*** (0.183)	0.787*** (0.163)	0.750*** (0.157)	0.655*** (0.147)	0.693*** (0.166)	0.627*** (0.190)
Panel B	Partial effects					
Local	83.246 [53.8;122]	62.051 [35.6;113.1]	51.151 [27.0;86.8]	68.712 [46.2;96.5]	45.042 [17.0;79.0]	70.187 [44.7;101.9]
Spillover	146.251 [34.3;1334.2]	205.463 [45.9;2684.7]	139.356 [34.6;1487.7]	121.588 [35.5;735.8]	93.801 [20.0;804.8]	110.602 [24.0;921.6]
Total	229.498 [108.9;1435.8]	267.515 [93.4;2785.1]	190.507 [72.2;1562.5]	190.3 [92.7;809.4]	138.843 [45.9;866.7]	180.789 [87.3;1010.0]
Panel C	Goodness of fit					
J-stat (df)	7.62 (8)	7.38 (8)	7.55 (8)	6.41 (8)	8.96 (8)	7.08 (8)
p-value	0.47	0.5	0.48	0.6	0.35	0.53
R ²	0.6	0.55	0.58	0.63	0.53	0.59

Notes: Dependent variable: PISA mathematics score. Robust standard errors adjusted for clustering at the country level are in parentheses. The 95% confidence intervals provided in brackets are constructed from 10,000 simulations of partial effects. All specifications control for year fixed effects, income category, private school share, external monitoring, shortage of instruction materials, and GDP per capita. *Significance levels:* *** 1%, ** 5%, * 10%.

Table 3.2: SAR Results by Subdomains for Science

	School				Personnel	Budget
	Assessments	Textbooks	Content	Course choice		
	(1)	(2)	(3)	(4)	(5)	(6)
<i>Panel A</i>						
	Coefficients					
Autonomy	68.259*** (14.758)	49.64*** (10.339)	41.289*** (10.835)	58.549*** (10.648)	32.745** (12.653)	55.885*** (12.649)
ρ	0.607*** (0.181)	0.705*** (0.164)	0.665*** (0.168)	0.620*** (0.151)	0.650*** (0.166)	0.563*** (0.188)
<i>Panel B</i>						
	Partial effects					
Local	70.791 [43.3;103.3]	52.562 [32.6;81.4]	43.299 [22.8;68.2]	60.856 [40.2;85.0]	34.231 [9.3;62.4]	57.566 [33.7;84.8]
Spillover	103.086 [23.5;719.9]	115.875 [28.6;1094.1]	80.097 [20.0;590.9]	93.346 [26.7;496.0]	59.431 [10.2;420.6]	70.291 [13.7;461.2]
Total	173.877 [84.0;804.5]	168.437 [70.7;1164.8]	123.395 [52.9;642.6]	154.202 [77.5;567.7]	93.662 [24.7;469.8]	127.857 [62.0;524.7]
<i>Panel C</i>						
	Goodness of fit					
J -stat (df)	5.59 (8)	6.64 (8)	5.90 (8)	5.31 (8)	8.97 (8)	6.63 (8)
p -value	0.69	0.58	0.66	0.72	0.34	0.58
R^2	0.61	0.57	0.58	0.64	0.55	0.61

Notes: Dependent variable: PISA science score. Robust standard errors adjusted for clustering at the country level are in parentheses. The 95% confidence intervals provided in brackets are constructed from 10,000 simulations of partial effects. All specifications control for year fixed effects, income category, private school share, external monitoring, shortage of instruction materials, and GDP per capita. *Significance levels:* *** 1%, ** 5%, * 10%.

Table 3.3: Robustness Analyses for Mathematics

	Drop Missing (1)	OECD only (2)	Europe only (3)	Country-fixed effects (4)
<i>Panel A</i> Coefficients				
Autonomy	81.606*** (14.198)	62.571*** (11.667)	69.41*** (15.620)	43.434*** (8.521)
ρ	0.758*** (0.166)	0.472 (0.430)	0.760** (0.354)	0.158*** (0.030)
<i>Panel B</i> Partial effects				
Local	87.997 [60.9;144.8]	63.798 [46.0;97.7]	75.936 [50.0;175.9]	43.51 [51.4;84.5]
Spillover	249.904 [61.3;2813.1]	54.665 [-21.9;1130.1]	213.488 [1.3;3049.9]	8.103 [6.8;20.1]
Total	337.901 [137.6;2948.3]	118.463 [49.8;1218.3]	289.424 [78.2;3226.5]	51.614 [60.5;102.1]
<i>Panel C</i> Goodness of fit				
J -stat (df)	3.57 (8)	10.90 (7)	14.48 (7)	276.30 (8)
p -value	0.89	0.14	0.04	0.00
N (Countries)	56	35	31	56
R^2	0.64	0.65	0.55	0.98

Notes: Dependent variable: PISA mathematics score. Robust standard errors adjusted for clustering at the country level are in parentheses. The 95% confidence intervals provided in brackets are constructed from 10,000 simulations of partial effects. Standard errors in specification (4) are only heteroskedasticity-robust because the cluster-robust covariance matrix is not invertible. All specifications control for year fixed effects, income categories, private school share, external monitoring, shortage of instruction materials, and GDP per capita. *Significance levels:* *** 1%, ** 5%, * 10%.

Table 3.4: Robustness Analyses for Science

	Drop Missing (1)	OECD only (2)	Europe only (3)
<i>Panel A</i>	Coefficients		
Autonomy	78.795*** (11.769)	62.134*** (10.981)	60.804*** (13.969)
ρ	0.702*** (0.166)	0.353 (0.461)	0.894*** (0.343)
<i>Panel B</i>	Partial effects		
Local	83.445 [61.0;121.1]	62.737 [44.8;92.0]	77.059 [-22.1;149.0]
Spillover	181.314 [46.7;1733]	33.315 [-26.8;794.7]	498.302 [-2405.5;2513.8]
Total	264.760 [120.1;1853.4]	96.051 [41.9;884.6]	575.361 [-2404.6;2653.1]
<i>Panel C</i>	Goodness of fit		
J -stat (df)	3.50 (8)	5.93 (7)	12.21 (7)
p -value	0.90	0.55	0.09
N (Countries)	56	35	31
R^2	0.66	0.66	0.52

Notes: Dependent variable: PISA science score. Robust standard errors adjusted for clustering at the country level are in parentheses. The 95% confidence intervals provided in brackets are constructed from 10,000 simulations of partial effects. All specifications control for year fixed effects, income categories, private school share, external monitoring, shortage of instruction materials, and GDP per capita. *Significance levels:* *** 1%, ** 5%, * 10%.

Table 3.5: SAR Results for Alternative Spatial Matrices

	GDP per capita (1)	OECD membership (2)	Income categories (3)
Autonomy	52.847*** (10.227)	77.899*** (15.076)	79.948*** (18.862)
ρ	-8.655 (1.952)	0.601*** (0.161)	0.260 (0.216)
<i>Panel B</i>		Partial effects	
Local	65.499 [41.7;96.2]	80.462 [53.9;113.8]	80.379 [45;118]
Spillover	-60.026 [-90.2;-37.9]	114.933 [33.8;579.7]	27.685 [-13;146.1]
Total	5.473 [2.8;10.8]	195.394 [108.4;672.5]	108.064 [58.4;233.0]
<i>Panel C</i>		Goodness of fit	
<i>J</i> -stat (df)	13.73 (8)	9.48 (8)	8.93 (8)
<i>p</i> -value	0.06	0.22	0.18

Notes: Outcome variable: Reading Scores. Total number of country-year observations is 168. Robust standard errors adjusted for clustering at the country level are in parentheses. The 95% confidence intervals for partial effects provided in brackets are constructed from 10,000 simulations – see Lesage and Pace (2009) and Fischer et al. (2009). Spatial matrices in columns (2) and (3) are based on a binary OECD membership and World Bank income categories (1=high income, 2=upper-middle income, 3=lower-middle income). *Significance levels:* *** 1%, ** 5%, * 10%.

spatial matrix. The spatial matrix based on geographic distance appears to be the most viable as models based on other spatial matrices are either rejected by the data (GDP per capita) or the spatial matrix has too little variation (e.g., only two categories used in the construction of the OECD spatial matrix).

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