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## Kurzarbeit and natural disasters: How effective are short-time working allowances in avoiding unemployment?

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# 1909

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## Kurzarbeit and Natural Disasters: How Effective Are Short-Time Working Allowances in Avoiding Unemployment?

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# Kurzarbeit and natural disasters: How effective are short-time working allowances in avoiding unemployment?

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There is substantial evidence on the effectiveness of short-time work on reducing unemployment. However, no study looks at its role during natural disasters. This article exploits the exogenous nature of the 2013 European floods to assess if the impact depends on the quality of the short-time work mechanism across affected counties. We use regression discontinuity designs to show that unemployment does not increase in regions with robust programs while rising up to seventeen percent in areas with less robust mechanisms. Our results are relevant to the literature on how institutional quality influences recovery and suggests that short-time work programs are useful against unforeseeable productivity shocks besides financial crises.

**JEL codes:** J68, H84, Q54, C22

**Keywords:** Flooding, short-time work, regional unemployment, regression discontinuity in time, institutions

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# 1. Introduction

In May and June 2013, extreme precipitation caused many Central European rivers to overflow, inundating several urban, industrial, and agricultural areas across Austria, the Czech Republic, Germany, Hungary, and Slovakia. Studies of this event show evidence of its effects on the transportation network (Fournier Gabela and Sarmiento, 2020), industrial production (in den Bäumen et al., 2015; Oosterhaven and Többen, 2017), insurance claims (Munich RE, 2014), and general infrastructure (Thieken et al., 2016). Following the literature on how institutions can influence recovery after a natural disaster (Cavallo et al., 2013; Barone and Mocetti, 2014), in this article, we exploit differences in short-time work programs across affected nations to understand the ability of these mechanisms to dampen the adverse consequences of natural disasters on employment.<sup>1</sup>

Natural disasters decrease the productivity of firms through several channels, including capital destruction, supply chain interruptions, and demand-side pressures. Lower productivity forces affected companies to reduce their labor demand (total work hours) through layoffs (extensive margin) or reduced working time (intensive margin). The absence of wage support mechanisms promoting adjustments via the intensive margin can lead to inefficient separations and unequal distribution of uncertainty among the workforce (Van Audenrode, 1994; Arpaia et al., 2010). Short-time work programs aim to stabilize labor markets by avoiding involuntary dismissals, fostering labor hoarding, and encouraging work-sharing. They work through direct government transfers providing wage support to firms in financial distress and are complements to other working-time flexibility instruments.<sup>2</sup> However, compared to other alternatives, short-time work provides help to firms in financial difficulties by freeing them from paying wages for non-worked hours. It is a substitute for labor adjustments via the extensive margin and a superior strategy depending on the nature of the shock (Rinne and Zimmermann, 2012).

Studying the adequacy of short-time work mechanisms under different conditions

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<sup>1</sup>Alternative names for short-time work programs are short-time compensation systems and job retention schemes.

<sup>2</sup>In Germany and Austria, firms must first exhaust alternative flexibility instruments before commencing short-time work (Eurofound, 2010a).

29 is essential for improving future program design. For instance, gained insights can help  
30 orientate efforts to alleviate the impacts of other types of catastrophes, such as the  
31 COVID-19 outbreak. Furthermore, studies on the economic consequences of repetitive  
32 events, like floods, are highly relevant because climate change will exacerbate both  
33 the frequency and intensity of natural disasters around the globe (IPCC, 2012). In  
34 particular, climate change is likely to increase the number of Central European floods  
35 because of its effect on European weather patterns (Jongman et al., 2014).

36 Existing studies on the effect of natural disasters on unemployment find negative  
37 impacts in affected regions during the immediate aftermath of the disaster (Belasen  
38 and Polachek, 2008; Ewing et al., 2009; Xiao and Feser, 2014; Brown, 2006). Natural  
39 disasters affect labor markets because physical damage can hinder normal working  
40 conditions while creating structural changes, mismatches between workers and firms,  
41 as well as barriers to the demand and supply of labor (Venn, 2012). Examples include  
42 the evacuation of people, workers who cannot arrive at work, the incapacity to work  
43 because of damage to buildings or machinery, as well as firms that cannot operate  
44 because of supply chain problems.

45 Early contributions on the labor market effects of short-time work indicate that  
46 German firms using this instrument display less employment volatility (Deeke, 2005).  
47 Abraham and Houseman (1993); Van Audenrode (1994) show that countries with gen-  
48 erous short-time work programs achieve a high speed of adjustment in total working  
49 hours to changes in output.<sup>3</sup> This is possible because short-time work effectively com-  
50 pensates for firing restrictions consequence of strict employment protection legislation.  
51 The strictness of employment protection increases the probability of participating in  
52 short-time work programs, while the generosity of unemployment benefits works in the  
53 opposite direction (Van Audenrode, 1994; Boeri and Bruecker, 2011; Cahuc and Car-  
54 cillo, 2011). Although the average contribution of the intensive margin to Germany's  
55 labor adjustment was close to 50% during historic recessions, the use of these adjust-  
56 ments reached unprecedented levels during the 2008 financial crisis in this country and  
57 other advanced nations (Boeri and Bruecker, 2011).

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<sup>3</sup>The level of generosity refers to workers' current income under short-time work as a percentage of their previous (regular) income.

58 During the 2008 financial crisis, despite large drops in output, unemployment levels  
59 in countries with high short-time work participation were far from being proportionally  
60 affected, with the German case standing out as a miracle (Messenger, 2009).<sup>4</sup> The  
61 primary source of adjustment for the German labor market was a reduction in working  
62 hours along the intensive margin, with short-time work as the main protagonist (Burda  
63 and Hunt, 2011; Sacchi et al., 2011; Balleer et al., 2016). Hijzen and Venn (2011); Boeri  
64 and Bruecker (2011); Hijzen and Martin (2013) give empirical evidence that short-time  
65 work helped preserve jobs in OECD countries during the 2008 financial crisis. However,  
66 the number of jobs saved was lower than the number of full-time equivalents, indicating  
67 the existence of dead-weight losses, which occur when short-time hours finance hour  
68 reductions that would have happened in any event or that would not have existed in  
69 the absence of the subsidy.<sup>5</sup>

70 However, evidence showing that crises previous to 2008 saw unemployment in-  
71 creases in Germany despite short-time work motivates the search for alternative ex-  
72 planations to the German miracle (Möller, 2010; Boysen-Hogrefe and Groll, 2010;  
73 Burda and Hunt, 2011; Rinne and Zimmermann, 2012; Dustmann et al., 2014). These  
74 studies show that besides working time flexibility, the miracle resulted from a series  
75 of business cycle conditions and asymmetries in how the crisis affected each country.  
76 While, in Germany, most of the affectation accrued to the 2008 financial crisis hap-  
77 pened in sizeable export-oriented manufacturing companies, in the USA, most of the  
78 affectation was related to housing market conditions.

79 Besides short-time work, other remarkable working time flexibility instruments in  
80 Germany during the 2008 financial crisis included working-time accounts and weekly  
81 working time reductions (Möller, 2010; Bogedan et al., 2009; Fuchs et al., 2010; Schnei-  
82 der and Graef, 2010).<sup>6</sup> An analysis based on the 2009 European Company Survey  
83 shows that European firms do not use flexibility measures in isolation, rather these  
84 are combined to different degrees (Eurofound, 2010b). The study also constructs com-

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<sup>4</sup>Hoffmann and Lemieux (2016) show that there is no German miracle when using data until 2011. However, there is still a German puzzle: employment barely declined early in the crisis despite a sharp fall of GDP.

<sup>5</sup>Full-time equivalents are a fictitious number giving the potential number of full- and part-time jobs saved due to the implementation of short-time work.

<sup>6</sup>In Germany, working time reductions are possible thanks to sector-specific opening clauses that allow for non-compensated working hours reductions up to 25% (Bispinck, 2009).

85 pany profiles according to the previous flexibility degrees and shows that each profile  
86 type exists in every country. Despite this, a survey of German works councils in 2009  
87 reveals that, relative to other instruments, the most substantial difference between  
88 affected and unaffected firms was in the use of short-time work (Bogedan et al., 2009).  
89 This result is in line with Boeri and Bruecker (2011), who show that working time  
90 accounts did not suffer a significant increase during the crisis, implying that it is not  
91 an instrument for short-time economic shocks but rather for the ups and downs of  
92 the business cycle. A further important consideration is that mechanisms other than  
93 short-time work do not apply to firms with liquidity problems as firms still need to  
94 continue paying wages. Evidence along these lines indicates that firms without finan-  
95 cial frictions relied less intensively on short-time work during the 2008 financial crisis  
96 (Bohachova et al., 2011).

97 Although the 2008 financial crisis and the 2013 floods fulfill the omnipresent short-  
98 time work eligibility condition requiring that shocks are "unexpected, inevitable, and  
99 temporary," there are significant differences in how each affected firms and labor mar-  
100 kets. The shock imposed by the 2013 floods was unrelated to the business cycle and  
101 different in nature, duration, and spatial extent to the financial crisis. The floods  
102 shocked regions in the same way, through inundations of varying intensities. Their  
103 effect did not concentrate on specific sectors, curtailed local demand, and caused  
104 capital destruction. It affected many neighboring border regions whose economies,  
105 despite different national regulations, have many common characteristics. Moreover,  
106 the shock had a much shorter duration of, at most, a couple of weeks. A transient  
107 shock decreases uncertainty, favors labor hoarding, makes layoffs almost the only avail-  
108 able extensive margin flexibility instrument, and makes dismissals more difficult under  
109 strict employment protection legislation.<sup>7</sup>

110 Germany and Austria have long-standing experience with short-time work, shared  
111 similar generous program features, and developed tailored programs to support com-  
112 panies in flooded areas by reducing requirements and further increasing generosity. On  
113 the contrary, while the Czech Republic and Slovakia used these mechanisms for the

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<sup>7</sup>Other popular extensive margin instruments include letting fixed-term contract expire, stop hiring, and early retirement schemes (Bogedan et al., 2009).



114 first time during the 2008 financial crisis, Hungary did not have any active program  
115 in 2013. Further, while Austria, Germany, and Slovakia share similarities concerning  
116 the strictness of employment protection and unemployment benefits, the institutional  
117 setting impedes (facilitates) extensive margin adjustments in the Czech Republic (Hun-  
118 gary).

119 This study is the first examining the effectiveness of short-time work programs for  
120 shocks other than the 2008 financial crisis. Can a labor market instrument capable of  
121 saving hundreds of thousands of jobs throughout economic crises prevent unemploy-  
122 ment during a natural disaster? Given the shock characteristics of the 2013 floods and  
123 evidence indicating that nations with robust short-time work programs (Boeri and  
124 Bruecker, 2011; Cahuc and Carcillo, 2011; Rinne and Zimmermann, 2012) and expe-  
125 rience in implementation (Boeri and Bruecker, 2011; Rinne and Zimmermann, 2012)  
126 achieve higher participation rates, we propose that different labor market outcomes in  
127 each of the flooded countries are due to differences in the program features.<sup>8</sup>

128 To estimate the floods' impact, we use a local-linear regression discontinuity in  
129 time (RDiT) design (Hausman and Rapson, 2018). Studies employing a similar quasi-  
130 experimental approach include several areas such as transportation (Anderson, 2014;  
131 Burger et al., 2014), health (Toro et al., 2015), and environmental economics (Grainger  
132 and Costello, 2014). Compared to the traditional regression discontinuity design,  
133 RDiT uses time as the running and treatment assignment variables. In other words,  
134 it estimates the discontinuity in the flooded month by comparing the dependent vari-  
135 ables just before and after it. To avoid bias from correlated temporal unobservables,  
136 we use the augmented version of RDiT (ARDiT), as suggested in Hausman and Rap-  
137 son (2018). The main idea behind the ARDiT is to divide the estimation procedure  
138 into two steps, one initial regression taking away the time variation in the dependent  
139 variable and a second regression using the residuals from the first step in a RDiT  
140 framework. It is necessary to use an ARDiT specification because using variables over  
141 a large time window increases the risk of having biased estimates arising from unob-  
142 served time-varying factors. We test for the robustness of the design with a placebo

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<sup>8</sup>Generosity and experience also raise participation rates for other social programs (McLaughlin, 1987; Hernanz et al., 2004).

143 test studying the effect of the flood on unaffected European countries.

144 We begin by exploring the effect of the floods on short-time work participation in  
145 Germany. The results show that companies and employees in Germany actively used  
146 the short-time work mechanism during the floods; the number of short-time companies  
147 and the number of short-time employees increasing by 29% and 25%, respectively. Af-  
148 terward, we examine how the inundations affected the unemployment rates of five Cen-  
149 tral European countries afflicted by the floods. In line with our expectations, countries  
150 with robust programs suffered no significant effects while uncovering negative conse-  
151 quences for the other affected Central European countries. For the Czech Republic,  
152 Hungary, and Slovakia, the flood increases regional unemployment in flooded counties  
153 by 7%, 9%, and 6%, respectively. To determine if the German labor market's stability  
154 is related to its robust short-time work program, we re-estimate the flood effects for all  
155 variables using different flood extent intensities. As we reduce the sample to include  
156 only those regions with a larger flooded area, we find that Germany's short-time work  
157 participation increases further up to 75%. As expected, while unemployment remains  
158 unaffected in Germany and Austria, it further increases to 14%, 17%, and 9% in the  
159 other flooded countries, respectively.

160 Our findings suggest that well-designed short-time work programs can flatten the  
161 negative impact of natural disasters on employment, implying that these programs  
162 can also be useful in the case of short-lived events, including famines, pandemics, or  
163 terrorist attacks. Our findings support arguments in favor of implementing short-time  
164 work programs in countries where they do not exist and to the adjustment of already  
165 implemented programs during periods of unforeseeable productivity shocks.

## 166 **2. Background**

### 167 **2.1. Theoretical background**

#### 168 **2.1.1. A labor market model under disaster risk**

169 To provide intuition into the effect of unexpected natural disasters on unemployment  
170 and describe how short-time work programs can support labor markets in adjusting

171 against these types of shocks, we develop a simplified model with endogenous job  
172 separations arising from natural disaster shocks. The model is based on the Diamond  
173 (1982) and Mortensen and Pissarides (1994) search and matching frictions framework,  
174 which is also used by Cooper et al. (2017) and Balleer et al. (2016) to study the effects  
175 of short-time work.

176 In this model, employed and unemployed make up the labor force  $L$ . Workers  
177 are homogeneous, risk-neutral, immortal, and their utility evolves linearly with wages.  
178 Each firm needs only one worker to produce. However, each firm's production process  
179 is subject to exogenous natural disaster shocks, which reduce the firm's productivity  
180 through several channels, including capital destruction, supply chain interruptions,  
181 decreases in demand, and labor supply restrictions. The disaster shock  $\gamma$  affects the  
182 firm's productivity  $p(h)$  through  $(1-\gamma)\cdot p(h)$ . The larger the  $\gamma$  coefficient, the larger the  
183 productivity reduction. We assume that  $\gamma$  is a random variable drawn from a fixed  
184 and strictly increasing distribution  $F(\gamma) \forall \gamma \in [\underline{\gamma}, \bar{\gamma}]$ . The lower end of the interval  
185 equals zero, thus denoting the absence of a disaster shock. The upper end equals one.  
186 A cut-off shock value  $\tilde{\gamma}$  determines job destruction such that whenever  $\gamma > \tilde{\gamma}$ , the firm  
187 will destroy the match.  $\lambda$  denotes the Poisson probability that the shock hits a job  
188 match.

189 The initial labor market equilibrium defines the overall levels of unemployment  
190  $u$ , job creation, optimal working hours  $h$ , wages  $\omega(h, \gamma)$ , and the firing threshold  $\tilde{\gamma}$ .  
191 Note that the initial equilibrium is defined in the absence of disaster shocks, that is,  
192 at  $\gamma = \underline{\gamma}$  and, hence, with the greatest possible productivity. Furthermore, firms can  
193 adjust the number of working hours instantaneously and without any constraint. In  
194 Appendix A, we derive the full equilibrium conditions and provide additional details.

### 195 **2.1.2. Equilibrium under hours constraint and short-time work**

196 To show how short-time work programs help labor markets reduce labor agreements'  
197 destruction in the face of an exogenous disaster shock, we show how increasing the  
198 generosity of short-time work mechanisms increases the model's endogenous firing  
199 threshold. An increase in this threshold means that the disaster shock must be more  
200 severe for a firm to destroy a job match or, equivalently, reduces the probability of

201 match destruction. Consequently, the impact that a natural disaster exerts on over-  
 202 all unemployment is smaller than in a scenario with less generous short-time work  
 203 mechanisms.

204 In the new equilibrium, firms realize disaster shocks and decide whether or not to  
 205 destroy job matches according to the firing threshold  $\tilde{\gamma}$  defined in the initial equilibrium  
 206 by setting  $rJ(\tilde{\gamma}) = 0$ . We assume that wages  $\bar{w}$  remain as in the initial equilibrium.  
 207 These are affected neither by the shocks nor by the short-time work policy. Further-  
 208 more, following Cooper et al. (2017), we assume that contractual working hours  $\underline{h}$   
 209 impose a lower threshold to the optimal number of hours a firm can set,  $h \geq \underline{h}$ . These  
 210 restrictions reflect a short-term scenario of wage rigidities and the absence of working  
 211 time flexibility instruments typically enforced by employment protection laws.

212 Let us define a short-time work program as  $\mathcal{STW} = \{\Xi, \xi_f, \xi_w\}$ . The first policy  
 213 component refers to the number of permissible hours reductions, with  $0 < \Xi \leq \underline{h}$ .  
 214 While  $\Xi = 0$  represents a case without a short-time work policy,  $\Xi = \underline{h}$  represents the  
 215 most generous case of full hours coverage. The other two components refer to the level  
 216 of government wage compensation of non-worked hours received by firms and workers,  
 217 respectively, with  $0 < \xi_f, \xi_w \leq 1$ . The upper end represents the maximum possible  
 218 generosity level since employees and firms will receive a full salary compensation for  
 219 non-worked hours.

220 The first policy component loosens the contractual hour constraint such that each  
 221 firm is now allowed to set hours subject to  $h \geq \underline{h} - \Xi$ . Equation 1 gives the corre-  
 222 sponding firm's decision on the number of optimal hours. According to it, a firm will  
 223 choose the highest value from two options: the binding constraint given by  $\underline{h}$  minus  
 224 the number of permissible hour reductions and the optimal working hours from the  
 225 initial equilibrium.

$$h^* = \max \left\{ \underline{h} - \Xi, \left[ \frac{\Omega_h(h^*)}{\alpha(1-\gamma)} \right]^{\frac{1}{\alpha-1}} \right\} \quad (1)$$

226 The value functions for workers and jobs are given by equations 2 and 3, respec-  
 227 tively. According to the first, workers receive income from the new optimal number

228 of hours plus a share  $\xi_w$  of the difference between contractual and new optimal hours,  
 229 that is, non-worked hours.  $\Omega(h)$  stands for the dis-utility of labor and the last term  
 230 in the equation is the worker surplus. Similarly, the new present discounted value of  
 231 a job now depends on the new optimal number of hours plus a share  $\xi_f$  of the non-  
 232 worked hours. The last term in the equation is the job surplus after using the free  
 233 entry condition  $V = 0$ . Thus, the short-time work components  $\xi_w$  and  $\xi_f$  increase the  
 234 value of jobs and employed persons in the economy.

$$rW(\gamma) = \bar{w} \cdot h + \bar{w} \cdot \xi_w(\underline{h} - h) - \Omega(h) + \lambda[E(W) + F(\tilde{\gamma})U - W(\gamma)] \quad (2)$$

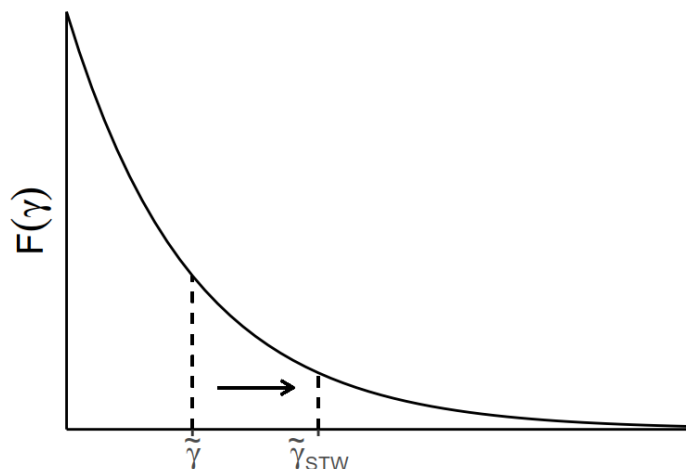
$$rJ(\gamma) = (1 - \gamma) \cdot p(h) - \bar{w} \cdot \underline{h} + \bar{w} \cdot \xi_f(\underline{h} - h) + \lambda[E(J) - J(\gamma)] \quad (3)$$

235 By using the job value function and replacing  $h$  with the binding constraint  $\underline{h} - \Xi$ ,  
 236 equation 4 shows the new firing threshold as a function of short-time work instruments.  
 237 Notably, as the generosity of the instruments  $\xi_f$  and  $\Xi$  increases, the firing threshold  
 238 increases [ $\tilde{\gamma}_i \geq 0 \quad \forall \quad i = \xi_f, \Xi$ ]. Figure 1 gives a visual representation of the right  
 239 shift of the firing threshold.

$$\tilde{\gamma} = 1 - \frac{\bar{w}}{p(h)}(\underline{h} - \xi_f \Xi) + \frac{\lambda}{r + \lambda} \int_{\underline{\gamma}}^{\tilde{\gamma}} (\tilde{\gamma} - x) dF(x) \quad (4)$$

240 An increase of the firing threshold decreases the unemployment effect following  
 241 a natural disaster, which is evident from the evolution of unemployed individuals  
 242  $\dot{u} = \lambda F(\tilde{\gamma}) \cdot (1 - u) - \lambda_w \cdot u$ , with  $\lambda_w$  standing for the rate of match creation and  $F(\tilde{\gamma})$   
 243 for the rate of match destruction. As  $\tilde{\gamma}$  increases,  $F(\tilde{\gamma})$  decreases, hence reducing the  
 244 number of individuals entering unemployment.

Figure 1: Firing threshold and short-time work



**Notes:** This figure shows the distribution of natural disaster shock intensities and how the firing threshold shifts to the right due to short-time work.

## 2.2. The 2013 European floods

In May and June 2013, intense rainfall caused abnormal water levels across Central European river basins.<sup>9</sup> Although the flood start and duration vary across countries, the first floods occurred in the second half of May and reached a maximum during the first week of June. Flooded areas included 1,800 municipalities in twelve federal states in Germany, seven states in Austria, 1,400 municipalities in ten provinces within the Czech Republic, the Bratislava – Devín region in Slovakia, and eight counties along the Danube valley in Hungary (ICPDR, 2014).<sup>10</sup> The inundations also affected large urban centers including Dresden, Vienna, and Prague.

Although Germany had the most substantial direct losses (€ 8.2 billion), loss estimates in other countries also point to considerable damage: € 0.9 billion in Austria, € 0.6 billion in the Czech Republic, and € 0.03 billion in Hungary (European Commission, 2015). The administrative regions with the greatest financial losses were Saxony-Anhalt (40%), Saxony (29%), Bavaria (20%), and Thuringia (7%) in Germany (Thieken et al., 2016); Upper Austria (40%), Lower Austria (24%), Tyrol (23%), and

<sup>9</sup>The most affected river basins were the Danube, Elbe, Rhine, Wesser, Inn, Morava, Vltava, Ohre, Odra, Berounka, and their tributaries.

<sup>10</sup>Many of these regions declared a state of emergency, among them, eight states in Germany and six provinces in the Czech Republic. Further countries with minor damage include Croatia, Serbia, Romania, and Bulgaria.

260 Salzburg (10%) in Austria (European Commission, 2018); and Central Bohemia (27%),  
261 Prague (25%), Ústí nad Labem (23%), and South Bohemia (13%) in the Czech Repub-  
262 lic (Czech Hydrometeorological Institute, 2014). Given the size of the losses, all of the  
263 aforementioned countries, except Hungary, received support from the European Union  
264 Solidarity Fund (EUSF) (European Commission, 2015). In Germany, the government  
265 launched flood-relief funds for around € 8 billion, and the insurance industry covered  
266 around € 1.65 billion (Thieken et al., 2016).

267 The flood caused infrastructure damages, including the transport, telecommunica-  
268 tion, water, electricity, and gas networks. In Germany, reports reveal 250,000 hectares  
269 of flooded agricultural land and production disruptions in several prominent firms,  
270 including Porsche (Leipzig), Volkswagen (Zwickau), and Südzucker (Zeitz) (Khazai  
271 et al., 2013). Thieken et al. (2016) report that more than 32,000 residential buildings  
272 suffered damage and that around 19% of the direct losses corresponded to companies  
273 in the industrial and commercial sectors. The Czech Republic had 48,000 hectares of  
274 flooded agricultural land, 7,000 affected residential buildings, and about 16% of the  
275 direct costs accruing to businesses (Czech Hydrometeorological Institute, 2014). In  
276 Austria, 22,000 hectares of agricultural land remained underwater and over 300 firms  
277 were directly affected, while in Hungary, reports indicate 2,500 hectares of flooded  
278 farmland (European Commission, 2015).

### 279 **2.3. Short-time work programs**

280 Short-time work programs are employment subsidy mechanisms designed to prevent  
281 involuntary dismissals during periods of temporary business-downturn. Short-time  
282 working allowances are the corresponding transfers received by firms and paid to em-  
283 ployees who benefit from temporary income support. Companies also benefit from the  
284 programs, as they retain core employees, avoid dismissal costs, and regain production  
285 levels without delay once the crisis is over. From a macro perspective, short-time work  
286 can slow the spiral of declining unemployment, wage deflation, and demand. Addi-  
287 tionally, the psychological effect of being under the program rather than unemployed  
288 has a more substantial impact in supporting domestic demand than unemployment  
289 benefits (Crimmann et al., 2010).

290        However, like other subsidies, short-time work schemes are subject to several prob-  
291        lems that reduce their cost-effectiveness (Hijzen and Venn, 2011). The two most  
292        prominent are dead-weight losses and displacement costs. Dead-weight losses occur  
293        when benefiting employees would anyway be regular-time employed in the absence of  
294        short-time work. Displacement costs happen when the allowances preserve jobs that  
295        would have been destroyed in the absence of the subsidy, hence locking workers into  
296        low-productivity job matches. The consequences of the latter include the potential of  
297        preventing creative destruction processes (Crespo Cuaresma et al., 2008; Leiter et al.,  
298        2009) and impeding companies with strong growth potential to hire locked-in workers.  
299        These problems become more dramatic when crises last for a long time (Brenke et al.,  
300        2013).

301        Short-time work programs vary depending on generosity, work-sharing, eligibil-  
302        ity, and conditionality requirements (Hijzen and Venn, 2011). These program design  
303        features can account for differences in participation rates across different countries  
304        (Boeri and Bruecker, 2011; Cahuc and Carcillo, 2011). Generosity refers to the cost  
305        of implementation, such as the share covered by firms, worker’s perceived income,  
306        and the maximum duration of the program. Concerning company requirements to  
307        receive allowances, these include setting up the distribution of hour reductions among  
308        workers, providing evidence of temporary business downturns, or training obligations.  
309        Amendments to the regulatory framework, for instance, by making conditions more  
310        attractive or speeding up implementation, aim at increasing participation rates during  
311        periods of economic downturn. However, amendments imply a trade-off between take-  
312        up and cost-effectiveness, which in periods of crisis usually shifts toward maximizing  
313        participation (Hijzen and Venn, 2011). The shift occurs because dead-weight and dis-  
314        placement costs are less significant during economic downturns (Boeri and Bruecker,  
315        2011).



## 2.4. Short-time work programs in nations affected by the 2013 floods

Considering that previous cross-country studies on short-time work only provide information about the programs during the 2008 financial crisis, Table 1 presents some of the features of affected nations' short-time work programs in 2013.<sup>11</sup> With a long history of implementation, significant duration, and high levels of generosity, Germany and Austria had the most robust mechanisms across all five nations during the 2013 European floods. This is in line with Sacchi et al. (2011), who show that, compared to the Italian short-time work program, the program features in Germany and Austria share many similarities. In contrast, Hungary had no active program, while the Czech Republic and Slovakia had a significantly less generous and shorter in duration program.<sup>12</sup> Moreover, the Czech Republic and Slovakia, already less experienced with implementing these types of programs, did not modify their existing programs to encourage take-up during the catastrophe. According to Arpaia et al. (2010, p. 5), countries with less robust programs also imposed stricter conditions on the application process. We next take a closer look at some of these characteristics.

Germany was the first country to implement short-time work policies over a century ago (Messenger and Ghosheh, 2013). The German short-time work program or Kurzarbeit saw considerable participation rates particularly during both post-war periods, the Great Depression, the 1970s and 80s oil crises, German reunification, and throughout the 2008 financial crisis (Brenke et al., 2013). Economic short-time work applies if a company suffers from business downturns or unavoidable events. To qualify for the program, the employer must send a report to the Federal Employment Agency after reaching an agreement with its employees and after alternative work-reduction measures, such as the use of overtime hours, are exhausted. Essential conditions include the "one-third" rule, requiring that at least one-third of the company employees are affected by a loss of earnings of ten to hundred percent of their gross monthly

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<sup>11</sup>The German Social Security Code **SGB** III, the Austrian Labor Market Services Act (§37b), and the Slovak Employment Services Act (§50k) contain additional details on the programs.

<sup>12</sup>Hungary implemented three different programs during the financial crisis, the two nationally-financed schemes finished in 2009 and an ESF-financed project completed in early 2010 (OECD, 2010). There was no evidence of any active post-recession short-time work scheme in the country.

Table 1: Differences between short-time work programs in 2013

	Austria	Germany	Czechia	Hungary	Slovakia
Permissible reductions	10% - 90%	10% - 100%	20% - 60%	-	6% - 20%
Maximum duration (months)	24	24	12	-	3
Replacement rate	55%	60%	60%	-	60%
Compensation rate	55%	60%	N/D	-	30%
Compensation limit			✓	-	✓
Cost to employer	15%	10%	25%	-	50%
Initial job retention (paid by employer)			✓	-	✓
Program before 2008	✓	✓		-	
Program in 2013	✓	✓	✓	-	✓
Flood amendments	✓	✓		-	

**Notes:** This table compares program characteristics in different affected nations in 2013. Permissible reductions refer to the minimum and maximum reductions in weekly working hours. The maximum duration refers to the maximum number of months that an employee can receive the subsidy. The cost to the employer is the percentage of the wage covered by firms for hours not worked (we borrow 2008 values from Hijzen and Venn (2011)). Evidence refers to the requirement of showing evidence of a business downturn. Flood amendments refer to the existence of any amendment facilitating participation during the 2013 floods.

343 salary. Although the regular maximum duration of the subsidy is six months, it can  
344 be extended up to twenty-four months under exceptional circumstances. The subsidy  
345 amounts to sixty percent of the difference between the target and net wage.<sup>13</sup> Compa-  
346 nies also have to cover part of the costs of non-worked hours. For instance, they need  
347 to cover around eighty percent of employer's and employee's share of social security  
348 contributions of non-worked hours.<sup>14</sup> During the 2013 floods, not only could directly  
349 affected companies receive the benefit, but also those indirectly affected.<sup>15</sup> Under a  
350 € 15 million special program implemented between June and December 2013, 3,400  
351 directly affected companies (and almost 18,000 employees) could get their social secu-  
352 rity contributions reimbursed for a maximum of three months (European Commission,  
353 2013; BA, 2014). Furthermore, the Federal Employment Agency circulated an infor-  
354 mation sheet to companies affected by the flood, offering assistance and reporting  
355 simplifications to the application process (BA, 2013).

356 Austria implemented short-time work (Kurzarbeiterbeihilfe) for the first time dur-

<sup>13</sup>For a 100% loss of working time, the employee receives the same income as with unemployment benefits.

<sup>14</sup>These additional costs represented about 46% - 59% of usual labor costs for each working hour lost in 2008 (Brenke et al., 2013).

<sup>15</sup>A company is indirectly affected when it limits production because the supplying companies cannot deliver due to flooding.

357 ing the inter-war period of 1918-1939 (Suschitz, 2010). In 2013, employers whose ac-  
358 tivity was affected by temporary non-seasonal economic difficulties were eligible as  
359 long as they applied for assistance three weeks before the start of the program. The  
360 regular program's duration was between six and twenty-four months, requiring the loss  
361 of work to be between ten and ninety percent of the regular weekly working hours.  
362 Depending on the net remuneration level and irrespective of the number of working  
363 hours and associated loss, employees receive about ninety percent of their monthly  
364 salary. This program also saw considerable participation rates during previous disas-  
365 ters, such as the 2002 floods (Bock-Schappelwein et al., 2011). Furthermore, in the  
366 event of natural disasters, individual companies can bypass the requirement of having  
367 a collective agreement. Additionally, Austria employed several mechanisms to encour-  
368 age participation during the floods. Through a public announcement, the authorities  
369 assured that the process was going to be handled "quickly and easily," as opposed  
370 to regular conventions (Niederösterreichische Nachrichten, 2013). The Labor Market  
371 Service in Tirol even launched a unique disaster-specific project under the title "Flood  
372 Disaster June 2013" (Tiroler Tageszeitung, 2013).

373 The Czech Republic implemented the program "Educate Yourself for Stability"  
374 (Vzdělávejte se pro stabilitu) between September 2012 and August 2015 (MLSACZ,  
375 2012). The program received a total of CZK 400 million (around € 16 million in 2013)  
376 (85% ESF and 15% national) to enable employers to obtain a financial contribution for  
377 implementing professional development programs during periods of economic down-  
378 turn, including support to the wage costs of trained employees. To be eligible, com-  
379 panies needed to show a decrease of more than twenty percent in the volume of sales  
380 per employee in three calendar months before applying compared with the equivalent  
381 period of the previous year. Additionally, they must show that they could not allocate  
382 work for more than twenty percent of the weekly working hours (up to a maximum of  
383 sixty percent). Besides this, they must provide evidence that, at their own expense,  
384 they retained jobs for at least one month before the application. Note that employers  
385 must pay a wage compensation of at least sixty percent of average earnings to affected  
386 employees throughout the whole downturn period. The government subsidy supports  
387 this wage compensation. The monthly allowance covered up to CZK 31,000 (around

388 € 1200 in 2013) of the wage compensation amount. The regular period of granting  
389 the support was six months (up to twelve months).

390 Slovakia implemented the program "Contribution to Support the Maintenance of  
391 Jobs" (Príspevok na podporu udržania pracovných miest) (UPSVR, 2012). This pro-  
392 gram has many similarities to the one in the Czech Republic. To be eligible, employers  
393 must give evidence of a transitional business downturn and pay a wage compensation  
394 of at least sixty percent of average earnings to affected employees throughout that  
395 period. However, stricter than in the Czech Republic, they must show that they re-  
396 tained jobs at their own expense for at least three months before the application. The  
397 monthly short-time work allowance was fifty percent of this wage compensation, up  
398 to fifty percent of the country's average wage in the previous year (Slovakia's average  
399 gross monthly wage was close to € 800 in 2012). The loss of work had to be between  
400 six and twenty percent of the contractual weekly working hours. Employers could  
401 implement the program for sixty working days, as long as the contractual relationship  
402 started at least twelve months before the request.

403 Despite the existence of short-time work in Slovakia and the Czech Republic, we  
404 could not find any information indicating its use or any amendment facilitating par-  
405 ticipation during the floods. Besides the lack of crisis-specific modifications, their  
406 programs' restrictive characteristics suggest that these countries did not have suit-  
407 able mechanisms to reduce the disaster's adverse effects on their labor market. These  
408 restrictive characteristics include budget constraints and low levels of generosity in  
409 Slovakia or the training obligation and the "loss in the last three months" requirement  
410 in the Czech Republic. Motivated by this, in Slovakia as of 2020, there is pressure to  
411 shift to the German short-time work model. However, government officials claim that  
412 the introduction of such a model would require extensive legislative changes that the  
413 government does not foresee (MLSAF, 2020). Moreover, because participation rates  
414 in the Czech Republic in 2013 were lower than expected, in 2014, the authorities made  
415 several amendments to the program's features (LOCZ, 2014).

416 Figure 2 presents yearly series for the average number of reports and the total  
417 number of workers under short-time work in Germany and Austria. Although Germany  
418 discloses monthly data on a periodical basis, which we use later in the paper, we plot

419 yearly values for comparison reasons given that Austria only reports data with yearly  
420 frequency.<sup>16</sup> The left panel shows values from 2007 to 2015; the right panel zooms  
421 in on the 2011-2015 period. Following the enormous increase in participation during  
422 the 2008 financial crisis, there is a downward sloping trend after 2009 in both nations.  
423 Despite this, we see that in 2013 there seems to be an unusual increase in the use of  
424 short-time work. For instance, Austria had 1,797 reports and a total of 4,010 short-  
425 time employees in 2013, corresponding to a year-to-year increase of 32% and 13%,  
426 respectively.

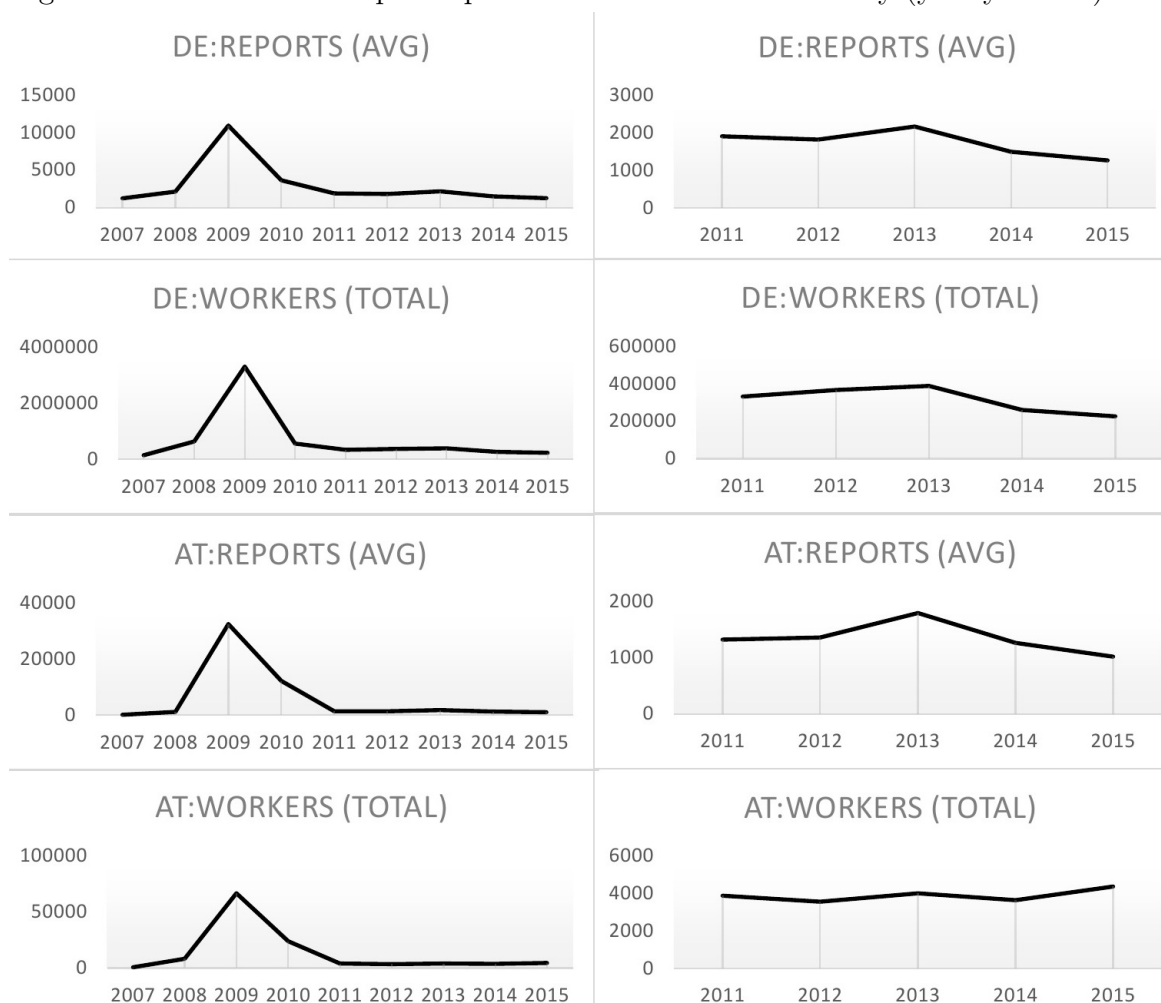
## 427 **2.5. Other institutional arrangements and interaction**

428 Two major national-level labor institutions affecting dismissals and, therefore, the de-  
429 mand for short-time work refer to employment protection legislation and the generos-  
430 ity of unemployment benefits (Van Audenrode, 1994; Boeri and Bruecker, 2011; Cahuc  
431 and Carcillo, 2011). Strict employment protection and less generous unemployment  
432 benefits are related to higher take-up rates during the 2008 financial crisis (Boeri and  
433 Bruecker, 2011; Cahuc and Carcillo, 2011). Employment protection raises the relative  
434 costs of layoffs, making work-sharing strategies more attractive. Stable employment  
435 during periods of economic downturn affecting labor demand means that employers  
436 could not layoff or voluntarily decided not to do so. Whereas the latter strategy refers  
437 to labor hoarding strategies, the former is closely related to the prevailing strictness  
438 of employment protection (Möller, 2010). The generosity of unemployment benefits,  
439 on the other hand, works in the opposite direction. Generous unemployment benefits,  
440 relative to the generosity of the short-time work compensation, make unemployment a  
441 superior income maintenance strategy. According to Van Audenrode (1994), to gener-  
442 ate significant fluctuations in working hours, short-time work must be more generous  
443 than unemployment benefits. Note that under generous unemployment benefits but  
444 the absence of short-time work, firms would solely rely on unemployment insurance  
445 to finance dismissals, making the latter less efficient and imposing a greater negative  
446 fiscal externality (Arpaia et al., 2010; Boeri and Bruecker, 2011).

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<sup>16</sup>Unfortunately, we could not find quantitative information regarding short-time work participa-  
tion for other countries.

Figure 2: Short-time work participation in Austria and Germany (yearly values)



**Notes:** This figure shows short-time work participation in Austria and Germany. The left panel shows values from 2007 to 2015. To better visualize the shock in 2013, the right panel repeats the values from 2011 to 2015. For Austria, reports are the annual average of the number of monthly funding cases and workers are the total number of employees who received funding in the year (Nagl et al., 2019). For Germany, reports are the annual average number of monthly reports (economic short-time work) and workers are the total number of employees that appear in the reports in that year (BA, 2020). Note that the magnitudes between the two countries are not directly comparable since each person is counted once in Austria, and not all reports receive funding in Germany.

447 Table 2 presents values on the two institutions for each of the five inundated coun-  
 448 tries. Regarding the strictness of employment protection, we see that although Aus-  
 449 tria, Germany, and Slovakia have similar index values, the Czech Republic has a much  
 450 stricter employment protection legislation. It stands in contrast to Hungary, which has  
 451 a much lower index value. These values suggest that in the Czech Republic, layoffs are  
 452 more expensive relative to other countries. To substitute for this, companies will try  
 453 to use time-flexibility measures and apply for wage-support assistance programs. Con-

Table 2: Institutional interaction indicators in 2013

	Austria	Germany	Czechia	Hungary	Slovakia
Employment protection strictness	2.29	2.60	3.26	1.59	2.51
Generosity of unemployment benefits (percentage of previous income)	55%	59%	65%	68%	62%

**Notes:** This table reports values on the strictness of employment protection and the generosity of unemployment benefits for each inundated country. For the strictness of employment protection, we use the OECD index on individual and collective dismissals of regular contracts in 2013. For the generosity of unemployment benefits, we use the OECD net replacement rates in unemployment, which refer to the percentage of previous in-work income after two months of being unemployed in 2013.

cerning the generosity of unemployment, we see that while Austria and Germany have slightly lower values than the rest of the countries, Hungary has the most generous unemployment benefits. This means that employees in Hungary are, from an income perspective, better off going into unemployment than employees in other countries. Compared to short-time work replacement rates, we see that, while most countries have very similar values, the replacement rate of unemployment in the Czech Republic (Slovakia) is higher than that of short-time work by five (two) points. From an income perspective, employees might again prefer unemployment to short-time work. Altogether, it is possible to say the institutional setting in Hungary facilitates labor adjustments via the extensive margin by combining lenient employment protection with high unemployment benefits. Although unemployment benefits are also high in the Czech republic, employment protection makes short-run employment adjustments somewhat prohibitive.

### 3. Data and overview

Conforming to the floods' duration and different severity levels by region, we use monthly data at the county level for the analysis.<sup>17</sup> For all variables, we work exclusively with information for years 2011 to 2015, which corresponds to the most

<sup>17</sup>To homogenize counties across nations, we work at the NUTS (Nomenclature of Territorial Units for Statistics) 3 level.

471 prolonged symmetric period around the flooded month (June 2013) not overlapping  
472 with the long-term effects of the financial crisis in 2008. Monthly data on short-time  
473 work and unemployment across all German counties comes from the Federal Employ-  
474 ment Agency (BA, 2020).<sup>18</sup> We consider three key participation variables: the number  
475 of short-time companies, the number of short-time employees, and the number of full-  
476 time equivalents (FTEs).<sup>19</sup> Although the remaining countries do not disclose monthly  
477 short-time work data, we retrieve unemployment data from the Public Employment  
478 Service of Austria (AuM, 2020); the Ministry of Labour and Social Affairs of the  
479 Czech Republic (MLSACZ, 2020); the Ministry of Labor, Social Affairs and Family of  
480 the Slovak Republic (MLSAFSK, 2020); and the Hungarian Central Statistical Office  
481 (Hungarian Statistical Office, 2020).<sup>20</sup>

482 To calculate the flood extent, we use inundation maps from NASA’s MODIS Near  
483 Real-Time Global Flood Mapping Project (Policelli et al., 2017). These maps are based  
484 on MODIS 250m resolution (10x10 degree tiles) data from NASA’s Terra and Aqua  
485 satellites. The project uses an algorithm that identifies flooded areas by comparing  
486 detected water to a reference water layer. To minimize shadow problems from clouds  
487 and terrain, it generates several multi-day composites of water surfaces. In this study,  
488 we use the 3-day composite product, which uses three consecutive days to determine  
489 the flood extent for one particular day. To get the maximum flood extent, we overlay  
490 all daily flood extents during the flood period (May 20th to June 30th).<sup>21</sup>

491 Figure 3 depicts affected counties according to three different flood extent groups:  
492 counties with less than one, one to five, and more than five square kilometers of  
493 flooded land.<sup>22</sup> In line with information on the regions with the highest financial  
494 losses presented above, the most affected areas cluster along the Elbe river in Germany

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<sup>18</sup>We only use data on economic short-time work since it is the only category covering unexpected events including natural disasters.

<sup>19</sup>The Federal Employment Agency calculates the latter based on the difference between target and actual remunerations.

<sup>20</sup>Given that the Hungarian Central Statistical Office only discloses quarterly unemployment at the county level, we impute missing monthly values by using monthly national unemployment rates and quarterly regional shares of employment.

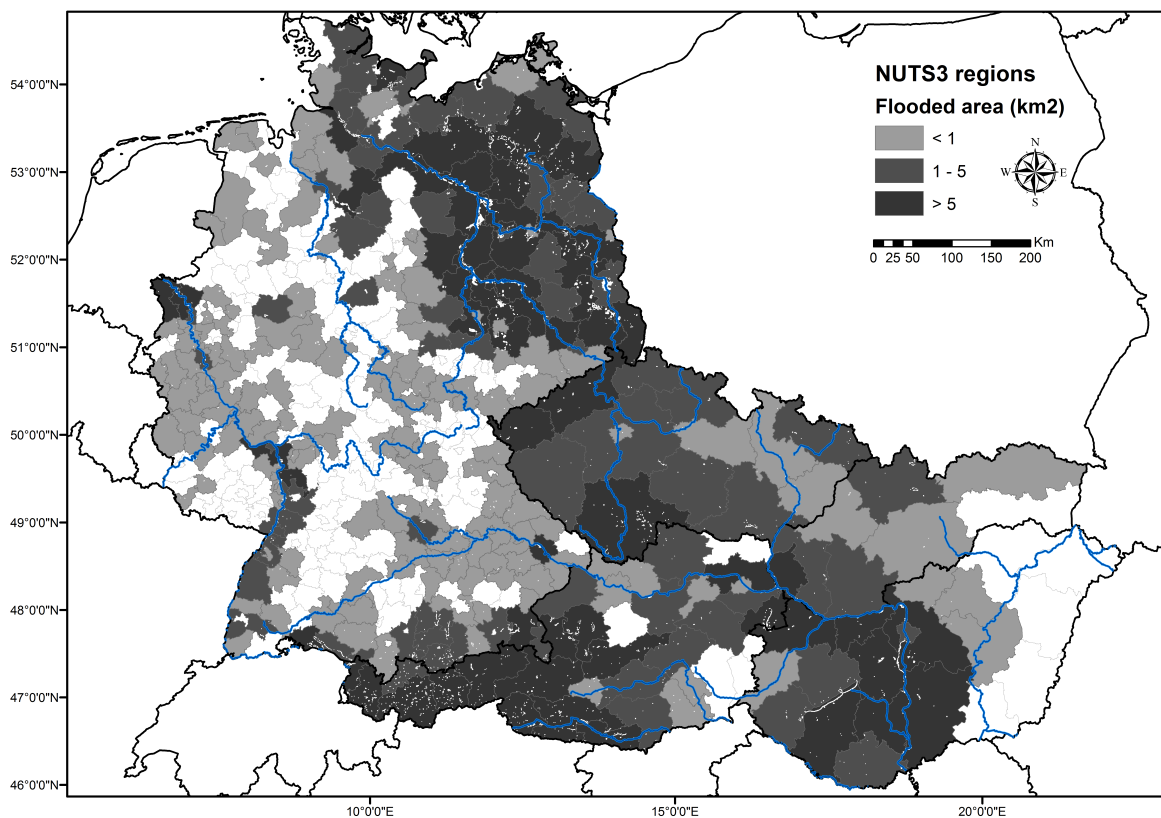
<sup>21</sup>Given that the algorithm generates several pixel edge errors along the coastline due to the use of a static reference water layer, we exclude inundations along the coast.

<sup>22</sup>Inundation areas per region follow a very skewed distribution, with a mean (median) value of 4.87 (0.86) square kilometers and a standard deviation of 14.41.



495 (north-east of the country), the Danube river (close to the border between Austria,  
 496 Slovakia, and Hungary and through central Hungary), the Ohre and Vltava rivers in  
 497 the Czech Republic (west of the country), and the Rhine and Inn rivers in Austria  
 498 (west of the country). With almost 200 square kilometers of flooded land, Stendal is  
 499 the (German) county with the greatest extent of flooding. Table 3 presents further  
 500 descriptive information on the inundations. With 1,424 square kilometers of flooded  
 501 land, the inundations affected 61% of all counties: 227 in Germany, 30 in Austria, 14  
 502 in the Czech Republic, 15 in Hungary, and 7 in Slovakia. Note, however, that although  
 503 Germany has the highest number of affected counties, the flood only affects 57% of its  
 504 counties, while affecting all counties of the Czech Republic.

Figure 3: The 2013 Central European floods by county and flood extent



**Geo-source:** Policelli et al. (2017)

**Notes:** This map shows flood-affected counties (NUTS 3 regions) in the five affected nations according to three flood extent levels. To calculate flooded areas in  $km^2$  for each county, we sum up all inundations (in white) within each county. The main river network is in blue.

Table 3: Flooded regions by flood extent and country

	Number of affected counties	% of all counties in the country	Total flooded area ( $km^2$ )	% of total area of affected counties
<b>Counties with reported high-water levels</b>				
Germany	227	56.61	1059	0.42
Austria	30	85.71	155	0.21
Czechia	14	100	44	0.06
Hungary	15	75.00	148	0.23
Slovakia	7	87.50	19	0.05
Total	293	61.30	1426	0.28

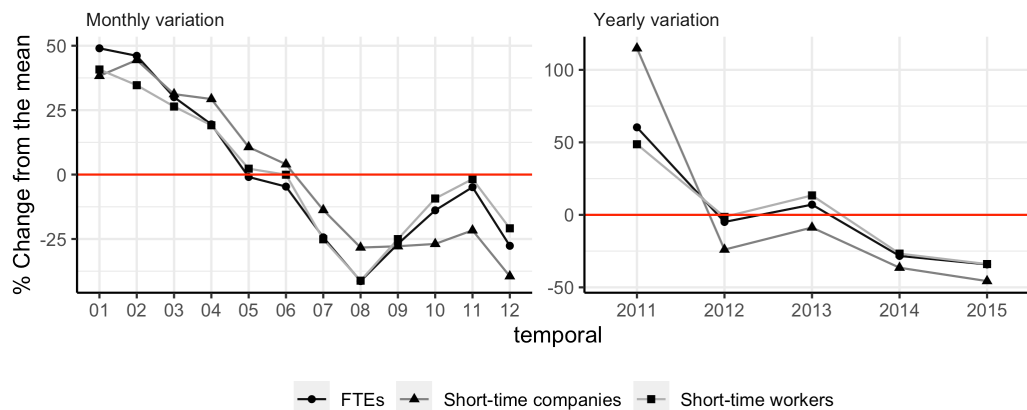
**Notes:** For each flood-affected nation, this table presents the number and percentage of affected counties and corresponding flooded area in  $km^2$ .

505 Figure 4 plots the temporal variation of the three variables measuring short-time  
506 work in Germany. From the left panel, we see that, at the monthly level, short-time  
507 work is higher during the first months of the year and lower in the summer months  
508 and December. Concerning yearly behavior, short-time work decreases throughout  
509 the sample period, with its highest value in 2011 and its lowest in 2015, in line with  
510 the yearly country-level figures presented above. This long-term behavior comes from  
511 the German busyness cycle and its recovery after the 2008 financial crisis. To have  
512 a better look at the behavior of the variables during the flood, Table 4 presents the  
513 May-to-June growth rates in 2012, 2013, and 2014. The first row in each panel shows  
514 the value for all counties in the country, the next only for flooded counties, and the  
515 third for Stendal, the most flooded county. While, in line with the average monthly  
516 variation, changes in 2012 and 2014 are generally negative and always small; in 2013,  
517 they are positive and larger in magnitude. As expected, the effects become larger  
518 when we only include flooded counties, and they become enormous for Stendal, with  
519 growth values over 4,000% in the number of FTEs.<sup>23</sup>

520 Finally, Figure 5 presents monthly and yearly variation in regional unemployment  
521 rates across affected Central European countries. On average, regional unemployment  
522 rates are higher in Slovakia and lower for Austria and Germany. All nations exhibit a  
523 u-shaped monthly behavior with valleys in the summer and peaks during the winter,  
524 notably Austria and the Czech Republic. Concerning the long-term behavior, we can  
525 see a negative trend in Germany, Hungary, and the Czech Republic. In Slovakia,  
526 unemployment increases until 2013 and drops sharply thereafter, while in Austria, we

<sup>23</sup>The results keep increasing in size as we increase the flood threshold to consider a county as inundated.

Figure 4: Temporal variation in regional short-time work in Germany



**Notes:** The figure shows the temporal variation in average regional short-time work participation for each month of the year (left panel) and each year of the sample period (right panel). The y-axis gives the percentage deviation from the overall average. For example, a value of zero means that for that month (year), short-time work is the same as the average over all months (years).

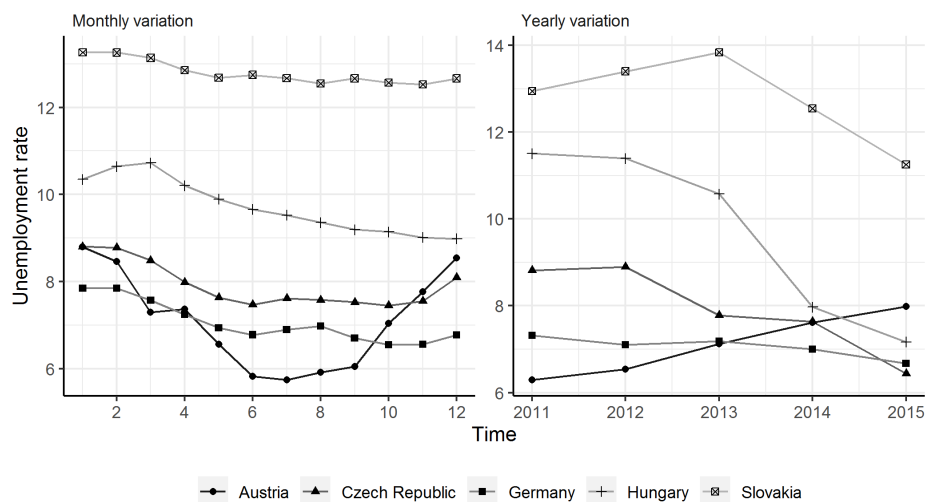
Table 4: May-to-June regional short-time work participation growth rates in Germany

	May-to-June growth		
	2012	2013	2014
	<b>Short-time companies</b>		
All counties	-7.76%	24.25%	-11.96%
Flooded counties	-5.49%	41.52%	-13.07%
Stendal	-14.29%	2100.00%	0.00%
	<b>Short-time employees</b>		
All counties	-10.26%	16.73%	-7.76 %
Flooded counties	-6.77%	21.38%	-6.70%
Stendal	3.85%	1844.83%	0.00%
	<b>FTEs</b>		
All counties	-9.76%	28.36%	-19.69%
Flooded counties	-5.52%	35.75%	-8.35%
Stendal	49.06%	4465.81%	0.00%

**Notes:** This table presents May-to-June growth rates of short-time companies (upper panel), employees (middle panel), and FTEs (lower panel) in 2012, 2013, and 2014, for different groups of counties. Except for the district of Stendal, values are regional averages over all counties in a given group.

527 can see a stable increase between 2011 and 2015.

Figure 5: Temporal variation in regional unemployment



**Notes:** This figure shows the temporal variation in average regional unemployment rates for the Central European countries affected by the 2013 European floods. The left panel shows the month to month averages and the right panel the yearly means.

## 4. Empirical strategy

To determine if short-time work programs are effective in avoiding unemployment after a natural disaster, we first provide empirical evidence on the use of short-time work in Germany and the stability of employment in Germany and Austria during the floods. If the floods have an impact, we would expect to see a significant increase in all short-time work variables. Although data limitations prevent us from conducting this exercise for other nations, we expect these to have lower participation rates considering that the restrictive characteristics of the programs limit participation (Boeri and Bruecker, 2011; Cahuc and Carcillo, 2011). Further, given the robust characteristics of programs in Germany and Austria, we expect to find little to no monthly unemployment effects.

Could Germany and Austria have experienced no unemployment changes even in the absence of a robust short-time work program? To see if short-time work is related to previous labor market outcomes, we exploit the variation in short-time work program characteristics in other flooded nations and flood extent intensities. Although we would ideally compare flooded regions in Germany and Austria with other same countries' flooded regions without (sufficient) access to short-time work, the country-wide coverage of the programs does not allow us to construct such a counterfactual.

545 To substitute for that, we refer to labor market outcomes in the three other affected  
546 nations. Although these countries show high variability in their programs, all had  
547 more restrictive characteristics. Based on previous studies giving evidence on lower  
548 short-time participation rates in countries with less robust programs and on the adverse  
549 effects of natural disasters in labor markets, we expect to find (larger) positive changes  
550 in unemployment in countries with such programs compared to countries with robust  
551 programs. To strengthen the previous argument, we exploit the differences in flood  
552 intensities by stepwise restricting the sample to regions with a larger flooded area.  
553 As we reduce the sample, we expect to find higher short-time work participation in  
554 Germany along with no unemployment changes in countries with robust programs,  
555 but more substantial employment effects in the other countries.

556 To avoid contaminated point estimates arising from unaccounted temporal effects,  
557 we run an augmented local-linear regression discontinuity in time design (ARDiT)  
558 (Hausman and Rapson, 2018).<sup>24</sup> The ARDiT framework divides the estimation into  
559 two stages. In the first stage, we control for temporal covariates by running a fixed-  
560 effects panel regression of our dependent variables as a function of time effects. In  
561 the second stage, we use the residuals from the first stage in a standard local-linear  
562 regression discontinuity design.<sup>25,26</sup> As such, the ARDiT design captures the local  
563 average treatment effect of the inundations on our dependent variables.

564 Equation 5 shows the first stage regression. In line with studies on the growth  
565 effects of natural disasters,  $\Delta \ln y_{ct}^i$  is the first log-difference  $[\ln(y_{ct}^i) - \ln(y_{ct-1}^i)]$  of  
566 variable  $i$  at time  $t$  in county  $c$ .  $\ln y_{ct-1}^i$  is the lagged natural logarithm of  $y_{ct}^i$ ,  $\omega_t$   
567 controls for the year of the observation,  $v_t$  for the month,  $\gamma_c$  is a term of county-  
568 specific fixed effects, and  $\mu_{ct}^i$  are the residuals.<sup>27</sup> The dependent variable  $i$  is the  
569 growth rate of the number of short-time firms, the number of short-time employees,  
570 the number of FTEs, and the unemployment rate in county  $c$  and month-year  $t$ . Due  
571 to information limitations, we only run the first three variables for Germany.

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<sup>24</sup>For instance, if May and June are months with high levels of unemployment, failing to control for the month effect would increase the coefficients of a simple regression discontinuity design.

<sup>25</sup>Gelman and Imbens (2019) provide evidence on the better performance of local linear fits versus higher-order polynomials of the running variable in regression discontinuity designs.

<sup>26</sup>For all regressions, we use the R package 'rdrobust' (Calonico et al., 2015).

<sup>27</sup>Studies using the same first log-difference growth specification include Felbermayr and Gröschl (2014) or Loayza et al. (2012).

$$\Delta \ln y_{ct}^i = \rho_i \ln y_{ct-1}^i + \omega_t + v_t + \gamma_c + \mu_{ct}^i \quad (5)$$

Equation 6 specifies the functional form of the second stage.  $\mu_{st}^i$  are the residuals from the previous equation.  $Flood_{ct}$  is a dummy variable that equals one after the flood and zero otherwise.  $\beta_i$  is the point estimate of interest as it measures the impact of the flood at the discontinuity.  $x_{ct}$  is a running variable measuring the temporal distance to the discontinuity date.  $f(Flood_{ct} \times x_{ct})$  is a linear trend before and after the discontinuity, and  $\epsilon_{ct}$  is an idiosyncratic error term. Because the floods began in May 2013, and companies were not able to receive benefits until June, we set the discontinuity for the short-time work variables to June and for the unemployment rates to May. Finally, we cluster standard errors at the month  $\times$  county level.

$$\mu_{ct}^i = \beta_i Flood_{ct} + f(Flood_{ct} \cdot x_{ct}) + \epsilon_{ct}^i \quad (6)$$

We report results using robust-bias-corrected (RBC) confidence intervals. RBC differs from conventional OLS confidence intervals in that they take into consideration the bias stemming from the non-parametric approximation of the local polynomial in the determination of point estimates and standard errors at the discontinuity. According to Cattaneo et al. (2019), these estimates are theoretically valid, enjoy excellent optimality properties, and perform well in empirical applications. Additionally, we report observations to the left and right of the discontinuity, the bandwidth around the threshold, and the polynomials for both the estimate fit and its bias correction. The bandwidth around the discontinuity comes from the plug-in rules based on mean square error expansions described by Calonico et al. (2015).

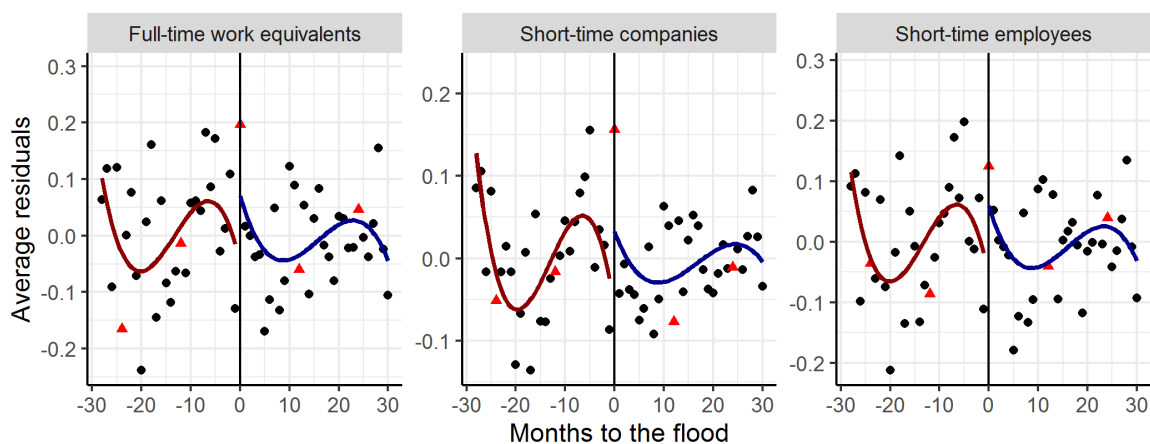
The basis for identification is the idea that the floods are the only reason behind changes in our dependent variables at the date of the discontinuity. The only threat to identification is that conditional on year, month, and county fixed effects, there might still be uncontrolled and discontinuous time effects on the month of the floods. However, we do not find evidence of other relevant shocks occurring in the same counties and dates of the 2013 events. To test the robustness of the results, we also conduct placebo tests that randomize the discontinuity across space and time.

## 598 5. Results

### 599 5.1. Short-time work in Germany

600 Figure 6 shows the discontinuity in the residuals of short-time work participation  
601 variables in Germany's flooded counties. All three variables exhibit a clear spike in  
602 June 2013, the month of the inundation. This finding is remarkable given that June  
603 is traditionally a month with low levels of short-time work. Table 5 contains the  
604 estimation results at the discontinuity. We see a significant increase in the number  
605 of short-time companies by 29%, short-time employees by 25%, and full-time work  
606 equivalents by 33%. The endogenously estimated bandwidth revolves between three  
607 and ten months. It is in concordance with the maximum duration of the special flood  
608 program covering social security contributions of directly affected companies and the  
609 regular duration of short-time work.

Figure 6: Discontinuity of short-time work residuals in Germany



**Notes:** This figure contains the graphical representation of the discontinuity at  $t = 0$  (June 2013) of the average residuals from the first difference of short-time-work variables (Equation 5). The red marks correspond to June 2011, 2012, 2013, 2014, and 2015. The global polynomial is of order 3 and uniform kernel.

### 610 5.2. Unemployment in flooded nations

611 Figure 7 shows the discontinuity in the unemployment residuals in flooded counties in  
612 Germany and Austria. Unlike the previous figures, there is a small negative spike for

Table 5: Regression discontinuity results for short-time work participation in Germany

<i>Discontinuity: 2013 European Floods</i>			
	$\Delta \ln$ Companies	$\Delta \ln$ Employees	$\Delta \ln$ FTEs
Robust Bias Corrected (RBC)	0.29*** (0.05)	0.25** (0.08)	0.33*** (0.07)
Obs. to the Left	669	894	894
Obs. to the Right	881	1101	1101
Conventional Est. Bandwidth	3.85	4.74	4.41
Bias-Corrected Est. Bandwidth	10.77	8.64	9.75

**Notes:** \*\*\* $p < 0.001$ , \*\* $p < 0.01$ , \* $p < 0.05$ ; this table contains the results from the augmented local linear regression discontinuity design on the average number of short-time companies, short-time workers, and full-time work equivalents in the German counties affected by the 2013 European floods. The discontinuity month is June 2013. Standard errors are clustered at the county  $\times$  month level. The order of the local-polynomial to construct the estimator (bias-correction) is 1 (2). The kernel function is triangular.

613 Austria and no spikes for Germany at the discontinuity. Table 6 shows the coefficients  
614 of the ARDiT specification. As suggested by the figures, the point estimate exhibits a  
615 non-significant negative effect in Austria while showing a significant marginal decrease  
616 of one percent in Germany. This counter-intuitive reduction in unemployment after  
617 the flood might be related to dead-weight losses in the implementation of short-time  
618 work.<sup>28</sup>

Table 6: Regression discontinuity results for unemployment in Austria and Germany

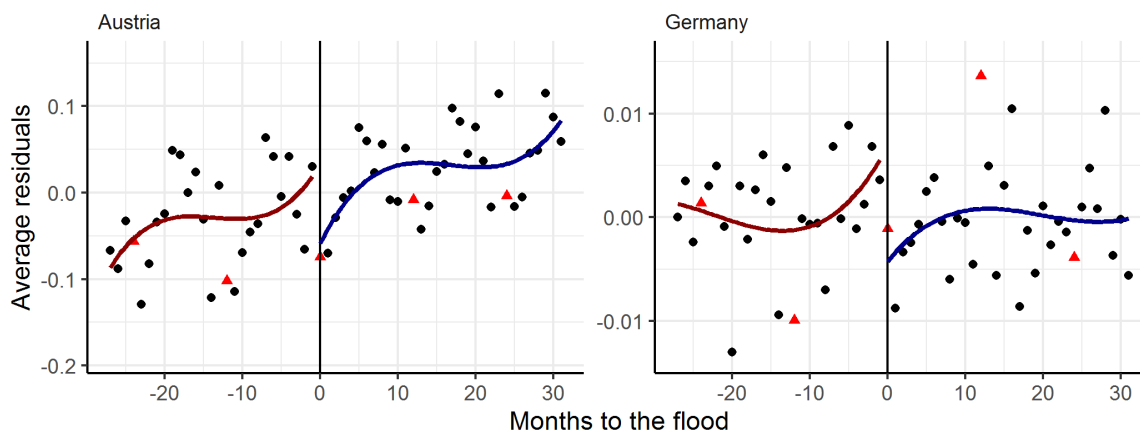
<i>Discontinuity: 2013 European Floods</i>		
	Austria	Germany
	$\Delta \ln$ Unemployment	$\Delta \ln$ Unemployment
Robust Bias Corrected (RBC)	-0.09 (0.09)	-0.01** (0.00)
Obs. to the Left	150	2043
Obs. to the Right	180	2270
Conventional Est. Bandwidth	5.62	9.32
Bias-Corrected Est. Bandwidth	9.77	15.03

**Notes:** \*\*\* $p < 0.001$ , \*\* $p < 0.01$ , \* $p < 0.05$ . This table contains the results from the augmented local linear regression discontinuity design on the rates of unemployment for Austria and Germany. The discontinuity month is May 2013. Standard errors are clustered at the county  $\times$  month level. The order of the local-polynomial to construct the estimator (bias-correction) is 1 (2). The kernel function is triangular.

<sup>28</sup>As noted in the introduction and in line with this finding, Germany's unemployment rate also declined during the 2008 financial crisis (Messenger and Ghosheh, 2013).



Figure 7: Discontinuity of unemployment residuals in Austria and Germany



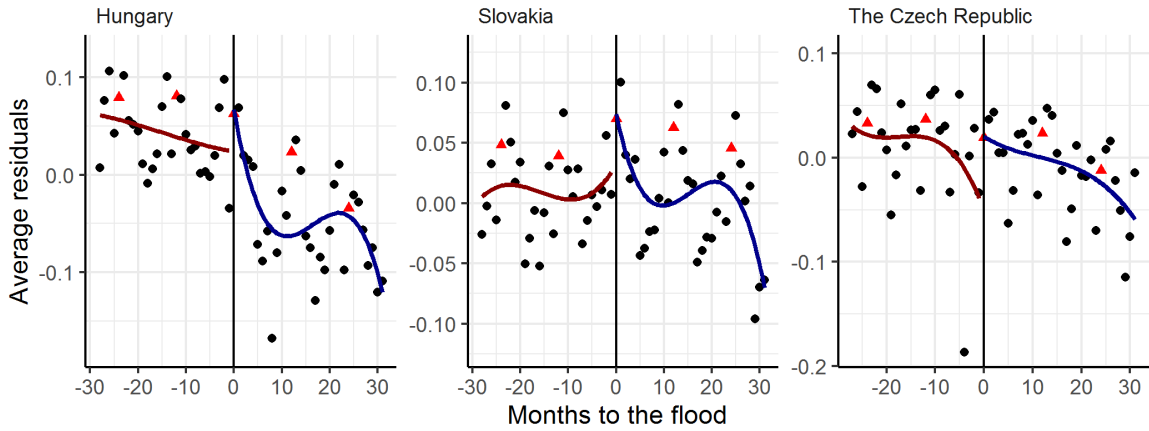
**Notes:** This figure contains the graphical representation of the discontinuity at  $t = 0$  (May 2013) of the average residuals from the first difference of unemployment (Equation 5). The red marks correspond to June 2011, 2012, 2013, 2014, and 2015, except for Austria, for which we do not have data for 2011. The global polynomial is of order 3 and uniform kernel.

619 Figure 8 shows the discontinuity in the unemployment residuals in flooded counties  
 620 of the other affected nations. In all cases, we can visually distinguish positive spikes  
 621 at the discontinuity in the month of the flood, albeit smaller in magnitude compared  
 622 to short-time participation variables. Table 7 shows the point estimates of the ARDiT  
 623 design. All three countries show a significant increment after the floods. For the  
 624 Czech Republic, Hungary, and Slovakia, the estimate indicates that the flood increased  
 625 unemployment by 7%, 9%, and 6%, respectively. These results are insightful in that the  
 626 unemployment rate of nations with less robust and generous short-time work schemes  
 627 increases in the aftermath of the flood. That the most substantial effect is for Hungary  
 628 is not surprising, given the absence of any short-time work program in this country.

### 629 5.3. Different flood extent intensities

630 Table 8 extends the previous results for different flood extent intensities: counties with  
 631 more than one and more than five square kilometers of flooded land. From the first  
 632 three columns, we see that all short-time work estimates grow significantly with the  
 633 size of the affectation. For the number of short-time companies, employees, and FTEs,  
 634 moving from all flooded counties to counties with more than five square kilometers of

Figure 8: Discontinuity of unemployment residuals in other flooded nations



**Notes:** This figure contains the graphical representation of the discontinuity at  $t = 0$  (May 2013) of the average residuals from the first difference of unemployment (Equation 5). The red marks correspond to June 2011, 2012, 2013, 2014, and 2015. The global polynomial is of order 3 and uniform kernel.

Table 7: Regression discontinuity results for unemployment in other flooded nations

<i>Discontinuity: 2013 European Floods (May 2013)</i>			
	The Czech Republic $\Delta \ln$ Unemployment	Hungary $\Delta \ln$ Unemployment	Slovakia $\Delta \ln$ Unemployment
Robust Bias Corrected (RBC)	0.07*** (0.02)	0.09* (0.04)	0.06*** (0.02)
Obs. to the Left	42	75	42
Obs. to the Right	56	90	49
Conventional Est. Bandwidth	3.60	5.73	6.02
Bias-Corrected Est. Bandwidth	6.22	10.19	8.69

**Notes:** \*\*\* $p < 0.001$ , \*\* $p < 0.01$ , \* $p < 0.05$ . This table contains the results from the augmented local linear regression discontinuity design on the rate of unemployment for the Czech Republic, Hungary, and Slovakia. The discontinuity month is May 2013. Standard errors are clustered at the county  $\times$  month level. The order of the local-polynomial to construct the estimator (bias-correction) is 1 (2). The kernel function is triangular.

635 flooded land, increases point estimates by 46%, 51%, and 43%, respectively. Regarding  
636 unemployment, from columns four and five, we see that, while the coefficient does not  
637 change for Germany, it slightly (negatively) grows for Austria but lacks significance  
638 throughout the inundation intensities. The last three columns give the results for the  
639 other nations. In line with our expectations, we see that unemployment increases with

640 the size of the inundation. Considering only significant coefficients, we see that, when  
641 moving from all flooded counties to counties with more than five square kilometers  
642 of flooded land, the Czech Republic and Hungary undergo unemployment increases  
643 of 7% and 8%, respectively. In Slovakia, unemployment increases by 3% at the one  
644 square kilometer threshold.

Table 8: Regression discontinuity results for different flood extent intensities

	<i>Discontinuity: 2013 European Floods</i>							
	$\Delta \ln$			$\Delta \ln$ Unemployment				
	Companies	Employees	FTEs	Austria	Germany	Czechia	Hungary	Slovakia
RBC (All)	0.29*** (0.05)	0.25** (0.08)	0.33*** (0.07)	-0.09 (0.09)	-0.01** (0.00)	0.07*** (0.02)	0.09* (0.04)	0.06*** (0.02)
RBC(1km <sup>2</sup> )	0.40*** (0.08)	0.39** (0.13)	0.46*** (0.12)	-0.13 (0.10)	-0.01** (0.00)	0.10*** (0.02)	0.11* (0.05)	0.09*** (0.03)
RBC(5km <sup>2</sup> )	0.75*** (0.15)	0.76*** (0.19)	0.76*** (0.17)	-0.13 (0.11)	-0.01* (0.01)	0.14* (0.07)	0.17* (0.07)	0.14 (0.11)

**Notes:** \*\*\* $p < 0.001$ , \*\* $p < 0.01$ , \* $p < 0.05$ ; this table contains the results from the augmented local linear regression discontinuity design on short-time work and unemployment variables in counties affected by the 2013 European floods. Standard errors are clustered at the county  $\times$  month level. RBC stands for robust-bias-corrected estimates. In parenthesis, the minimum flooded area required to include a county in the regression.

## 645 5.4. Robustness

646 We test the robustness of our results by shifting the floods to Finland, Scotland, and  
647 the United Kingdom, countries that were utterly unaffected by the 2013 European  
648 floods.<sup>29,30</sup> If the design is robust, we should not capture any impact at the disconti-  
649 nuity in these nation's unemployment rate. Table B.1 shows the estimation results. As  
650 expected, the point estimates are small and not significant for Finland and Scotland.  
651 Although the coefficient is significant in the UK-EWNI block, it is negative and small  
652 in magnitude.

<sup>29</sup>The estimates for the United Kingdom refer to England, Wales, and Northern Ireland.

<sup>30</sup>Monthly unemployment data for counties in Finland comes from the Employment Service Statistics of the Ministry of Economic Affairs and Employment (MEAE, 2020). Quarterly unemployment data for counties in the UK comes from the Annual Population Survey by the Office for National Statistics (ONS, 2020).

## 6. Conclusions

Based on evidence indicating that employment falls in the immediate aftermath of a natural disaster and on studies highlighting the effectiveness of short-time work programs in retaining jobs during the 2008 financial crisis, in this paper, we investigate the efficacy of short-time work to stabilize employment during the 2013 European floods. The empirical strategy uses regression discontinuity designs and exploits differences in the institutional background of affected nations to understand the dampening ability of short-time work programs. The model uses the sharp discontinuity in the flooded month to compare the value of variables just before and after the event.

Better than during the 2008 financial crisis, our results show that the short-time work mechanism could completely stabilize employment in flood-affected regions, in line with the literature that this mechanism reaches its maximum efficiency during short-lived shocks. We find high participation rates in Germany's flood-stricken regions and no unemployment changes in countries with robust short-time work programs (Germany and Austria), while uncovering increments in nations with less robust mechanisms. Specifically, regional unemployment rates in flooded regions of the Czech Republic, Hungary, and Slovakia increase by 7%, 9%, and 6%, respectively. As we reduce the sample only to include regions with a larger flooded area, we find that Germany's short-time work participation increases further, with unemployment remaining unaffected in Germany and Austria, but further increasing in the other flooded countries. Although the effects might point to different labor market mechanisms in each of the countries, we contend that, given that the impact happens simultaneously in many countries, it can be attributed to weaknesses or the absence of programs.

In a globalized world threatened with uncertainties of uncountable types, a better understanding of labor market programs' effectiveness is essential for ensuring economic well-being. The findings in this work are of interest for countries considering the implementation or adaptation of similar policies to cope with disasters' consequences. However, this does not mean that the German and Austrian programs can have the same effects in other contexts. As also argued by Boeri and Bruecker (2011), the success of such a program hinges upon other labor market institutions and their

683 interactions. Note also that, even if the short-time work mechanism was effective dur-  
684 ing the floods, we could not say anything about its cost-efficiency. It might be that,  
685 although the program could stabilize employment in flood-affected regions, the num-  
686 ber of subsidized hours was inefficient. In the case of dead-weight losses, programs  
687 might include experience-rating components.

688 Further analyses, similar to those studying the 2008 financial crisis, could combine  
689 plant-level data with flood extent and land-use information, to study the determinants  
690 of the short-time work take-up decision at the firm and regional levels. Further oppor-  
691 tunities include studying the behavior of additional labor market indicators, such as  
692 wages, or analyzing how the program affects the economy in the long run, for instance,  
693 by preventing creative destruction processes.

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## 985 **A Appendix: Initial labor market equilibrium**

986 In the model, the creation of matches  $m(u, v)$  depends on a traditional Cobb-Douglas  
 987 constant returns to scale matching function on the vacancy rate  $v$  and the unemploy-  
 988 ment rate  $u$ . The flow probability of matches for the job seeker and the company  
 989 are equivalent to  $\lambda_w = m(u, v)/u = \theta q(\theta)$  and  $\lambda_f = m(u, v)/v = q(\theta)$ , where  $\theta$   
 990 is the parameter of market tightness (fraction of vacancies over unemployed persons  
 991  $\theta = v/u$ ). The time evolution of unemployed persons in the economy is given by  
 992  $\dot{u} = \lambda F(\underline{\gamma}) \cdot (1 - u) - \lambda_w \cdot u$ , with existing matches endogenously separating at rate  
 993  $\lambda F(\underline{\gamma})$ , and new associations happening at rate  $\lambda_w$ . Equation A.1 shows the steady  
 994 state version of the equation. Note how disaster shocks shift the Beveridge curve  
 995 outward.

$$u = \frac{\lambda F(\underline{\gamma})}{\lambda F(\underline{\gamma}) + \lambda_w} \quad (\text{A.1})$$

996 Equation A.2 shows the present discounted value of a job, which depends on pro-  
 997 ductivity, total wage paid  $\omega(h, \gamma) \cdot h$ , and the job's surplus depending on the expected  
 998 job value  $E(J) = \int_{\underline{\gamma}}^{\tilde{\gamma}} J(x) dF(x)$ .  $r$  stands for the exogenous real interest rate. Note  
 999 that the job's value depends on the disaster shock  $\gamma$ , which directly affects produc-  
 1000 tivity: the larger the value of  $\gamma$ , the lower the firm's value. Equation A.3 shows the  
 1001 first-order-condition (FOC) of this equation concerning the intensive margin of labor  
 1002 demand ( $h$ ). This equation shows that the firm chooses the optimal number of labor-  
 1003 hours by subtracting from the marginal increase in productivity the marginal cost of  
 1004 paying this extra hour to the matched employee.

$$rJ(\gamma) = (1 - \gamma) \cdot p(h) - \omega(h, \gamma) \cdot h + \lambda[E(J) - J(\gamma)] \quad (\text{A.2})$$

$$(1 - \gamma) \cdot p_h(h) - \omega_h(h, \gamma) \cdot h - \omega(h, \gamma) = 0 \quad (\text{A.3})$$

1005 Equation A.4 shows the present discounted value of an unmatched firm (vacancy),  
 1006 where  $c$  is the cost of actively looking for a worker, and  $\lambda_f(J(\gamma) - V)$  the probability  
 1007 of finding a match multiplied by the job's surplus. A company will keep its job offer  
 1008 open as long as  $rV \geq 0$ . Contrary, the firm will close and leave the matching pool.

$$rV = -c + \lambda_f(J(\underline{\gamma}) - V) \quad (\text{A.4})$$

1009 Equations A.5 and A.6 show the value functions for employed and unemployed  
 1010 persons. The present discounted value of an employed person depends on the wage  
 1011  $\omega(h, \gamma)$ , the number of working hours  $h$ , the disutility of labor  $\Omega(h)$ , and the worker's  
 1012 surplus depending on the expected value of being employed  $E(W) = \int_{\underline{\gamma}}^{\tilde{\gamma}} W(x) dF(x)$ .  
 1013 For the unemployed person, the value function depends on its income from unemploy-  
 1014 ment benefits  $b$ , and the worker's surplus times the job-finding probability rate.

$$rW(\gamma) = \omega(h, \gamma) \cdot h - \Omega(h) + \lambda[E(W) + F(\underline{\gamma})U - W(\gamma)] \quad (\text{A.5})$$

$$rU = b + \lambda_w(W(\underline{\gamma}) - U) \quad (\text{A.6})$$

1015 Traditionally, search and matching literature settles salaries with a straightforward  
 1016 Nash bargaining rule. This rule emerges because both firms and workers create bi-  
 1017 lateral monopolies by bargaining over the match quasi-rents. Equation A.7 shows the  
 1018 bargaining rule, where individuals and firms share the surplus from matching according  
 1019 to the worker's bargaining power  $\beta$ .

$$(1 - \beta)(W(\gamma) - U) = \beta(J(\gamma) - V) \quad (\text{A.7})$$

1020 By substituting in this equation the previous value functions and using the free-

1021 entry conditions requiring that  $V = 0$ , we obtain wage-setting equation A.8. Note  
 1022 that as  $\gamma$  increases, wages fall. According to this equation, when the disaster causes a  
 1023 productivity shock, the worker would earn a new wage  $\omega^\gamma < \omega$ . The reduction from  $\omega$   
 1024 to  $\omega^\gamma$  entails match destruction because, for a share of workers, the outside option is  
 1025 now more attractive. Moreover, for firms unable to reduce wages due to wage rigidities,  
 1026 the only option is to destroy labor agreements.

$$\omega(h, \gamma) \cdot h = \beta[(1 - \gamma) \cdot p(h) + \theta c] + (1 - \beta)(b + \Omega(h)) \quad (\text{A.8})$$

1027 Equation A.9 shows the optimal level of hours, after substituting the wage equation  
 1028 on the first-order condition of the firm's value function regarding working hours (Eq.  
 1029 A.3) and assuming that  $p(h) = h^\alpha$  with  $0 < \alpha < 1$ . Note that the intensive margin of  
 1030 labor also depends on the disaster shock: the greater the shock, the lower the number  
 1031 of optimal hours  $h_\gamma^* < 0$ .

$$h^* = \left[ \frac{\Omega_h(h)}{\alpha(1 - \gamma)} \right]^{\frac{1}{\alpha-1}} \quad (\text{A.9})$$

1032 To derive the equilibrium values for job creation and the firing threshold, we plug in  
 1033 the equilibrium wage in the job value function, compute  $J(\gamma) - J(\tilde{\gamma}) = 0$ , use the free-  
 1034 entry condition  $V = 0$  and the job destruction condition  $J(\tilde{\gamma}) = 0$ , and evaluate the  
 1035 expressions at  $\gamma = \underline{\gamma}$ . Equations A.10 and A.11 give the resulting conditions. Together,  
 1036 equations A.1, A.8, A.9, A.10, and A.11 characterize the labor market equilibrium.

$$\frac{(1 - \beta)}{r + \lambda}(\tilde{\gamma} - \underline{\gamma})p(h) = \frac{c}{\lambda_f} \quad (\text{A.10})$$

$$\tilde{\gamma} = 1 - \frac{1}{p(h)}(b + \Omega(h) + \frac{\beta}{1 - \beta}\theta c) + \frac{\lambda}{r + \lambda} \int_{\underline{\gamma}}^{\tilde{\gamma}} (\tilde{\gamma} - x)dF(x) \quad (\text{A.11})$$

## B Appendix: Results from placebo trials

Table B.1: Regression discontinuity results for unemployment in unaffected nations

<i>Discontinuity: 2013 European Floods</i>			
	Finland $\Delta \ln$ Unemployment	UK-EWNI $\Delta \ln$ Unemployment	Scotland $\Delta \ln$ Unemployment
Robust Bias Corrected (RBC)	0.01 (0.01)	-0.02*** (0.01)	0.06 (0.04)
Obs. to the Left	152	333	64
Obs. to the Right	171	444	87
Conventional Est. Bandwidth	8.86	3.26	3.18
Bias-Corrected Est. Bandwidth	13.24	5.40	5.57

**Notes:** \*\*\* $p < 0.001$ , \*\* $p < 0.01$ , \* $p < 0.05$ . This table contains the results from the augmented local linear regression discontinuity design on the rate of unemployment for Finland, UK-EWNI (England, Wales, and Northern Ireland), and Scotland. The discontinuity month is May 2013 for Finland and June 2013 for UK-EWNI and Scotland due to data limitations (quarterly unemployment). Standard errors are clustered at the county  $\times$  month level. The order of the local-polynomial to construct the estimator (bias-correction) is 1 (2). The kernel function is triangular.