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The role of regional economic diversity in shaping economic resilience: Evidence from EU regions

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Vienna, April 2026

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Economic Resilience: Evidence from EU Regions

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April 2026

The Role of Regional Economic Diversity in Shaping Economic Resilience: Evidence from EU Regions*

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Abstract

This paper examines how regional economic diversity shapes economic resilience across European regions during major crises. Using sectoral diversity indicators at the NUTS-2 level, we analyze the impact of diversity on three dimensions of resilience: the depth of economic downturns, the strength of the initial recovery, and the duration of recovery, focusing on the 2008 financial crisis and the COVID-19 pandemic. Our results show that higher economic diversity consistently mitigates the severity of economic shocks, reducing the immediate decline in regional economic activity in both crises. However, this stabilizing effect comes with a trade-off: More diversified regions tend to exhibit weaker short-term recovery dynamics and longer recovery periods. In contrast, regions characterized by higher innovation intensity and productivity-driven specialization recover more quickly. These findings highlight the importance of balancing structural diversity and innovation. While diversity enhances shock absorption, innovation and specialization appear crucial for accelerating recovery. The paper contributes to the literature on regional resilience by providing EU-wide evidence across multiple crises and offers policy-relevant insights on how structural economic characteristics shape regional responses to shocks.

Keywords: regional economics, resilience, COVID-19, Economic and financial crisis 2008

JEL codes: R11, R15, N41

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1 Introduction

This paper aims to investigate the effects of regional economic diversity on economic resilience, especially during times of crisis. We construct indicators of sectoral diversity at the NUTS-2 level for all EU-regions and analyze how these indicators correlate with the regions' ability to economically withstand or recover from the 2008 financial crisis and the COVID-19 crisis. Our results indicate that more diversified regions are more resilient to economic shocks at impact, however, they tend to recover more slowly from these shocks thereafter.

Economic resilience is still a rather new concept which still lacks a clear definition and around which the research is still in its early stages, despite the term already featuring prominently in public discourse (see for instance Martin & Sunley, 2014), . Economic resilience can be described as the ability to adapt to economic shocks and thus minimize harms during times of crisis, either by being less affected in the first place or by recovering more quickly (Wink, Kirchner, Koch, & Speda, 2015). While most authors agree that higher sectoral diversity enhances economic stability and thus resilience due to not all industries being equally affected by a crisis (see Brown & Greenbaum, 2016; Essletzbichler, 2005), there is still dispute on whether there is a trade-off with efficiency, as more specialization within a region is likely to enhance productivity and economic growth (Noor & Erickson, 2023; Shatters, Muneeppeerakul, & Lobo, 2015). While in the short-run and particularly during prosperous times, there does seem to be a trade-off between resilience and efficiency, the medium- and long-term effects are less clear, especially when considering that shocks might more easily open up new growth paths in diversified regions (J. Xiao, Boschma, & Andersson, 2018). Some researchers argue that sectoral interconnections could amplify the effects of certain crises as shocks are transmitted between sectors (Boschma, 2015; Crescenzi, Luca, & Milio, 2016).

Generally, empirical investigations of regional economic resilience more broadly, and its link to industrial diversity in particular, are still scarce and mostly focused on only one country or crisis. Much of the recent existing literature is about the United States (Chung, 2016; Fusillo, Consoli, & Quatraro, 2022; Kim, Lim, & Colletta, 2022; Park & Hewings, 2012), and most European studies only investigate the impact of diversity during the 2008 financial crisis, without comparing it to other shocks (Giannakis & Bruggeman, 2017; T. Kitsos, Grabner, & Carrascal-Incera, 2023; Wink et al., 2015). Sensier, Bristow, and Healy (2016) compare the resilience of European regions during the 2008 financial crisis to earlier shocks in the 1990s and early 2000s, however, they do not investigate its drivers. Runst, Thomä, Haverkamp, and Proeger (2021), on the other hand, specifically analyze the impact of regional economic structures that mostly rely on small enterprises

in a diverse set of industries on resilience during the COVID-19 crisis and find that more diverse regions experienced significantly lower employment losses, however, their study only covers German regions. Similar single-country studies across multiple crises also exist for Czechia (Šťastná, Ženka, & Krůčka, 2023), Great Britain (Bishop, 2018; A. Kitsos & Bishop, 2016) and China (He, Miao, & Qureshi, 2022; Hu, Li, & Dong, 2022; Wang & Wei, 2021) and find mixed results, with some crises and countries showing positive correlations between diversity and resilience while others are insignificant.

In terms of regional factors that enhance or mitigate regional shocks there is evidence that the industry structure might play a role in this respect. Park and Hewings (2012) find for a set of US states between 1980 and 2003 that the industry mix of a region causes some states to respond more rapidly to shocks than others and the the industry-mix might be a relevant source of difference in the business cycle behaviors of states. An important source of shocks stem from the national level (see for instance Chung & Hewings, 2015), however, their transmission to the regional level could be influenced by the regional industry mix, as also Chung (2016) notes.

Overall, there is still a gap in the literature regarding EU-wide regional studies across multiple crises that are recent enough to also investigate the COVID-19 crisis, where economic diversity might have been even more relevant since certain sectors experienced major downturns while others were largely unaffected or even benefitted. This paper aims to fill this gap in the literature by analysing the effects of sectoral/industrial diversity on economic resilience, defined as the ability to withstand or recover from a shock, for the 2008 financial crisis and the COVID-19 crisis across all EU NUTS-2 regions.

2 Data and Methods

As a measure for sectoral diversity we use the inverse of the Herfindahl-Hirschman-Index (HHI). The HHI in general is computed by summing the squared shares ($s_{i,j}$) of sectors in a given region i :

$$HHI_i = \sum_{j=1}^n s_{i,j}^2, \quad (1)$$

which is defined between 0 (= no concentration) and 1 (=strong concentration). This measure is commonly used to study market concentration in industries, thus a higher value of it signals a higher market concentration. In the regional context this concentration can be interpreted as

dominance of one particular sector, which indicates a strong specialization.

For the purpose of this work, we are interested in measuring the opposite of strong concentration, therefore we invert the scale of the statistic:

$$HHI_{inv} = 1 - HHI_i = 1 - \sum_{j=1}^n s_{i,j}^2 \quad (2)$$

This statistic is also defined between 0 and 1: the closer the index is to 1 the more equally distributed the shares of the sectors in a particular region i are, hence the more diverse the economic structure of this region. The closer the statistic is to 0 the more dominant are one or two sectors (stronger concentration or specialization). The summary statistics of the index for the years 2008 and 2019 are provided in table 1

	$HHI_{inv,2008}$	$HHI_{inv,2019}$
Min.	0.7105	0.5445
1st Qu.	0.8177	0.8152
Median	0.8344	0.8327
Mean	0.8291	0.8254
3rd Qu.	0.8474	0.8442
Max.	0.8708	0.8698

Table 1: Summary statistics of the inverse HHI for 2008 and 2019

The indices for both years vary between 0.54 and 0.87. The index centers around 0.83 in both years, but we find a larger spread at the low end of the distribution in 2019 compared to 2008, implying an increase in the concentration between 2008 and 2019. Figure 1 depicts the distribution of HHI-values across EU-regions in 2008 and 2019 (left panel) and the correlation between 2008 and 2019 (right panel). Despite the increase in sector concentration we nevertheless observe a similar picture for both periods.

To measure the ability to withstand economic shocks, which we refer to as resistance, we use the magnitude of the decline in output at the beginning and at the lowest point of each crisis compared to just before the crisis, largely following the methodology proposed by Sensier et al. (2016). For the strength of the recovery - the second aspect of resilience - we consider both, the duration (i.e. how long a region takes to return to or surpass its initial output levels after a crisis) and magnitude (i.e. by how much it was able to increase its output again within certain timeframes

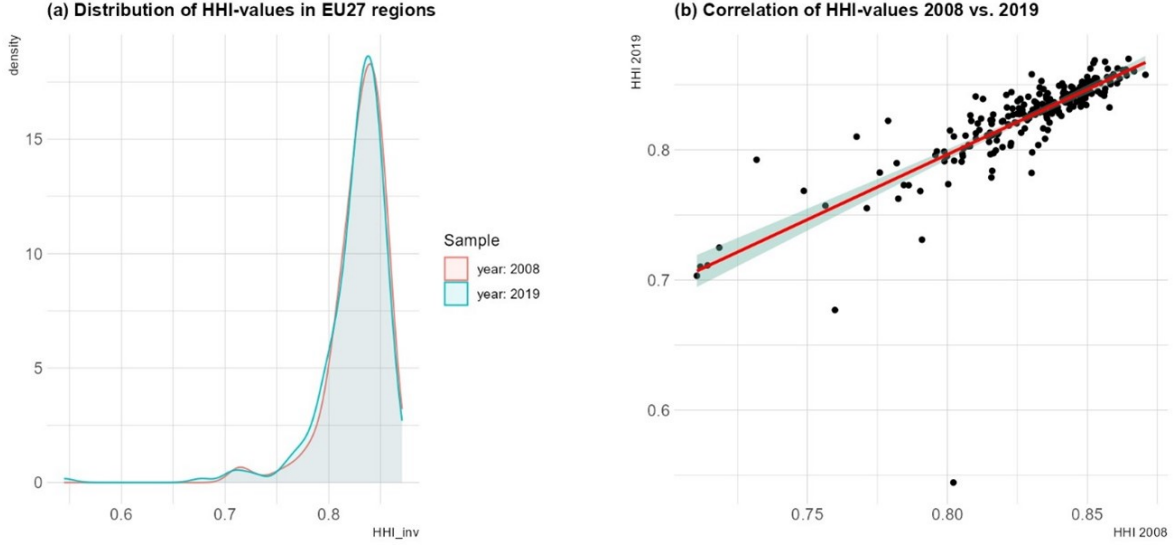


Figure 1: Distribution and correlations of HHI for the years 2008 and 2019

after the initial downturn).

For the magnitude of decline (resistance) in a crisis, we estimate

$$\Delta y_{cr,i} = \alpha + \beta * HHI_{inv,i,t-1} + \gamma X_i + \epsilon_i, \quad (3)$$

where $\Delta y_{cr,i}$ is the change in the gross value added to the lowest level in a given crisis (cr), $HHI_{inv,i,t-1}$ is the value of the inverse HHI prior to the crisis and X_i is a matrix of relevant control variables and ϵ_i is an error term of region i .

The rebound is modeled by the following two equations. Considering the rebound in the first year after the crisis we estimate

$$\Delta y_{cr+1,i} = \alpha + \beta * HHI_{inv,i,t-1} + \delta X_i + \xi_i, \quad (4)$$

where $\Delta y_{cr+1,i}$ is the change in gross value added after the lowest level in a given crisis (cr), $HHI_{inv,i,t-1}$ is the value of the inverse HHI prior to the crisis and X_i is a matrix of relevant control variables and ξ_i is an error term.

The second approach is estimating the duration of the recovery, which is done by employing a Poisson/ negative binomial regression model:

$$\log(t^*|HHI_{inv,i,t-1}) = c + \beta * HHI_{inv,i,t-1} + \delta * X_i + \nu_i, \quad (5)$$

where t^* is the number of years that gross value added of a region takes until it surpasses the precrisis level and X_i is the set of control variables.

3 Results

3.1 Recession Depth

The regression results¹ for equation (3) for both the recession of 2009 and the COVID-19 crisis are reported in table 2.

Overall, we observe a mitigating effect of economic diversity, as the coefficient of the inverse HHI appears to be positive and statistically different from zero in both crises. Apparently, in the COVID-Crisis this mitigating effect was larger than in the crisis of 2009. This might be due to measures of governments that affected certain sectors more directly, whereas the crisis of 2009 hit all sectors at once due to a decrease in final demand. In context of the 2020 crisis this implies that a more diverse economic structure played helped to cushion the economic slowdown at impact.

We controlled for the industry share in the year prior to the crisis, since a demand shock might probably hit sectors involved in trade more strongly, whereas other sectors, such as services, might experiences decreases in demand only in later stages of the crisis. In fact for the crisis in 2009, we observe a negative correlation for this variable. In the COVID crisis on the other hand, which was not driven by a slowdown in international demand in the first place, we observe a positive sign for the industry share. This means that regions with a higher industry experienced on average a milder slowdown in economic activity in the first year, as production industries were not directly affected by government measures preventing the fast spread of the pandemic.

We further controlled for productivity (alp_{t-1}) in the year prior to the crisis. However, we do not find any clear effect of this variable.

For the COVID-19 crisis, we also controlled for differences in the stringency of government regulations to prevent the spread of the pandemic in March and April 2020 (Hale et al., 2021). We observe a negative correlation with the reduction of economic activity, which was to be expected:

¹The summary statistics for all dependent variables as well as regressors can be found in table 6 and figures 2 and 3 in the appendix

Dependent Variable: $\Delta y_{cr,i}$				
	Gross Regional Product		Gross Value Added	
	2009	2020	2009	2020
α	-21.04 ^{***}	-32.71 ^{**}	-20.83 ^{***}	-30.09
	(7.602)	(14.342)	(7.863)	(18.299)
HHI_{inv}	23.58 ^{**}	46.56 ^{***}	26.66 ^{***}	42.75 ^{**}
	(9.213)	(16.427)	(9.684)	(20.641)
$ind - share_{t-1}$	-11.31 ^{***}	0.14 ^{***}	-16.66 ^{***}	0.14 ^{**}
	(3.602)	(0.048)	(3.789)	(0.066)
alp_{t-1}	0.60	-1.75	-36.77	-2.83
	(28.278)	(3.136)	(31.798)	(3.078)
stringency ₂₀		-0.27 ^{***}		-0.25 ^{***}
		(0.036)		(0.034)
R^2	0.15	0.38	0.19	0.30
n	180	209	168	208
Method	OLS	OLS	OLS	OLS

Notes: */**/** significant at the 10/5/1 percent level; heteroskedasticity robust standard errors in parentheses.

Table 2: Recession depth

the stronger the restrictions on personal interaction to prevent the spread of the crisis, the stronger the slowdown in economic activity.

Since some of our tests indicated non-normality of residuals of the estimated equations, we bootstrapped 95% confidence intervals for the equations, which are displayed in table 7 in the appendix. The results displayed show that our results remain unchanged.

3.2 Recovery

The results of the main regression for the first year rebound (equation 4) are displayed in table 3.

Dependent Variable: $\Delta y_{cr+1,i}$				
	Gross Regional Product		Gross Value Added	
	2009	2020	2009	2020
α	-11.64 (11.702)	6.82 (9.848)	-19.69** (9.939)	9.30 (9.715)
HHI_{inv}	-2.56 (13.945)	-0.57 (11.054)	7.46 (11.412)	-2.87 (11.041)
$ind - share_{t-1}$	30.56*** (4.727)	-0.09* (0.044)	29.53*** (4.898)	-0.08* (0.039)
alp_{t-1}	183.38*** (31.762)	0.54 (1.262)	168.11*** (28.714)	1.46 (1.628)
$\Delta y_{cr,i}$	-0.18* (0.097)	-0.22*** (0.062)	-0.28*** (0.097)	-0.06 (0.100)
R^2	0.41	0.15	0.42	0.09
n	168	222	168	208
Method	OLS	OLS	OLS	OLS

Notes: */**/** significant at the 10/5/1 percent level; heteroskedasticity robust standard errors in parentheses.

Table 3: 1st Rebound magnitude

For our measure of economic regional diversity, we do not observe any statistically significant coefficient. Economic diversity does not seem to be relevant in the first year after the drop in economic activity, at least in the two crises studied in this work.

The estimated industry share coefficients suggest that a higher share in production sectors appears to be relevant in the early stages of recovery, as the increase in international demand is picked up by tradeables more quickly than in most parts of the service industries.

Furthermore, for the recession of 2009, productivity seems to be an important determinant of the strength of the rebound, as it is significant and positive. Regions hosting highly productive firms therefore appear to benefit more quickly from a take-up in international demand.

In addition to the set of controls of the first equation we included the depth of the impact of the crisis as a control variable, which displays the expected sign: the deeper the reduction in economic activity, the stronger the rebound in the first place.

Again, as some of our tests indicated non-normality of residuals of the estimated equations, we bootstrapped 95% confidence intervals for the equations, which are displayed in table 8 in the appendix. The results displayed show that our results remain unchanged.

Lastly, we investigate whether structural economic diversity is associated with the length of a crisis. To this end we estimate equation (5) using a Poisson or negative binomial regression². Results are presented in table 4.

For the inverse HHI, our measure of regional diversity, we obtain ambiguous results at the regional level. For the crisis in 2009, a more diverse structure appears to be associated with a longer duration of the crisis, whereas this is not the case in the COVID-crisis. This hints at specialization advantages in overcoming the crisis of 2009, since a lower value of the HHI reflects specialization rather than diversity. Thus, once international trade picked up, regions that were more narrowly specialized experienced on average a shorter crisis.

We also accounted for the importance of the production sector ($ind - share_{t-1}$) as well as for productivity (alp_{t-1}) prior to the crisis, which both appear to be less important and display not significant coefficients.

Regarding the depth at impact ($y_{cr,i}$) and the strength of the first year rebound ($y_{cr+1,i}$) we obtain expected signs and statistically significant coefficients. In both crises, the higher the drop in economic activity as well as the stronger the rebound in the year after are associated with a shorter recovery at the regional level.

²If after running a Poisson regression tests indicated over-dispersion, we employed a negative binomial estimator, if not we used the results of the Poisson regression from the first step.

Dep. Var.: t^*	gross regional product		gross value added	
	2009ff	2020ff	2009ff	2020ff
α	-3.247** (1.529)	1.254 (1.526)	-3.735** (1.617)	1.459 (1.572)
HHI_{inv}	5.012*** (1.717)	-0.592 (1.753)	5.222*** (1.802)	-1.052 (1.800)
$ind - share_{t-1}$	1.033 (0.997)	0.000 (0.007)	1.445 (1.086)	-0.001 (0.007)
alp_{t-1}	-0.748 (5.637)	0.000 (0.213)	1.799 (6.210)	-0.005 (0.239)
$\Delta y_{cr,i}$	-0.117*** (0.017)	-0.078*** (0.015)	-0.133*** (0.018)	-0.087*** (0.015)
$\Delta y_{cr+1,i}$	-0.165*** (0.018)	-0.104*** (0.016)	-0.166*** (0.019)	-0.097*** (0.017)
θ	7.63	-	6.77	-
<i>obs.</i>	176	164	222	208
Method	neg. binomial	Poisson	neg. binomial	Poisson

Notes: standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1

Table 4: Crisis length in 2009ff and 2020ff

4 Discussion

4.1 Diversity and Resilience

The results imply that to better withstand future crises, European regions should aim to diversify their economic bases and promote sectoral interconnections rather than only specializing in very narrow industries, even if it implies a short-term trade-off with economic growth. However, the exact relationship between diversity and resilience depends on the definition of resilience, as well as on the nature of the crisis. While more structural variety lessened the depth of recessions across all our models, the effect on recovery duration seems to be either insignificant or implying that more specialized regions might actually be able to experience a stronger rebound immediately after the

crisis. Our results thus confirm the findings of other authors that there may be trade-offs between resilience and efficiency, or between different types of resilience (Noor & Erickson, 2023; Shutters et al., 2015).

We tested our models on an economic and financial crisis and a health crisis. Other events, such as natural disasters, energy price shocks, trade or military conflicts, have potentially other economic effects and require potentially different capabilities for mitigation. However, all these crises affect certain sectors more than others, and thus the general trend that regions that perform well in a range of activities can adapt more easily is likely to hold. Other studies have shown that this is not only the case for economic output as a measure of resilience, but also for employment (T. Kitsos et al., 2023). Regarding the different types of crises, Y. Xiao and Drucker (2014) show for the United States that structural diversity also enhanced resilience to natural disasters, and Štastná et al. (2023), who investigated five different crises in Czechia, found positive effects of diversity for some but not all shocks.

Furthermore, regional economic diversity can also be defined differently, e.g. with respect to economic interactions with other regions through import and export relationships as well as interactions between regions through global value chains (GVCs). Bolea, Duarte, Hewings, Jiménez, and Sánchez-Chóliz (2022) explore the role of European regions in global value chains. They argue that dependencies between regions have increased in the recent decade and that intra-industry trade has become more dominant, also at the regional level. Thus, inter-regional dependencies have increased and the role of regions in GVCs has become more important. In other words, economic diversity could also be defined in terms of the role of a region in value chains and the importance of specific regions or an equal distribution (i.e. diversity) across many regions in trade. However, international inter-regional input-output tables are scarce, the most recent one for European regions was published for the years 2000 - 2010 only recently (European Commission, 2020).

4.2 Related vs. Unrelated diversity

Although diversity generally seems to enhance economic resilience, the type of diversification matters: Related diversity tends to be most beneficial for efficiency and innovation, having only variety in highly interdependent sectors is unlikely to boost resilience, as it could instead lead to a domino effect in which a crisis in one sector spills over to the others (Chen, Li, & Zhu, 2023). T. Kitsos et al. (2023) found an inverted U-shaped relationship between industrial embeddedness and resilience, implying that regions with a medium level of related variety tended to be most resistant to the

2008 crisis.

Too much of or the wrong kind of related variety seems to be what mattered in the southern and western EU regions during the 2008 crisis, which previously performed well in a range of industries that were all interconnected with tourism and real estate, both of which were hit hard by the crisis and then dragged the other sectors down with them. Thus, to improve resilience, regions should aim to build both related and unrelated variety and promote complementarities while trying to avoid total reliance of one sector on another (He et al., 2022). Diversified exports can help reach this goal since the global market is more likely to be able to counterbalance shocks and it is less likely that the demand for whole sectors collapses on a global scale than in individual countries (Markakkaran & Sridharan, 2022).

Despite the importance of unrelated diversification for resilience, it is often much harder to achieve and maintain since regions are more likely to branch into industries that are technologically close to their existing comparative advantage (Neffke, Henning, & Boschma, 2011). Boschma and Capone (2015) argue that this is especially true for coordinated market economies, while liberal market economies are more likely to also diversify into unrelated industries due to their institutional framework giving them more freedom and possibilities to do so. Nonetheless, the right kind of related variety can also be highly beneficial to resilience; Asheim, Grillitsch, and Trippel (2016) for example argue in favor of “smart specialization” industrial policies, which they define as “*diversified’ specialization into areas of existing or potential competitive advantage*” (p. 2). This can include enhancing firms’ research competencies and combining both related and unrelated knowledge bases to move into unrelated and new but related sectors in a region. So, although smart specialization generally builds on existing capabilities, they are also utilized to branch into entirely new industries. Balland, Boschma, Crespo, and Rigby (2019) state that regions producing highly specialized products often possess a wider set of capabilities because the niches they are specialized in tend to be quite complex. Thus, despite seemingly focusing on a narrow product mix, those regions have significant related diversity in skills, which can be quickly adapted toward new uses in times of crisis. Balland and Boschma (2021a) additionally highlight the importance of inter-regional linkages for diversification, on top of strong regional capabilities. Those inter-regional connections are particularly beneficial if they provide access to complementary capabilities that are not present in the region itself but related to existing comparative advantages. This scenario also makes it most likely for a region to develop new technologies, which will again be related to both existing regional technologies and complementary inter-regional linkages.

4.3 Links to innovation and technological progress

Generally, innovative and high value-added sectors seem to be both most productive in non-crisis times and most resilient to a range of shocks (Bristow & Healy, 2018). Filippetti, Gkotsis, Vezzani, and Zinilli (2020) show that European NUTS-2 regions with high innovation activity tended to have fewer employment losses both during and after the crisis of 2009. More technologically diversified regions – holding overall innovation performance constant – performed better during the crisis, however, there was no difference in the recovery, which is in line with our ambiguous and often insignificant results for recovery duration.

To also account for innovation and economic diversity during a crisis, we augment equations (3) - (5) by the average number of regional 1,000 patents per capita³ registered in the five years before the crisis of 2009 as a measure for innovation. The results are displayed in table 5.

Adding regional patent activity does not qualitatively change the regressions previously obtained. Again, as previously seen, the coefficient of HHI_{inv} is positively related to the depth of the crisis. Furthermore, a higher degree of diversity tends to extend the duration of the crisis, pointing to advantages of specialisation. On the other hand, patenting activity is positively related (but not significant) to rebound magnitude and correlates negatively with the length of the crisis. In other words, whereas regional diversity can help dampen the impact of the crisis, innovation activity in a region can help speed up the recovery, which points at the mix of the two as potentially strengthening regional resilience best.

Muštra, Šimundić, and Kuliš (2020) further highlights the importance of smart specialization, while Clark, Huang, and Walsh (2010) found that especially regions with many innovative small firms perform well on a range of indicators, including income and resilience.

Urban centers tend to be both more diversified and more resilient than rural areas owing to the greater availability of skilled human resources and proximity to efficient infrastructure and supply networks, which can also be inferred from our robustness checks without capital regions (see Appendix). Camagni, Diappi, and Leonardi (2017) argue that among urban agglomerations, those which are more diversified tend to be more competitive and innovative than highly oligopolistic cities and can more easily advance to new stages of development during times of crisis as well as prosperity. Camagni and Capello (2017) then continue to highlight the importance of a “smart innovation” strategy for both rural and urban areas, which uses the concepts of “embeddedness”

³Data were obtained from the REGPAT database of the OECD. See Maraut et al. (2008) for details on the construction of the database.

Dep. Var.:	gross regional product			gross value added		
	$y_{cr,i}$	$y_{cr+1,i}$	t^*	$y_{cr,i}$	$y_{cr+1,i}$	t^*
α	-21.875*** (7.511)	-8.832 (11.785)	-2.958** (1.468)	-21.922*** (7.926)	-17.803* (9.472)	-3.429** (1.560)
HHI_{inv}	23.990** (9.315)	-4.424 (14.584)	4.405*** (1.655)	27.398*** (10.113)	6.871 (11.114)	4.605*** (1.746)
$ind-share_{t-1}$	-10.629*** (3.760)	28.591*** (5.003)	1.290 (0.977)	-15.997*** (3.979)	27.531*** (5.021)	1.681 (1.065)
alp_{t-1}	13.616 (36.023)	153.477*** (47.703)	7.033 (6.277)	-24.168 (41.793)	131.425*** (41.953)	9.498 (6.877)
$\Delta y_{cr,i}$		-0.123 (0.086)	-0.115*** (0.017)		-0.224** (0.091)	-0.131*** (0.018)
$\Delta y_{cr+1,i}$			-0.154*** (0.018)			-0.156*** (0.019)
pat p.c.	-2.207 (4.723)	9.714 (8.446)	-2.785** (1.201)	-1.843 (5.447)	11.661 (9.040)	-2.740** (1.278)
R^2	0.17	0.44	-	0.21	0.45	-
n	176	176	176	164	164	164
Method	OLS	OLS	neg. bin.	OLS	OLS	neg. bin.

Notes: standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1; OLS: Heterosekdsticity robust s.e.

Table 5: Patent activity and resilience

and “connectedness” to design targeted policies that can reinforce existing regional innovation processes and enhance diversification into related technological sectors. They group European regions into different categories depending on their current innovation patterns and argue that economic returns to R&D investment increase with the extent and sophistication of a region’s innovativeness. If true, this could make it difficult for less innovative regions to improve since their returns on R&D are currently low and raising it might therefore seem unattractive. However, it would greatly benefit them in the long run.

Innovation is not only directly related to resilience but also indirectly through diversity. Asheim et al. (2016) for example describe innovation as a key factor in promoting economic diversification

and increasing competitiveness, and Balland and Boschma (2021b) show that innovative European regions at the technology frontier are most likely to successfully diversify into new Industry 4.0-related technologies.

5 Conclusion

This paper examines the impact of regional economic diversity on economic resilience, with a specific focus on responses to two recent global crises. Using sectoral diversity indicators at the NUTS-2 level, we analyze how these measures correlate with regional resilience during the 2008 financial crisis and the COVID-19 pandemic. Regional resilience is assessed through three dimensions: the depth of the crisis, the strength of the initial recovery, and the duration of the recovery.

Our findings reveal a nuanced relationship between economic diversity and resilience. Across both crises, higher regional economic diversity consistently mitigated the depth of the downturn, cushioning the immediate economic impact. However, this diversity also moderated the magnitude of the first rebound, suggesting a trade-off between initial shock absorption and recovery momentum. Regarding recovery duration, the effects of diversity varied: it did not play a significant role in accelerating recovery during the COVID-19 pandemic but slowed down the recovery during the crisis in 2009, pointing to advantages of specialization for the length of crises.

The analysis further integrates measures of innovation to capture the interplay between diversity, innovation, and specialization. The results highlight that while diversity mitigates crisis severity, regions with higher levels of innovation and productivity-driven specialization experience faster recoveries. These findings suggest that fostering a balanced approach—leveraging diversity to absorb shocks while promoting innovation and productivity for recovery—can enhance regional economic resilience. This study contributes to the literature by providing empirical insights into how structural factors, such as diversity and innovation, shape regional responses to economic shocks, offering valuable implications for regional policy.

Whereas we restrict our analysis to regional diversity stemming from the industry-mix of regions, other forms of regional diversity might be important suggesting promising avenues for future research. These can be related to inter-regional trade between regions (either directly or through global value chains), where diversity stems from the number of trading partners or the position in global value chains (central vs. non-central). Furthermore, the technological specialization or diversification might be another source of regional economic diversity that might play a role related

to resilience of those regions. Third, related versus unrelated regional diversity might be a relevant factor that influences resilience of regions.

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Appendix

Statistic	HHI_{inv}	$alpt_{t-1}$	$\Delta y_{cr,i}$		$\Delta y_{cr+1,i}$		t^*	1,000 patents per cap.		ind_shares_{2008}
			GRP*	GVA**	GRP*	GVA**		GVA**	overall	
Min.	0.71	0.01	-16.33	-16.31	-8.66	-8.87	1	0	0	0.14
1st Qu.	0.82	0.03	-6.05	-6.18	0.27	0	2	1	0	0.26
Median	0.84	0.04	-4.31	-4.13	2.29	1.97	2.5	2	0.02	0.3
Mean	0.83	0.03	-4.87	-4.58	2.17	1.95	4.81	4.44	0.05	0.3
3rd Qu.	0.85	0.04	-3.11	-2.57	3.9	3.89	9	8	0.07	0.34
Max.	0.87	0.07	-0.11	0.57	17.67	12.29	10	10	0.43	0.49
crisis of 2009										
COVID-19 crisis										
Min.	0.7	0	-23.15	-32.94	-5.65	-6.03	1	0	-	0.93
1st Qu.	0.82	0.02	-8.31	-7.88	4.39	4.09	1	1	-	11.82
Median	0.83	0.04	-5.06	-5.05	5.84	6.01	2	2	-	16.74
Mean	0.83	0.08	-6	-5.8	6.18	5.92	1.93	1.78	-	17.25
3rd Qu.	0.84	0.05	-3.22	-3.13	7.68	7.54	2	2	-	22.87
Max.	0.87	2.8	-0.09	0.95	27.95	18.96	4	4	-	38.82
NA's	7	7	7	21	7	21	7	21	-	7

Notes:* gross regional product; ** gross value added; only observation included that experienced a drop in economic activity in 2009 and 2020 respectively.

Table 6: Summary statistics of the main variables

Pairwise Correlation Plot of relevant control variables 2009

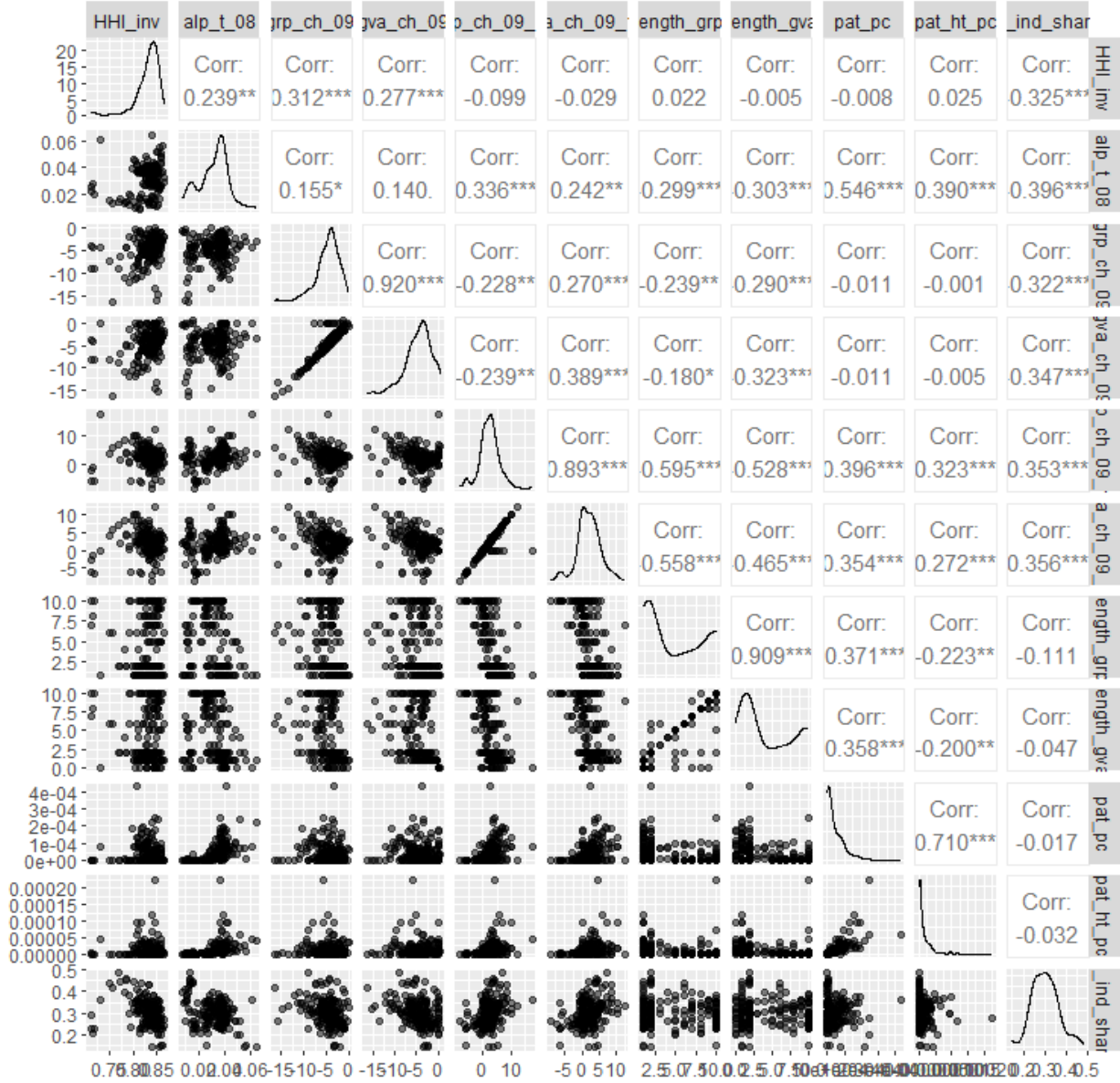


Figure 2: Correlation of main variable crisis of 2009

Pairwise Correlation Plot of relevant control variables 2020

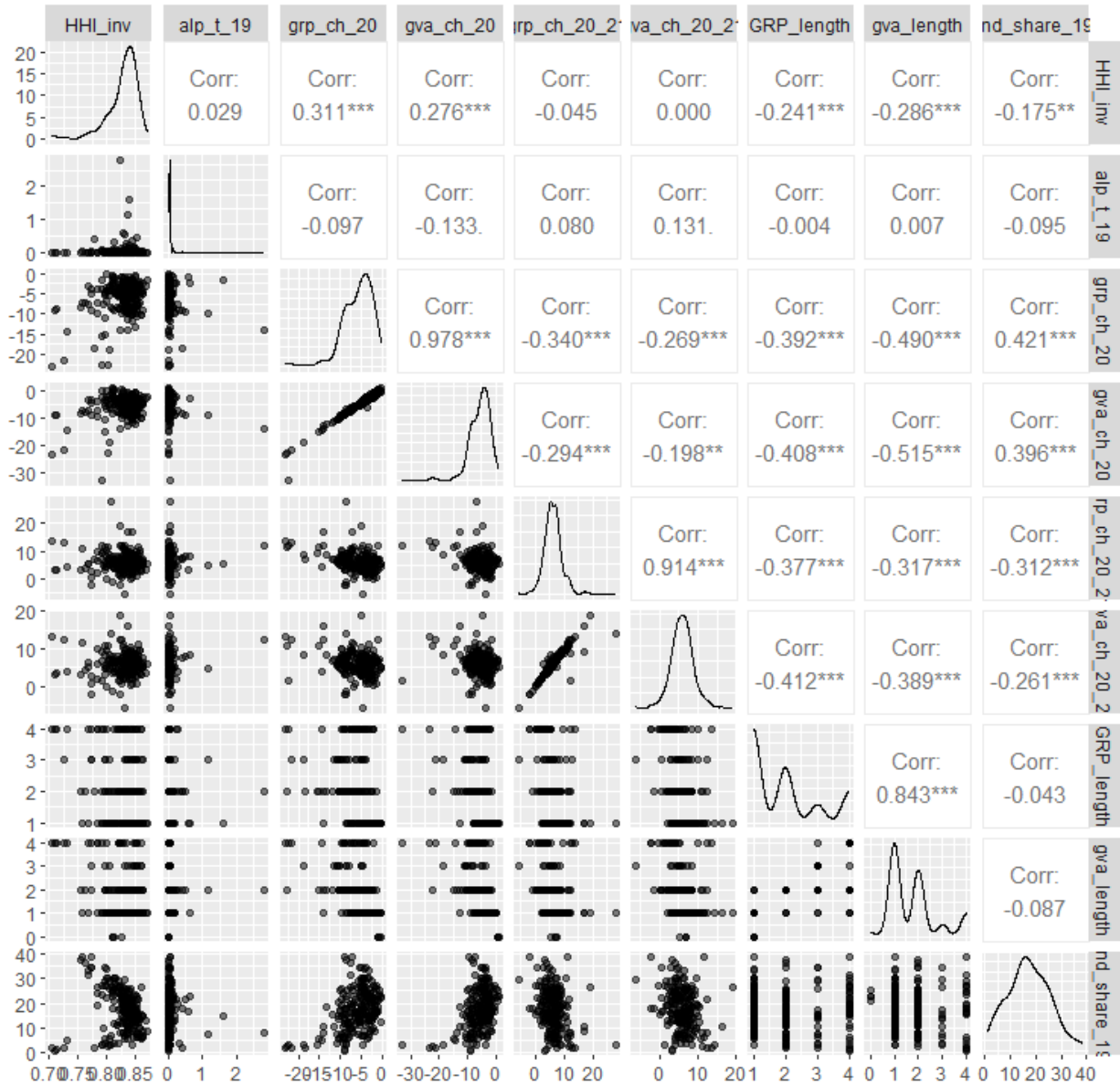


Figure 3: Correlation of main variable crisis of 2020

	Gross Regional Product			Gross Value Added		
	2.5%	Median	97.5%	2.5%	Median	97.5%
2009						
α	-37.90	-21.86	-8.13	-37.35	-21.00	-6.82
HHI_{inv}	7.31	24.29	43.17	8.61	26.75	46.97
$ind - share_{t-1}$	-17.13	-11.10	-4.20	-24.23	-16.21	-9.66
alp_{t-1}	-49.81	2.66	56.76	-89.81	-32.87	25.23
2020						
α	-62.65	-31.83	-10.87	-75.26	-28.38	-2.03
HHI_{inv}	22.81	45.90	82.21	11.47	41.29	95.77
$ind - share_{t-1}$	0.06	0.14	0.24	0.04	0.13	0.29
alp_{t-1}	-3.81	-1.48	2.60	-3.99	-2.66	1.85
stringency ₂₀	-0.34	-0.27	-0.21	-0.32	-0.26	-0.20

Note: 2.5th, median, 97.5th percentiles displayed

Table 7: Bootstrap confidence intervals of results in table (2)

	Gross Regional Product			Gross Value Added		
	2.5%	Median	97.5%	2.5%	Median	97.5%
2009						
α	-30.19	-11.70	13.87	-35.24	-19.18	2.95
HHI_{inv}	-30.66	-2.70	19.59	-17.75	6.92	26.13
$ind - share_{t-1}$	20.41	30.31	38.69	19.04	29.13	37.59
alp_{t-1}	122.83	180.93	235.75	111.94	168.01	218.85
$\Delta y_{cr,i}$	-0.37	-0.18	0.00	-0.46	-0.28	-0.10
2020						
α	-8.23	6.92	28.44	-5.43	9.00	28.80
HHI_{inv}	-24.71	-0.61	16.75	-24.30	-2.62	13.74
$ind - share_{t-1}$	-0.18	-0.09	-0.01	-0.16	-0.09	-0.01
alp_{t-1}	-2.58	0.45	1.46	-2.24	1.34	3.82
$\Delta y_{cr,i}$	-0.32	-0.21	-0.10	-0.24	-0.07	0.09

Note: 2.5th, median, 97.5th percentiles displayed

Table 8: Bootstrap confidence intervals of results in table (3)