

# Resilient Regional Labour Markets as Triggers of Innovation Success during Crises: Perspective of EU Innovation Leaders

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**Abstract:** Despite the growing interest in the impact of economic crises on regional labour markets, innovation, and regional resilience, the relationship between these economic aspects remains under-researched in the context of these crises. This research aims to fill this gap by investigating how regional labour markets affect the innovation success of European Union countries. We focus on analysing the impact of female and youth unemployment, labour costs, and hours worked on the innovation success of 22 European Union countries over the period 2013–2021, with a special focus on countries identified as innovation leaders in the European Union. Using regression analysis, we find that higher female unemployment and lower hours worked have a positive effect on innovation success. Higher labour costs then have a negative impact on innovation success in the European Union but are not significant for the innovation leaders' success, providing new insights into the complex relationship between the labour market and innovation success. Through a Difference-in-Differences analysis, we additionally demonstrate that there is a causal effect, revealing a greater decline in innovation success among innovation leaders with the advent of the COVID-19 pandemic compared to the remaining (control) 18 European states. The study further highlights the critical role of targeted social and employment policies in enhancing innovation performance,

emphasising the need for tailored strategies to support vulnerable labour market groups, and provides directions for future research to explore these dynamics in greater depth.

**Keywords:** *crisis, innovation, labour market, regional resilience, unemployment*

## 1. Introduction

European countries and their economies have experienced significant uncertainty over the past fifteen years. The global financial crisis that spilled over from the United States to Europe in 2008 immediately began to spread through European countries (Fratesi & Perucca, 2018), foreshadowing the most severe economic downturn in the history of the European Union (Koikkalainen, 2017; Bristow & Healy, 2018). The severe impacts of the financial crisis, while varying from country to country, have provided researchers with new insights into the factors that help countries and individual regions withstand, respond to, and recover from the effects of recession in a timely manner. These needs have led to the development of new conceptual frameworks for understanding crisis phenomena and measures to mitigate their impact. The concept of regional resilience can be viewed as an imaginary conceptual umbrella designed to address and prevent these phenomena (Martin & Sunley, 2015). In the context of regional resilience, it is crucial to understand that each crisis presents unique challenges to which individual regions must respond. Thus, regional resilience and associated vulnerability have become key topics for scholars. However, there is a need for caution, as regions that have demonstrated high resilience in the past may not necessarily be resilient in upcoming crises (Pitoyo *et al.*, 2021). Each crisis differs in its causes, the factors that influence it, and the consequences it brings.

Regions try to respond adequately to individual negative events or to minimise their economic and social impact. To a greater extent, they are doing so successfully, increasing their regional resilience over time. This positive trend has been particularly evident in Western and Northern Europe in recent years. In addition, these countries could be expected to be in the best possible position to make their economies productive in the long term. However, empirical findings in recent years reveal paradoxical trends, indicating that higher regional resilience does not necessarily imply higher

economic growth in different areas of the economy. For example, although empirical evidence has clearly shown that innovation is an important determinant of regional resilience during economic crises (Bristow & Healy, 2018; Filippetti *et al.*, 2020), there is a paradoxical trend for countries that can be considered European innovation leaders: despite their already high and growing regional resilience, their innovation success may gradually decline. This decline may be due to, among other things, the long-term and gradual effects of the crisis. This situation suggests that the factors influencing innovation and (simultaneously) regional resilience are interlinked and far more complex than they may initially appear. Therefore, further research and, above all, discussion on the choice of appropriate indicators are needed to fully understand the link between economic resilience and innovation success of regions during crises.

Regional labour markets are seen as a key aspect that speaks to both innovation and regional resilience, serving both as a mirror and an engine of innovation and regional resilience (Moro *et al.*, 2021). Just as innovation shapes jobs and skills, the labour market influences how effectively innovation can be applied and used for regional resilience. To the best of our knowledge, few studies have examined this particular trend, especially during crises. Our objective is to demonstrate selected relationships between regional labour markets and innovation in times of crisis, both at the level of innovation leaders and at the level of (almost) the entire EU. Therefore, our motivation is to investigate this trend using selected indicators from labour market and to assess their impact on the innovation success of the abovementioned group of countries. The results of our research are mainly methodological and can be divided into three parts. The first contribution relates to the impact on the so-called vulnerable groups in times of crisis—women and young people. The results show that female unemployment during the crisis is more strongly affected than youth unemployment. Despite being traditionally considered a highly vulnerable group, youth unemployment is virtually unaffected during crisis. The second contribution concerns the hours worked, where the results show that an increase in hours worked during the crisis negatively affects a region's innovation success and its economic resilience. The third contribution demonstrates a causal relationship regarding the decline in innovation success following the onset of the COVID-19 pandemic, with a more pronounced effect among innovation leaders than in the remaining (control) 18 European countries.

This article is structured as follows. Section 2 presents the latest findings from the existing literature and outlines the hypothesis development;

Section 3 briefly describes the methodology used; Section 4 presents the results of our research, which are then discussed in more detail in Section 5. Section 6 presents the conclusions, including theoretical and practical implications, research limitations, and proposals for future research.

## 2. Literature review and hypothesis development

The occurrence of many different crises in recent years has led to increased interest in the concept of regional resilience (Modica & Reggiani, 2015; Di Caro & Fratesi, 2018; Hu, Li & Dong, 2022). In this regard, many scholars (e.g., Sensier, Bristow & Healy, 2016; Di Caro & Fratesi, 2018; Hu, Li & Dong, 2022) have started to intensively address questions related to differences in regional resilience during different crises. Although interest in regional resilience is increasing, there are still shortcomings in its definition (Davies, 2011; Modica & Reggiani, 2015) and a possible risk that the concept may inadvertently serve as a tool to preserve existing structures, thereby creating resistance to change (Christopherson, Michie & Tyler, 2010). In the future, such a concept can significantly constrain innovation and sustainable development. In addition to a skilled workforce, industrial structure, or financial system stability (Christopherson, Michie & Tyler, 2010; Wang & Li, 2022), innovation is another important determinant of regional resilience (Bristow & Healy, 2018; Filippetti *et al.*, 2020; Wang & Li, 2022). It is equally important to recognise that a skilled workforce, industrial structure, and financial system stability have a significant impact on innovation itself.

Innovative regions are characterised by a higher concentration of scientific research activities as well as a more educated workforce (Felsenstein, 2015; Lubacha-Sember, 2021; Martinidis *et al.*, 2021). A sign of resilient regions is precisely their ability to retain their workforce in innovation-intensive industries. Here, the importance of an efficient and sustainable financing system comes into play (Jugend *et al.*, 2020; Lubacha-Sember, 2021). High-quality financing mechanisms allow firms to both secure the necessary resources to pay for and retain a highly skilled workforce. This factor is particularly relevant in times of crisis when firms are cutting back on production. While developing the individual hypotheses, we focused more closely on selected aspects of regional labour markets—namely, female unemployment, unit labour costs, and hours worked, and their potential relationship to innovation success.

Research carried out in Germany between 1999 and 2005 (Buerger, Broekel & Coad, 2012), in Spain in 1998–2015 (Triguero-Ocaña *et al.*, 2020), and in France in 2009–2015 (Duhautois *et al.*, 2022) has clearly shown that innovation-rich regions manage to retain existing employees even during times of crisis. In other words, a positive relationship between innovation support and resilient labour markets has been confirmed through lower unemployment rates. Matuzeviciute, Butkus and Karaliute (2017) have also contributed to this issue by investigating whether (specific) technological innovations affect unemployment using panel data from 25 European countries over the period 2000–2012. It was shown that technological innovation does indeed have a significant effect on regional unemployment, albeit with a time lag following the onset of the crisis. All of these studies focused on the period before, during, and after the economic crisis, respectively, when rise in unemployment was mainly driven by increases in youth (Zieliński, 2015; Roos & Zaun, 2016; Krasnopjorovs, 2020) and female unemployment (Zieliński, 2015; Green, Henseke & Vignoles, 2017). From a regional resilience perspective, both groups can be considered at risk (Doran & Fingleton, 2016; Krasnopjorovs, 2020; Borsekova & Korony, 2022; or Wahyudi, Yogya & Amrillah, 2023).

In relation to innovation, a logical question arises: what role does innovation play in the potential unemployment of these at-risk groups? It has been confirmed that European regions characterised by a higher share of knowledge and research economy (innovation leaders) are more effective in reducing unemployment, especially youth unemployment (Moutinho *et al.*, 2015; Bal-Domańska & Sobczak, 2019; or Bosna, 2022). A similar trend could be expected for female unemployment, but a sufficient body of empirical evidence of this relationship during crisis periods is lacking in the current literature. Collins (2020) offers one possible explanation for the lower productivity in science and research during the COVID-19 pandemic, particularly among women. This vulnerable group, especially in the early stages of the pandemic, had to balance paid work with caregiving responsibilities (for children, parents, etc.), which in some cases led to their leaving jobs and ultimately a decline in innovative activity. A similar long-term trend can be observed, particularly in professions with significant gender disparities (Görkey, 2022). Therefore, we propose the following hypothesis:

*H1: Female unemployment negatively influences innovation success within a region during crises.*

The resilience of regional labour markets has also faced other challenges since the financial crisis, including rising labour costs (Bernoth & Colavecchio, 2014; Li *et al.*, 2020; García-Vega, Kneller & Stiebale, 2021). However, recent research has shown that the relationship between rising labour costs and innovation success is not entirely straightforward. For example, in China during the 2005–2016 crisis period, higher labour costs induced a positive innovation stimulus (Li *et al.*, 2020). This experience suggests that higher labour costs indeed motivate firms to invest in new technologies. However, this trend was more evident for non-state firms over the period, as well as for firms with lower labour productivity. On the other hand, in some European countries an opposite trend was observed during the crisis. Specifically, this was the case in the period 2002–2008 in 17 countries of Central and Eastern Europe (Bernoth & Colavecchio, 2014), including Spain, as confirmed by García-Vega, Kneller and Stiebale (2021) for the crisis period 2007–2011. These ambiguous findings call for the need for further investigation, and in the context of European countries, we propose the following hypothesis:

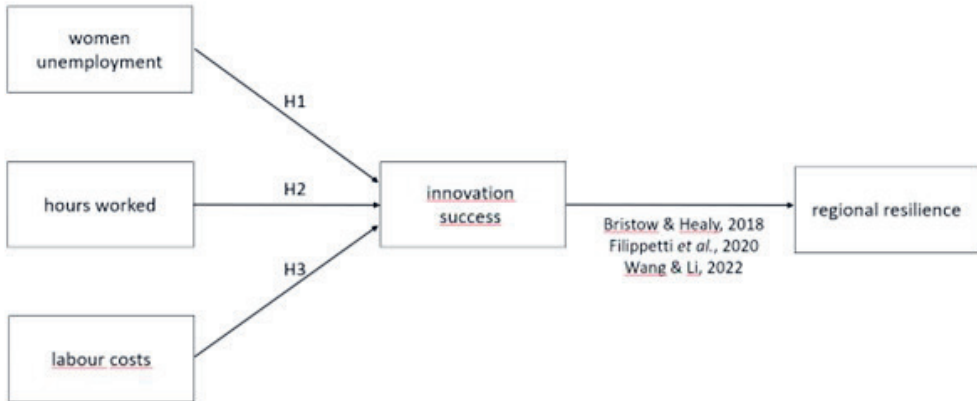
*H2: Labour costs negatively influence innovation success within a region during crises.*

In the context of studies focusing on the relationship between innovation and regional labour markets in times of crisis, a certain contradiction between innovation success and the number of hours worked cannot be overlooked. Although the implementation of industrial robots, as a result of innovation efforts, increased significantly in EU countries during the period before the financial crisis (1993–2007), it did not have a statistically significant effect on total working hours (Graetz & Michaels, 2018). However, research, especially from the US, has confirmed a negative relationship between working hours and the innovation environment for the periods 1993–2010 (Acemoglu & Restrepo, 2020) and 2001–2013 (Dahlander, O'Mahony & Gann, 2016). Moreover, the mentioned research has shown that the financial crisis has further strengthened this relationship. Chatzoudes, Chatzoglou and Diamantidis (2022) note that extended working hours during a crisis do not favour the maintenance of innovation activity. Instead, firms generally prioritise short-term survival over long-term innovation, which leads to the postponement of innovative projects. Based on these findings, we propose:

*H3: Hours worked negatively influence innovation success within a region during crises.*

Based on the literature review of individual factors influencing innovation success and the established hypotheses, we present a conceptual framework for this research (see Fig. 1).

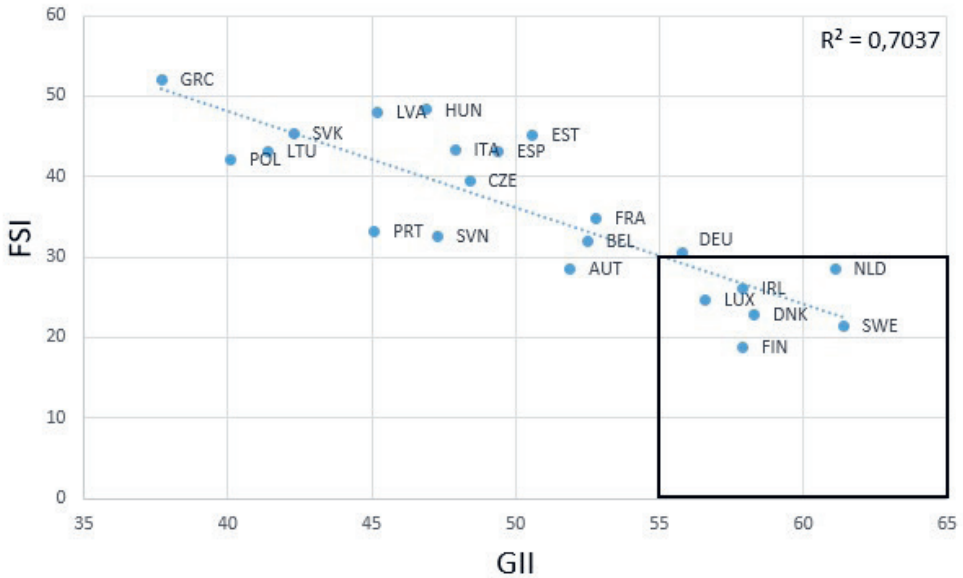
**Figure 1.** Research framework.



### 3. Data and methodology

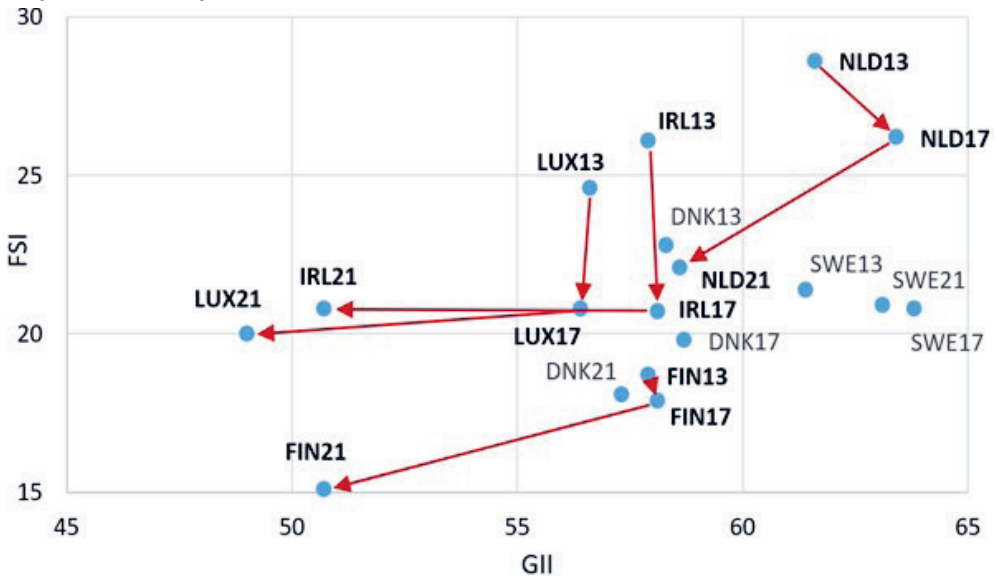
To build the regression model, we collected data from 22 EU countries, which are also OECD member countries, using the OECD Data Explorer and Eurostat databases for the years 2013–2021. For the purposes of our analysis, the term ‘region’ used in this study refers to a country, specifically at the NUTS 0 level according to the Eurostat classification. We created a pooled dataset covering nine calendar years, containing 198 observations in total. This dataset includes the following countries: Austria, Belgium, Czechia, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, the Netherlands, Poland, Portugal, Slovakia, Slovenia, Spain, and Sweden. Based on their scores on the Global Innovation Index (GII) and the Fragile States Index (FSI), we have created a simple chart (see Fig. 2), where a clear trend can be seen at a glance. The lower the country’s score on the FSI (the higher its economic resilience), the higher its score on the GII ( $R^2 = 0.7037$ ). In line with other studies, we consider vulnerability as the exact opposite of resilience in terms of empirical evidence (Cutter, Ash & Emrich, 2014; Tan, Song & Liu, 2021). Specifically, we focused on the countries shown in the figure in the black square. These countries can be considered innovation leaders in the European Union and at the same time they exhibit the highest economic resilience (or lowest vulnerability), not only in times of crisis.

**Figure 2.** Relationship between FSI and GII in 2013.



Source: Authors' compilation based on GII (2013) and FSI (2013).

**Figure 3.** The relationship between FSI and GII in innovation leaders (2013–2021).



Source: Authors' compilation based on GII and FSI (2013–2021).

Upon closer examination of Finland, Ireland, Luxembourg, and the Netherlands, a trend was identified showing a gradual decrease in their GII scores since 2013, despite these countries demonstrating increasingly higher economic resilience (or lower FSI scores) over these years. This trend is illustrated in Figure 3, which uses arrows to show the decline in GII scores between 2013–2017 and 2021, along with the increased economic resilience reflected by declining FSI scores. These are the countries that were included in the first regression model. A second regression model was then constructed for all 22 European countries.

When examining Figure 3, there was further reason to suspect that the COVID-19 pandemic in 2020 had a more significant impact on the innovation leaders included in the first model in terms of innovation success than on the remaining 18 countries. In this context, we included a third model in the analysis, using the Difference-in-Differences method (similarly to Li *et al.*, 2020; Duhautois *et al.*, 2022) to examine the causal relationship between the innovation leaders with a significant drop in GII scores and the other (control) countries. For this model, we based our analysis on the following equation:

$$GII_{it} = \beta_0 + \beta_1 * LEADERS_i + \beta_2 * POST_{INT_t} + \beta_3 * (LEADERS_i \times POST_{INT_t}) + \beta_4 * UNE_{it} + \beta_5 * UOW_{it} + \beta_6 * UOY_{it} + \beta_7 * ULC_{it} + \beta_8 * HWD_{it} + \beta_9 * GDP_{it} + \beta_{10} * R\&D_{it} + \varepsilon_{it},$$

where  $GII_{it}$  represents the Global Innovation Index score for country  $i$  in year  $t$ . The Beta parameters in the equation represent the regression coefficients. The binary variable  $LEADERS$  takes the value 1 for Finland, Ireland, Luxembourg, and the Netherlands.  $POST_{INT}$  represents a binary variable that takes the value 1 for the period after the outbreak of the COVID-19 pandemic (i.e., in the years 2020 and 2021). The interaction term  $LEADERS \times POST_{INT}$  captures the differential effect of the post-intervention period with innovation leadership. The remaining independent and control variables included in the model are illustrated in the following table. Additionally, we must not overlook the residuals  $\varepsilon_{it}$ .

**Table 1.** Overview of variables.

Type	Variable	Description	Unit	Source	References	
Dependent	GII	Score of Global Innovation Index	% GDP	GII	Rehman, Hysa & Mao, 2020	
Independent	UNE	Unemployment	% of the population in the labour force	EUROSTAT	Buerger, Broekel & Coad, 2012; Duhautois et al., 2020; Triguero-Ocaña et al., 2020	
	UOW	Unemployment of women	% of the population in the labour force		Green, Henseke & Vignoles, 2017	
	UOY	Youth unemployment	% of the population in the labour force (15-24)		Bal-Domańska & Sobczak, 2019; Zieliński, 2015	
	ULC	Unit labour costs (by hours worked)	% change to previous period		OECD	Bernoth & Colavecchio, 2014; García-Vega, Kneller & Stiebale, 2021
	HWD	Hours worked	hours/worker		Graetz & Michaels, 2018; Acemoglu & Restrepo, 2020	
Control	GDP	GDP per capita	US dollars/capita	OECD	Wang & Li, 2022; Tuysuz, Baycan & Altuğ, 2022	
	R&D	R&D expenditures	% GDP	EUROSTAT	Pegkas, Staikouras & Tsamadias, 2019; Min, Kim & Sawng, 2020	

The first step of the analysis, given the nature of our data, was normalisation of the data. Data normalisation was performed using the min-max method. Following normalisation, it was possible to proceed to fit two linear regression models and conduct a Difference-in-Differences analysis. All calculations were performed using STATA 13 SE software and RStudio.

The country variables included in our first model were Finland, Ireland, Luxembourg, and the Netherlands. Austria, Belgium, Czechia, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Italy, Latvia, Lithuania, Luxembourg, the Netherlands, Poland, Portugal, Slovakia, Slovenia, Spain, and Sweden were included in the second and third model.

We also calculated the determination coefficient to determine the appropriateness of applying our regression models to the data we were working with in this analysis, including the Difference-in-Differences analysis.

## 4. Results

The results of the first model, which included Finland, Ireland, Luxembourg, and the Netherlands, reveal a number of surprising findings (see Table 2). At the same time, based on the coefficient of determination (0.710) and the 99% significance level of the two control variables, these findings can legitimately be considered valid for our research.

**Table 2.** Results of the regression analysis for innovation leaders (Model 1).

Independent	Coeff. Estimate	Std. Error	t-value	p-value	
CONST	2.123	0.268	7.919	1.26E-08	***
UNE	-0.516	0.467	-1.104	0.279	
UOW	0.495	0.160	3.095	0.004	***
UOY	-0.576	0.423	-1.362	0.184	
ULC	0.096	0.099	0.968	0.341	
HWD	-0.610	0.164	-3.731	0.001	***
GDP	-1.039	0.199	-5.216	1.54E-05	***
R&D	-1.337	0.297	-4.502	0.000	***

**R-squared 0.710**

*Signif. codes: '\*\*\*\*' 0.01, '\*\*\*' 0.05, '\*\*' 0.1*

First, we reject hypothesis *H1* about the negative relationship between female unemployment and innovation success among innovation leaders. Although female unemployment (UOW) is revealed as significant at 99% significance level in the first model, it is associated with a positive parameter. On the other hand, unit labour costs (ULC) are not significant in this model, so we cannot reject hypothesis *H2* about the negative effect of this variable on innovation success. Finally, hours worked (HWD) shows significance again at 99% significance level, with a negative parameter. Thus, we confirm hypothesis *H3*, indicating a negative relationship between hours worked and innovation success among innovation leaders.

The second model, which includes 22 European countries (see ‘Data and methodology’), presents several differences compared to the first model (see Table 3). The coefficient of determination is slightly weaker than in the previous case (0.694), and both control variables are significant at the 99% significance level.

**Table 3.** Regression analysis results for all countries (Model 2).

Independent	Coeff. Estimate	Std. Error	t-value	p-value	
CONST	0.603	0.120	4.991	1.35E-06	***
UNE	0.275	0.166	1.654	0.099	*
UOW	0.097	0.060	1.614	0.1081	
UOY	-0.307	0.153	-2.015	0.0454	**
ULC	-0.350	0.111	-3.154	0.002	***
HWD	-0.338	0.082	-4.095	6.23E-05	***
GDP	0.418	0.074	5.606	7.23E-08	***
R&D	0.352	0.058	6.001	9.74E-09	***
<b>R-squared 0.694</b>					

*Signif. codes: '\*\*\*' 0.01, '\*\*' 0.05, '\*' 0.1*

Some interesting findings emerge from the results of the second model. We observe that female unemployment is not significant, so we do not reject hypothesis *H1*. Compared to the first model, labour costs (ULC) are significant, even at 99% significance level and with a negative parameter. Therefore, we confirm hypothesis *H2* and argue that there is a negative relationship between labour costs and innovation success. Finally, we confirm hypothesis *H3*, which presents a negative relationship between hours worked and innovation success, as HWD is significant at 99% significance level with a negative parameter.

The third model for 22 European countries, which divides the states into four innovation leaders with a significant drop in GII scores due to the COVID-19 pandemic (Finland, Ireland, Luxembourg, and the Netherlands) and 18 control countries, proves to be of the highest reliability, with a coefficient of determination equalling 0.805.

**Table 4.** Difference-in-Differences analysis (Model 3).

Independent	Coeff. Estimate	Std. Error	t-value	p-value	
CONST	0.620	0.095	6.518	6.46E-10	***
LEADERS	0.250	0.033	7.465	3.06E-12	***
POST_INT	-0.146	0.022	-6.613	3.84E-10	***
LEADERS:POST_INT	-0.090	0.049	-1.840	0.0674	*
UNE	-0.157	0.136	-1.149	0.2519	
UOW	-0.145	0.055	-2.645	0.0089	***
UOY	0.193	0.129	1.498	0.1358	
ULC	-0.208	0.089	-2.345	0.0201	**
HWD	-0.427	0.066	-6.507	6.84E-10	***
GDP	0.069	0.078	0.881	0.3796	
R&D	0.427	0.048	8.921	4.20E-16	***
<b>R-squared 0.805</b>					

Signif. codes: '\*\*\*' 0.01, '\*\*' 0.05, '\*' 0.1

A key benefit of the third model is the result of the variable *LEADERS:POST\_INT*, which is weakly significant at the 90% significance level and has a negative coefficient. Based on this result, we can assert that with the onset of the COVID-19 pandemic, there is a causal effect between innovation leaders and control countries in terms of the decline in GII scores.

## 5. Discussion

When examining the impact of the financial crisis on the innovation success of regions, we identified significant heterogeneity. This highlights the urgent need for further investigation of regional differences during crises (Sensier, Bristow & Healy, 2016; Di Caro & Fratesi, 2018; Hu, Li & Dong, 2022). Existing findings in the area of innovation and regional resilience suggest that the effects of financial crises are not only one-off in nature, but also spill over into subsequent years, reinforcing the need for further investigation over longer time horizons (Matuzeviciute, Butkus & Karaliute, 2017). Given the different settings of economic systems and often differing attitudes towards innovation, it was important to conduct an analysis among regions with similar innovation potential to avoid over-generalisation and bias in

research conclusions (Wang & Li, 2022). For the period 2013–2021, the study explored whether regional labour markets significantly influenced the innovation success of innovation leaders (Model 1), whether the significance differed when including all European countries (Model 2), whether there is a causal effect between innovation leaders and the remaining (control) countries in terms of the decline in GII with the onset of the COVID-19 pandemic (Model 3), and how these findings relate to the existing literature.

The following conclusions can be drawn about the research hypotheses. First, it cannot be argued that higher female unemployment negatively affects innovation success, both for innovation leaders and for all 22 European countries included in the analysis (*H1*). However, we see some shortcomings here: unlike Model 2, Model 1 does not confirm our assumption for establishing this research hypothesis, namely that there is a negative relationship between youth unemployment and innovation success (Moutinho *et al.*, 2015; Bal-Domańska & Sobczak, 2019). Innovation leaders often have dynamic and diverse economies that can provide more job opportunities for the younger generation. It is therefore important that policies in these countries focus primarily on supporting the medium-term integration of young people into productive employment. This will enable them not only to contribute to this dynamism but also to benefit from it (Eichhorst & Rinne, 2018). In this regard, the example of the innovation-led Netherlands, which has long had one of the highest youth employment rates in the EU, can be cited (Eichhorst & Rinne, 2018). At the same time, the Nordic countries rank among those with the highest rates of female employment and gender equality (Sanandaji, 2018).

Why, then, is it not possible to empirically confirm this relationship? Several possible reasons are offered, whether it is the time lag between innovative activities and real changes in youth and female unemployment or the implementation of specific social and employment policies. Identifying these factors and their impact on innovation success would require a much more comprehensive analysis. However, as pointed out by Collins (2020) and Görkey (2022), the negatives associated with significant differences in gender unemployment are a long-term problem in many countries, especially in technically oriented fields. For innovation, higher unemployment and the vulnerability of women in the labour market represent a significant innovation barrier, which is exacerbated during times of crisis.

Hypothesis 2 on the negative relationship between labour costs and innovation success was confirmed for all 22 European countries combined, but not for

innovation leaders. It can be hypothesised that innovation leaders may tend to have higher labour costs due to a highly skilled workforce, but at the same time possess higher levels of productivity. Thus, the negative relationship between labour costs and innovation is not necessarily significant. There are undoubtedly other factors that influence the complicated relationship between labour costs and innovation success. Our results are at least partially consistent with the findings of previous studies that have confirmed this negative relationship in the Spanish economy (García-Vega, Kneller & Stiebale, 2021) and for 17 Central and Eastern European countries (Bernoth & Colavecchio, 2014), respectively.

Regarding another aspect of regional labour markets to innovation success, we confirm Hypothesis 3. A negative relationship between the number of hours worked and innovation success was found not only for the innovation leaders but also for all 22 European countries. This finding is consistent with previous findings in the literature (Dahlander, O'Mahony & Gann, 2016; Acemoglu & Restrepo, 2020). Thus, we can argue that with the development and improvement of current technologies, there is greater efficiency in work, flexibility in working hours, and associated lower time consumption. The reality is that advanced technological tools allow workers to achieve the same or even better results in less time, reducing the need for long working hours. From another perspective, as argued by Chatzoudes *et al.* (2022), the onset of the crisis (in this case, the COVID-19 pandemic) may have forced companies to prioritise operational activities leading to survival over long-term innovation projects. Although this conclusion cannot be confirmed or refuted during the COVID-19 pandemic, given the nature of our research, it opens the possibility for further examination of the relationship between regional labour markets and innovation success.

Beyond the regression models, the Difference-in-Differences method indicated a weak causal effect with the onset of the COVID-19 pandemic, where selected innovation leaders (Finland, Ireland, Luxembourg, and the Netherlands) experienced greater losses in terms of innovation success (GII scores) compared to the remaining 18 control countries. This result suggests that the pandemic had a disproportionate impact on innovative countries, which are often more integrated into global value chains and dependent on international collaboration and mobility (Curran & Eckhardt, 2023). The restrictions and disruptions caused by the pandemic therefore likely had a significant effect on these regions. Furthermore, innovation leaders invest more in research and development, areas that can be more easily curtailed during a crisis due to the redirection of resources to more immediate

needs. Existing literature supports this conclusion; for instance, a study by Crescenzi, Luca & Milio (2016) shows that during the economic crisis, more innovation-intensive regions suffered greater losses. The COVID-19 pandemic may have had a similar effect, where increased uncertainty and economic shocks negatively impacted innovation activities in these countries more than in less innovative areas. Potential solutions include diversifying global partnerships where possible and supporting international collaboration even during crises (Curran & Eckhardt, 2023).

Last but not least, we can point out the surprising negative relationship between innovation success and the control variable R&D expenditures for innovation leaders. Similarly to Muscio, Reid and Rivera Leon (2015), here we reach a certain innovation paradox. Innovation leaders can use their R&D investments more efficiently, outperforming innovation-less developed regions even with lower expenditures. This means that while they spend less on science and research, their investments are better targeted and have the potential to be more efficient. It is therefore highly controversial whether R&D expenditure is an appropriate indicator for analysing innovation success (Prokop, Kotkova Striteska & Stejskal, 2021; or Gyamfi *et al.*, 2024). Therefore, pumping more structural funds into R&D infrastructure may absorb funds, but is unlikely to lead to the expected results in terms of increased innovation success (Muscio, Reid & Rivera Leon, 2015). Much more fruitful outcomes may be achieved if policies focus more on managing innovation at the regional level rather than on funding.

## 6. Conclusion

The results of our study point to the interconnectedness of regional labour markets and innovation, as well as the importance of the maturity of the innovation success, which fundamentally influences the economic resilience of regions (Bristow & Healy, 2018) and thus the ability of a region to withstand an economic crisis. In particular, the results of our study highlight the issue of vulnerable labour market groups in times of economic crisis, especially female and youth unemployment, where our results clearly show that innovation leaders are more adversely affected by female unemployment. In contrast, youth unemployment, traditionally considered one of the most vulnerable groups in the labour market, remains virtually unaffected in times of crisis. Similarly, our study shows that with the onset of the COVID-19

pandemic, there was a significantly greater impact on innovation among the innovation leaders compared to the remaining European countries.

The main limitation of this study is the diversity and individual uniqueness of the countries analysed. Despite being a group of innovation leaders in the European Union, all the studied countries have their own unique approach to social and employment policies, as well as to financial markets. At the same time, we cannot overlook the often significant regional differences within individual countries, which are not reflected in the chosen data. Another limitation is the choice of indicators. This study focuses exclusively on the labour market and its indicators, which have seen the lagged effects of the financial crisis that has rocked Europe over the past decade, but the labour market is only one of many areas that have been affected by the crisis. The final limitation is the period under study, which covers 2013 to 2021, by which time the effects of the US financial crisis were already fully apparent. However, other crises of a different nature are currently shaking Europe, which we were unable to include in our dataset due to the time lag.

We find opportunities for future research in the incorporation of the opposite imaginary pole of states. While our study focuses exclusively on European innovation leaders, there are also countries that exhibit both poor innovation success and poor economic resilience. Future research could therefore focus on these countries, including the Balkan countries, also Poland, Slovakia, and Greece. Given the indicators we have chosen in this study, it would be appropriate to conduct a deeper examination of vulnerable groups in the labour market (women and youth) in relation to innovation, similar to the impact of labour costs or the number of hours worked, especially during periods of economic growth and, subsequently, in times of crisis. A more in-depth examination could benefit from analysis at the level of individual firms (innovative v. less innovative), rather than at the country level, as in this research. There is also room to explore other area of indicators that have been affected by the financial crisis. Typically, these may be aggregate demand indicators, debt indicators, or focus exclusively on R&D expenditures, which offers room for deeper analysis in our study as well. A final recommendation for future research is to include a more up-to-date dataset that already fully incorporates the effects of the 2020–2022 health crisis and, for example, the energy crisis that impacted Europe in 2022. Given our third model, the inclusion of additional years (from 2022 onwards) would be particularly relevant and would help clarify the possible causal effect between the innovation leaders and the remaining European countries in relation to innovation success according to the GII score.

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