Online Supplementary Material

Table A1. Sample structure and regional coverage.

Country	NUTS Level	No. of Regions	Regions in the Sample	Percentage Covered
Austria	1	3	3	100.00
Belgium	1	3	3	100.00
Bulgaria	1	2	2	100.00
Croatia	2	2	2	100.00
Czech Republic	2	8	8	100.00
Denmark	2	5	5	100.00
France	1	8	8	100.00
Germany	2	39	38	97.44
Greece	2	13	13	100.00
Hungary	2	7	7	100.00
Italy	2	21	21	100.00
Netherlands	2	12	12	100.00
Poland	2	16	16	100.00
Portugal	2	7	5	71.43
Republic of Ireland	2	2	2	100.00
Romania	2	8	8	100.00
Slovak Republic	2	4	4	100.00
Spain	2	17	17	100.00
Sweden	2	8	8	100.00
United Kingdom	1	12	12	100.00
Total Sample		197	194	98.48

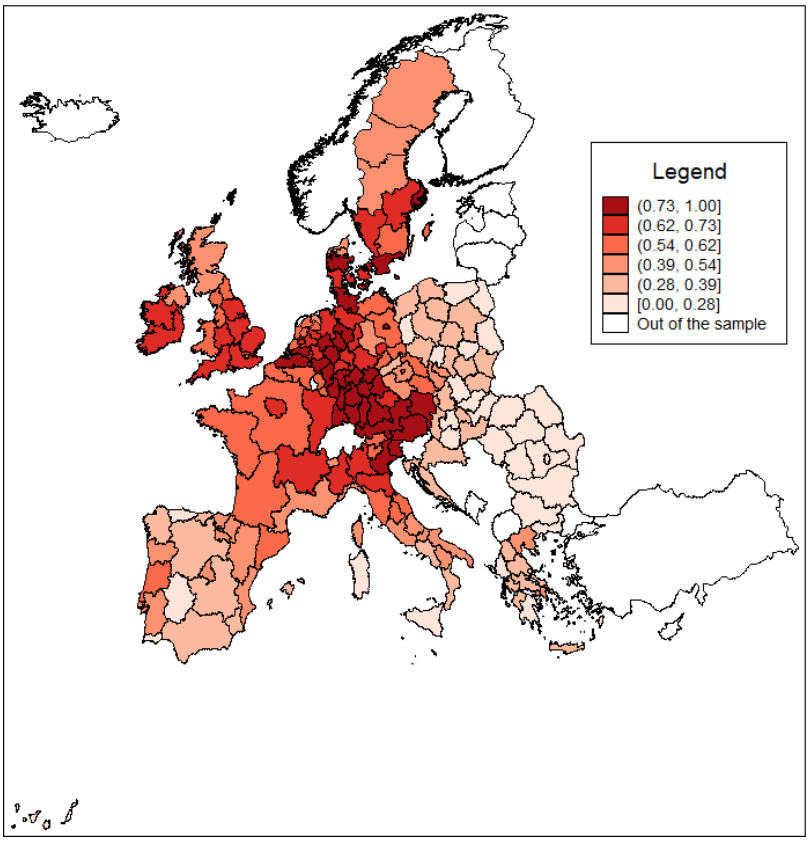
Notes: The French *Département d'Outre-Mer* and the Spanish autonomous cities of Ceuta and Melilla are excluded from the analysis *à priori*. The sample does not include the German region of Chemnitz, and the Portuguese autonomous regions of Azores and Madeira due to data unavailability.

Table A2. Estimated coefficients of the Heteroskedastic Fractional Probit Models.

Estimation Method	Heteroskedastic Fractional Probit Model				
Dependent Variable	Innovation Output$_r$				
Institutional Quality as Moderating Variable	No	No	No	No	Yes
	(1)	(2)	(3)	(4)	(5)
Innovation Input$_r$	5.365****	3.923****	2.054****	…	…
	(0.608)	(1.008)	(0.551)		
Public R&D Expenditure$_r$	…	…	…	-0.259	-0.554**
				(0.238)	(0.272)
Business R&D Expenditure$_r$	…	…	…	1.018**	-0.243
				(0.402)	(0.258)
Non-R&D Innovation Expenditure$_r$	…	…	…	0.889***	0.698***
				(0.284)	(0.232)
SMEs Collaborating for Innovation$_r$	…	…	…	0.804**	0.540
				(0.393)	(0.426)
Employment in MHTM and KIS Secors$_r$	…	…	…	0.493**	0.382***
				(0.230)	(0.138)
Scientific Publications$_r$	…	…	…	0.461*	1.292**
				(0.273)	(0.541)
Human Capital$_r$	…	…	…	-0.055	-0.130
				(0.287)	(0.203)
Lifelong Learning$_r$	…	…	…	0.337	0.036
				(0.417)	(0.516)
GDP Per Capita$_r$	…	3.738****	-0.702	-0.302	-0.036
		(1.055)	(0.430)	(0.383)	(0.185)
Unemployment Rate$_r$	…	-4.821***	-1.979***	-1.219**	-0.358*
		(1.557)	(0.623)	(0.607)	(0.188)
Employment Density$_r$	…	-1.250	1.071*	0.694	0.032
		(2.178)	(0.606)	(0.629)	(0.153)
Population$_r$	…	1.550	0.625**	0.454	0.151***
		(1.078)	(0.251)	(0.286)	(0.050)
Institutional Quality$_r$	…	1.263*	0.718**	0.554*	0.693***
		(0.720)	(0.287)	(0.316)	(0.231)
Institutional Quality$_r$ × Innovation Input:					
Public R&D Expenditure$_r$	…	…	…	…	1.051**
					(0.437)
Business R&D Expenditure$_r$	…	…	…	…	0.772
					(0.494)
Non-R&D Innovation Expenditure$_r$	…	…	…	…	-0.642**
					(0.263)
SMEs Collaborating for Innovation$_r$	…	…	…	…	-0.306
					(0.573)
Employment in MHTM and KIS Secors$_r$	…	…	…	…	-0.264
					(0.253)
Scientific Publications$_r$	…	…	…	…	-1.620**
					(0.679)
Human Capital$_r$	…	…	…	…	-0.114
					(0.233)
Lifelong Learning$_r$	…	…	…	…	0.046
					(0.734)
Country Dummies	No	No	Yes	Yes	Yes
Number of Regions	194	194	194	194	194
H_0: Homoskedastic Variance (χ^2 [p-value])	38.29 [0.000]	84.17 [0.000]	17.69 [0.007]	23.94 [0.032]	117.35 [0.000]
Log Pseudo-Likelihood	-122.24	-118.67	-117.27	-116.67	-116.43
Model Wald χ^2 [p-value]	77.74 [0.000]	38.72 [0.000]	120.48 [0.000]	75.04 [0.000]	83.19 [0.000]
Akaike Information Criterion	250.47	263.34	290.55	317.34	272.86

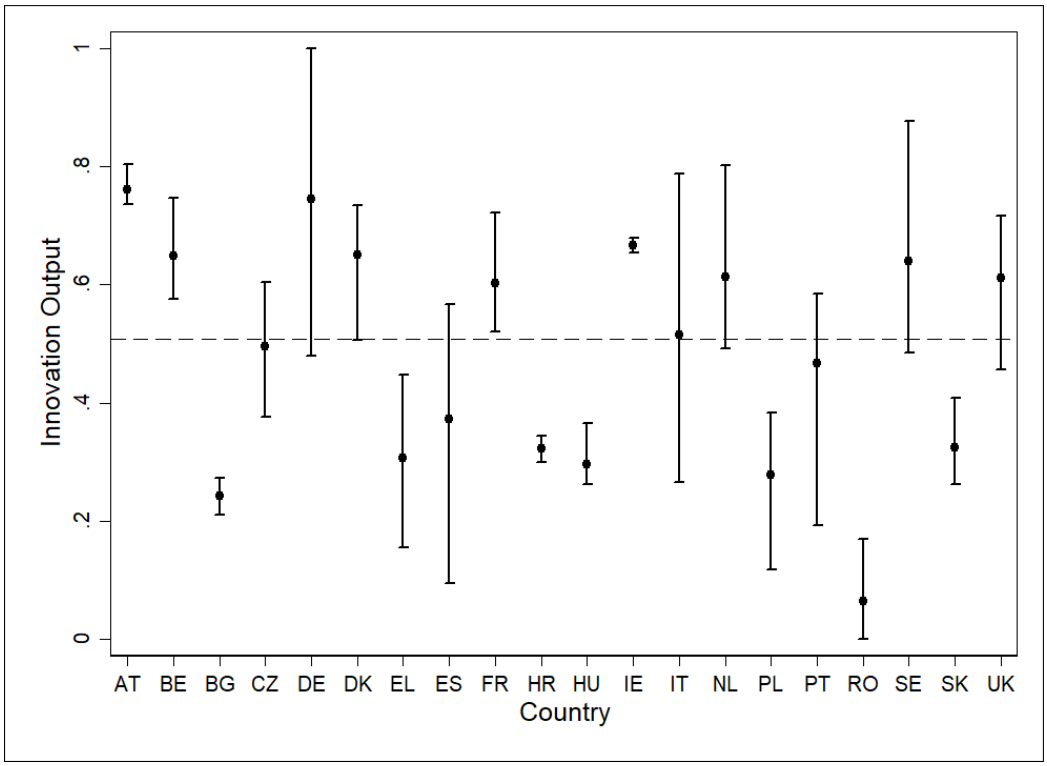
Notes: * $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$; **** $p < 0.001$. Robust standard errors in parentheses.

Figure A1. Spatial distribution of regional innovation output.



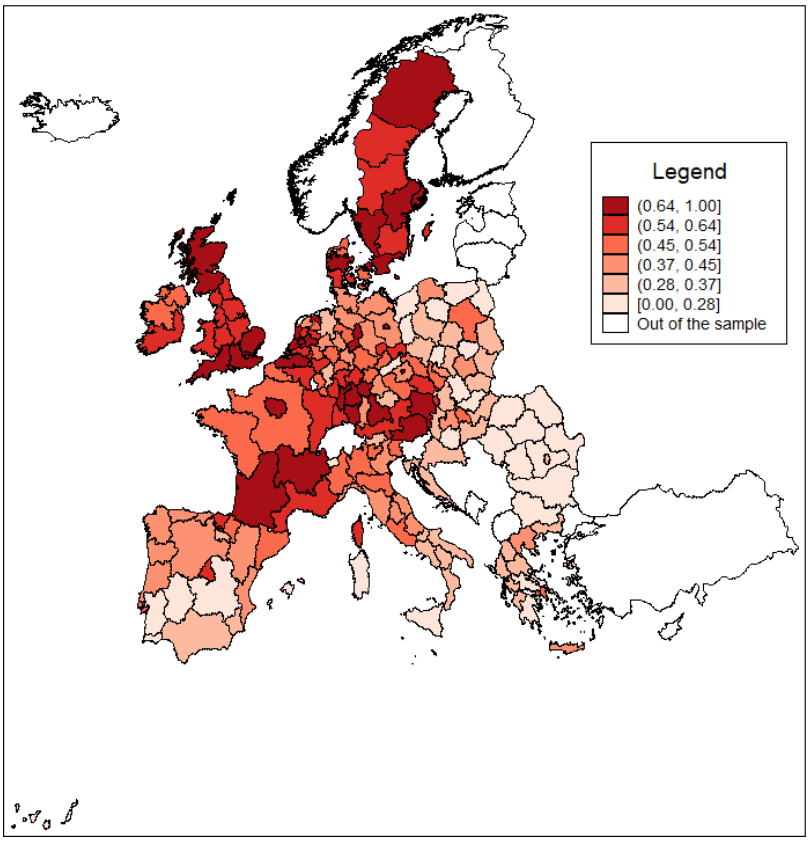
Notes: Values of the regional innovation output variable ($Innovation\ Output_r$) are normalised in the interval $[0, 1]$. Darker shades denote higher values of the variable.

Figure A2. Within-country variability of regional innovation output.



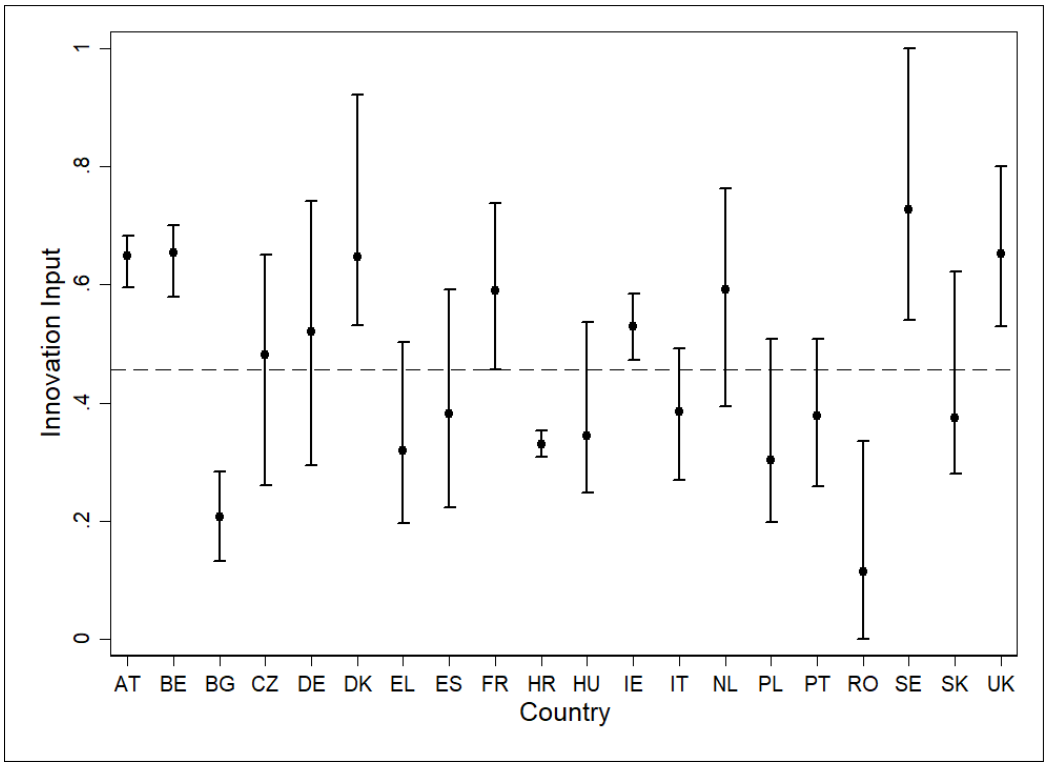
Notes: Values of the regional innovation output variable ($Innovation\ Output_r$) are normalised in the interval $[0, 1]$. The dashed line refers to the sample mean value, while the dots refer to country-level mean values.

Figure A3. Spatial distribution of regional innovation input.



Notes: Values of the regional innovation input variable ($Innovation\ Input_r$) are normalised in the interval $[0, 1]$. Darker shades denote higher values of the variable.

Figure A4. Within-country variability of regional innovation input.



Notes: Values of the regional innovation input variable ($Innovation\ Input_r$) are normalised in the interval $[0, 1]$. The dashed line refers to the sample mean value, while the dots refer to country-level mean values.

Table A3. Average marginal effects of the Heteroskedastic Fractional Probit Models removing patents and/or SMEs innovating in-house from the innovation output variable.

Estimation Method	Heteroskedastic Fractional Probit Model			
Dependent Variable	$\text{Innovation Output}_r$			
	Excluding Patents	Excluding SMEs Innovating In-House	Excluding Patents and SMEs Innovating In-House	
Institutional Quality as Moderating Variable	No	No	No	Yes
	(1)	(2)	(3)	(4)
$\text{Public R\&D Expenditure}_r$	-0.081	-0.075	-0.051	-0.003
	(0.052)	(0.075)	(0.051)	(0.058)
$\text{Business R\&D Expenditure}_r$	0.279****	0.324****	0.268***	0.263****
	(0.055)	(0.058)	(0.095)	(0.054)
$\text{Non-R\&D Innovation Expenditure}_r$	0.227****	0.212****	0.240***	0.234****
	(0.049)	(0.043)	(0.085)	(0.060)
$\text{SMEs Collaborating for Innovation}_r$	0.153**	0.146***	0.165**	0.156**
	(0.075)	(0.054)	(0.081)	(0.076)
$\text{Employment in MHTM and KIS Secors}_r$	0.155***	0.153***	0.160**	0.194***
	(0.060)	(0.048)	(0.071)	(0.068)
$\text{Scientific Publications}_r$	0.087*	0.153**	0.116*	0.129*
	(0.050)	(0.071)	(0.067)	(0.070)
Human Capital_r	0.035	-0.071	-0.006	-0.099
	(0.069)	(0.068)	(0.072)	(0.073)
$\text{Lifelong Learning}_r$	0.103	0.024	0.120	0.058
	(0.131)	(0.118)	(0.082)	(0.110)
Control Variables	Yes	Yes	Yes	Yes
Country Dummies	Yes	Yes	Yes	Yes
Number of Regions	194	194	194	194
H_0: Homoskedastic Variance (χ^2 [p-value])	25.17 [0.005]	24.98 [0.023]	31.89 [0.003]	85.40 [0.000]
Log Pseudo-Likelihood	-117.70	-116.43	-117.65	-117.34
Model Wald χ^2 [p-value]	80.14 [0.000]	68.12 [0.000]	48.45 [0.000]	32.89 [0.000]
Akaike Information Criterion	301.40	316.87	309.31	334.67

Notes: * $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$; **** $p < 0.001$. The table reports estimated average marginal effects of HFPMs. Robust standard errors in parentheses. Full tables with estimated coefficients and average marginal effects of all variables are available from the authors upon request.

Table A4. Marginal effects of innovation inputs and the moderating role of institutional quality, removing patents and/or SMEs innovating in-house from the innovation output variable.

Dependent Variable	Innovation Output$_r$ (Excluding Patents and SMEs Innovating In-House)				
Moderating Variable	Institutional Quality$_r$				
Distribution of the Moderating Variable	1st Percentile	25th Percentile	50th Percentile	75th Percentile	99th Percentile
Public R&D Expenditure$_r$	-0.306	-0.009	0.107**	0.142****	0.157****
	(0.246)	(0.110)	(0.052)	(0.022)	(0.039)
Business R&D Expenditure$_r$	0.135	0.157**	0.204**	0.253***	0.326***
	(0.117)	(0.073)	(0.083)	(0.091)	(0.109)
Non-R&D Innovation Expenditure$_r$	0.270***	0.268****	0.260**	0.241*	0.224
	(0.082)	(0.064)	(0.109)	(0.140)	(0.180)
SMEs Collaborating for Innovation$_r$	0.254**	0.195**	0.157*	0.123	0.109
	(0.122)	(0.096)	(0.089)	(0.096)	(0.170)
Employment in MHTM and KIS Secors$_r$	0.343****	0.238****	0.197***	0.186**	0.184*
	(0.093)	(0.056)	(0.061)	(0.078)	(0.105)
Scientific Publications$_r$	0.592*	0.382***	0.160	-0.005	-0.217
	(0.341)	(0.124)	(0.098)	(0.105)	(0.161)
Human Capital$_r$	-0.069	-0.133	-0.144	-0.164	-0.170
	(0.068)	(0.115)	(0.124)	(0.142)	(0.113)
Lifelong Learning$_r$	-0.058	-0.035	0.029	0.054	0.065
	(0.305)	(0.179)	(0.189)	(0.164)	(0.189)

Notes: * $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$; **** $p < 0.001$. Robust standard errors in parentheses. The table reports the estimated marginal effects of the individual innovation inputs at different percentiles of the institutional quality variable. Estimated marginal effects refer to specification (4) in Table A3 (Online Supplementary Material).

Table A5. Average marginal effects of the Heteroskedastic Fractional Probit Models controlling for local spillovers in innovation inputs.

Estimation Method	Heteroskedastic Fractional Probit Model		
Dependent Variable	Innovation Output$_r$		
Institutional Quality as Moderating Variable	No	No	Yes
	(1)	(2)	(3)
Innovation Input$_r$	0.452****	…	…
	(0.080)		
Public R&D Expenditure$_r$	…	-0.023	-0.042
		(0.068)	(0.053)
Business R&D Expenditure$_r$	…	0.207**	0.198****
		(0.094)	(0.036)
Non-R&D Innovation Expenditure$_r$	…	0.223****	0.215****
		(0.056)	(0.039)
SMEs Collaborating for Innovation$_r$	…	0.216***	0.188***
		(0.074)	(0.071)
Employment in MHTM and KIS Secors$_r$	…	0.118**	0.170****
		(0.053)	(0.046)
Scientific Publications$_r$	…	0.081	0.111*
		(0.060)	(0.060)
Human Capital$_r$	…	-0.002	-0.004
		(0.084)	(0.063)
Lifelong Learning$_r$	…	0.097	0.114
		(0.105)	(0.121)
Spatial Lag of:			
Innovation Input$_r$	0.091*	…	…
	(0.050)		
Public R&D Expenditure$_r$	…	0.020	-0.002
		(0.040)	(0.027)
Business R&D Expenditure$_r$	…	0.000	0.025
		(0.066)	(0.043)
Non-R&D Innovation Expenditure$_r$	…	-0.081	-0.050
		(0.067)	(0.068)
SMEs Collaborating for Innovation$_r$	…	0.028	-0.008
		(0.047)	(0.042)
Employment in MHTM and KIS Secors$_r$	…	0.102*	0.056
		(0.057)	(0.034)
Scientific Publications$_r$	…	0.034	0.055
		(0.066)	(0.066)
Human Capital$_r$	…	-0.049	-0.047
		(0.049)	(0.048)
Lifelong Learning$_r$	…	-0.053	-0.008
		(0.078)	(0.065)
Control Variables	Yes	Yes	Yes
Country Dummies	Yes	Yes	Yes
Number of Regions	194	194	194
H_0: Homoskedastic Variance (χ^2 [p-value])	33.59 [0.000]	29.98 [0.005]	117.77 [0.000]
Joint Significance of Spatially Lagged Variables (χ^2 [p-value])	2.89 [0.089]	5.12 [0.745]	8.55 [0.381]
Log Pseudo-Likelihood	-117.06	-116.57	-116.25
Model Wald χ^2 [p-value]	175.55 [0.000]	85.32 [0.000]	78.66 [0.000]
Akaike Information Criterion	300.11	333.14	272.51

Notes: * $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$; **** $p < 0.001$. The table reports estimated average marginal effects of HFPMs. Robust standard errors in parentheses. Spatial lags of the innovation input variables are defined using a first-order contiguity row-standardised spatial weights matrix. Full tables with estimated coefficients and average marginal effects of all variables are available from the authors upon request.

Table A6. Marginal effects of innovation inputs and the moderating role of institutional quality, controlling for local spillovers in innovation inputs.

Estimation Method	Heteroskedastic Fractional Probit Model				
Dependent Variable	$\text{Innovation Output}_r$				
Moderating Variable	$\text{Institutional Quality}_r$				
Distribution of the Moderating Variable	1st Percentile	25th Percentile	50th Percentile	75th Percentile	99th Percentile
$\text{Public R\&D Expenditure}_r$	-0.395*	-0.098	0.068	0.162****	0.277***
	(0.207)	(0.107)	(0.050)	(0.030)	(0.087)
$\text{Business R\&D Expenditure}_r$	-0.005	0.047	0.146***	0.230***	0.355***
	(0.135)	(0.072)	(0.045)	(0.074)	(0.129)
$\text{Non-R\&D Innovation Expenditure}_r$	0.399**	0.297****	0.213****	0.157**	0.082
	(0.177)	(0.063)	(0.053)	(0.063)	(0.077)
$\text{SMEs Collaborating for Innovation}_r$	0.305**	0.303**	0.250***	0.204**	0.135
	(0.135)	(0.125)	(0.090)	(0.081)	(0.128)
$\text{Employment in MHTM and KIS Secors}_r$	0.229*	0.146**	0.120**	0.115	0.115
	(0.137)	(0.058)	(0.058)	(0.092)	(0.148)
$\text{Scientific Publications}_r$	0.567**	0.370***	0.156***	-0.003	-0.225
	(0.241)	(0.121)	(0.057)	(0.067)	(0.170)
Human Capital_r	0.149	0.008	-0.064	-0.103	-0.149
	(0.096)	(0.053)	(0.066)	(0.091)	(0.130)
$\text{Lifelong Learning}_r$	-0.066	0.137	0.222	0.260	0.295
	(0.361)	(0.216)	(0.197)	(0.165)	(0.302)

Notes: * $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$; **** $p < 0.001$. Robust standard errors in parentheses. The table reports the estimated marginal effects of the individual innovation inputs at different percentiles of the institutional quality variable. Estimated marginal effects refer to specification (3) in Table A5 (Online Supplementary Material).

Table A7. Average marginal effects of the Heteroskedastic Fractional Probit Models by low vs. high institutional quality.

Estimation Method	Heteroskedastic Fractional Probit Model			
Dependent Variable	$\text{Innovation Output}_r$			
Institutional Quality Included Among Control Variables	Yes		No	
Low vs. High Institutional Quality (Median Value)	Low	High	Low	High
	(1)	(2)	(3)	(4)
$\text{Public R\&D Expenditure}_r$	-0.156**	0.104**	-0.162**	0.089**
	(0.070)	(0.046)	(0.074)	(0.045)
$\text{Business R\&D Expenditure}_r$	0.205***	0.338****	0.217***	0.344****
	(0.074)	(0.080)	(0.076)	(0.081)
$\text{Non-R\&D Innovation Expenditure}_r$	0.266****	0.071**	0.283****	0.073**
	(0.049)	(0.031)	(0.049)	(0.032)
$\text{SMEs Collaborating for Innovation}_r$	0.271***	0.020	0.277***	0.029
	(0.090)	(0.049)	(0.088)	(0.050)
$\text{Employment in MHTM and KIS Secors}_r$	0.149**	0.113	0.144**	0.115
	(0.070)	(0.080)	(0.070)	(0.087)
$\text{Scientific Publications}_r$	0.353****	-0.071	0.379****	-0.058
	(0.102)	(0.059)	(0.107)	(0.059)
Human Capital_r	0.075	-0.014	0.054	-0.036
	(0.068)	(0.072)	(0.066)	(0.079)
$\text{Lifelong Learning}_r$	0.020	-0.096	0.047	-0.067
	(0.119)	(0.071)	(0.122)	(0.064)
Control Variables	Yes	Yes	Yes	Yes
Country Dummies	Yes	Yes	Yes	Yes
Number of Regions	97	97	97	97
H_0: Homoskedastic Variance (χ^2 [p-value])	25.71 [0.001]	66.45 [0.000]	38.98 [0.000]	52.86 [0.000]
Log Pseudo-Likelihood	-57.54	-58.89	-57.55	-58.90
Model Wald χ^2 [p-value]	102.20 [0.000]	40.50 [0.000]	106.50 [0.000]	46.12 [0.000]
Akaike Information Criterion	177.08	159.78	175.10	159.80

Notes: * $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$; **** $p < 0.001$. The table reports estimated average marginal effects of HFPMs. Robust standard errors in parentheses. Regions are split around the median value of the institutional quality variable. Full tables with estimated coefficients and average marginal effects of all variables are available from the authors upon request.

Table A8. Average marginal effects of the Heteroskedastic Fractional Probit Models by low vs. high institutional quality, controlling for local spillovers in innovation inputs.

Estimation Method	Heteroskedastic Fractional Probit Model			
Dependent Variable	$\text{Innovation Output}_r$			
Institutional Quality Included Among Control Variables	Yes		No	
Low vs. High Institutional Quality (Median Value)	Low	High	Low	High
	(1)	(2)	(3)	(4)
$\text{Public R\&D Expenditure}_r$	-0.098	0.089**	-0.101	0.073***
	(0.090)	(0.041)	(0.089)	(0.022)
$\text{Business R\&D Expenditure}_r$	0.161*	0.352****	0.181**	0.362****
	(0.088)	(0.061)	(0.085)	(0.052)
$\text{Non-R\&D Innovation Expenditure}_r$	0.291****	0.118**	0.306****	0.129***
	(0.053)	(0.047)	(0.052)	(0.045)
$\text{SMEs Collaborating for Innovation}_r$	0.291***	0.079**	0.293***	0.072*
	(0.107)	(0.035)	(0.107)	(0.038)
$\text{Employment in MHTM and KIS Secors}_r$	0.182*	0.150**	0.181*	0.113
	(0.095)	(0.068)	(0.092)	(0.076)
$\text{Scientific Publications}_r$	0.321**	-0.093****	0.358**	-0.082***
	(0.139)	(0.021)	(0.143)	(0.026)
Human Capital_r	0.090	-0.010	0.057	-0.012
	(0.071)	(0.035)	(0.065)	(0.058)
$\text{Lifelong Learning}_r$	0.006	-0.163	0.033	-0.135
	(0.138)	(0.115)	(0.138)	(0.097)
Spatial Lag of:				
$\text{Public R\&D Expenditure}_r$	-0.061	0.078****	-0.050	0.072****
	(0.127)	(0.021)	(0.125)	(0.014)
$\text{Business R\&D Expenditure}_r$	0.081	0.072	0.072	0.062
	(0.070)	(0.050)	(0.072)	(0.043)
$\text{Non-R\&D Innovation Expenditure}_r$	-0.047	-0.120	-0.058	-0.122
	(0.064)	(0.078)	(0.065)	(0.075)
$\text{SMEs Collaborating for Innovation}_r$	0.029	-0.005	0.016	-0.002
	(0.084)	(0.045)	(0.077)	(0.043)
$\text{Employment in MHTM and KIS Secors}_r$	-0.007	0.052	-0.030	0.062***
	(0.052)	(0.065)	(0.049)	(0.023)
$\text{Scientific Publications}_r$	0.092	-0.009	0.094	-0.014
	(0.096)	(0.044)	(0.093)	(0.046)
Human Capital_r	-0.025	-0.048	-0.025	-0.036
	(0.061)	(0.047)	(0.063)	(0.049)
$\text{Lifelong Learning}_r$	-0.013	-0.087	0.035	-0.049
	(0.108)	(0.077)	(0.103)	(0.066)
Control Variables	Yes	Yes	Yes	Yes
Country Dummies	Yes	Yes	Yes	Yes
Number of Regions	97	97	97	97
H_0: Homoskedastic Variance (χ^2 [p-value])	20.47 [0.009]	42.33 [0.000]	30.04 [0.000]	39.10 [0.000]
Joint Significance of Spatially Lagged Variables (χ^2 [p-value])	4.40 [0.819]	103.74 [0.000]	4.93 [0.765]	121.43 [0.000]
Log Pseudo-Likelihood	-57.52	-58.80	-57.53	-58.82
Model Wald χ^2 [p-value]	126.06 [0.000]	395.88 [0.000]	130.31 [0.000]	110.77 [0.000]
Akaike Information Criterion	193.04	141.59	191.05	139.63

Notes: * $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$; **** $p < 0.001$. The table reports estimated average marginal effects of HFPMs. Robust standard errors in parentheses. Spatial lags of the innovation input variables are defined using a first-order contiguity row-standardised spatial weights matrix. Regions are split around the median value of the institutional quality variable. Full tables with estimated coefficients and average marginal effects of all variables are available from the authors upon request.

Table A9. Innovation productivity and institutional quality – Average marginal effects of the Heteroskedastic Fractional Probit Models.

Estimation Method	Fractional (Heteroskedastic) Probit Model								
Dependent Variable	Productivity of								
	Innovation Input_r	Public R&D Expenditure_r	Business R&D Expenditure_r	Non-R&D Innovation Expenditure_r	SMEs Collaborating for Innovation_r	Employment in MHTM and KIS Sectors_r	Scientific Publications_r	Human Capital_r	Lifelong Learning_r
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Institutional Quality_r	0.222**	0.186**	0.070**	0.117	0.045**	0.082**	0.055	0.174	-0.011
	(0.089)	(0.081)	(0.033)	(0.145)	(0.023)	(0.037)	(0.082)	(0.121)	(0.042)
Control Variables	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country Dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Number of Regions	194	194	194	194	194	194	194	194	194
H_0: Homoskedastic Variance (χ^2 [p-value])	26.56 [0.000]	13.59 [0.019]	69.04 [0.000]	13.03 [0.023]	61.32 [0.000]	77.90 [0.000]	29.59 [0.000]	68.37 [0.000]	10.56 [0.061]
Log Pseudo-Likelihood	-125.38	-102.03	-60.52	-112.05	-58.45	-87.96	-98.55	-97.80	-55.32
Model Wald χ^2 [p-value]	465.78 [0.000]	1,092.22 [0.000]	80.01 [0.000]	617.86 [0.000]	6.74 [0.034]	29.12 [0.000]	1,978.34 [0.000]	370.77 [0.000]	456.32 [0.000]
Akaike Information Criterion	300.76	254.06	157.05	244.10	120.89	189.91	217.10	215.60	130.63

Notes: * $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$; **** $p < 0.001$. The table reports estimated average marginal effects of HFPMs. Robust standard errors in parentheses. Full tables with estimated coefficients and marginal effects of all variables are available from the authors upon request.