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Matthew E. Kahn

Accelerating Adaptation to Extreme Weather in Europe

In recent years, Europe has experienced extreme heat, flooding, and spikes in air pollution. In 2022 and 2023, roughly 50,000 people died in Europe in heat-related and flood-related events. Between 2000 and 2024, the US experienced 623 shocks, resulting in 10,619 deaths, while Europe experienced 1,388 shocks, resulting in 266,527 deaths (calculations based on EM-DAT disaster data).¹ On a per capita basis, Europe's disaster death rate is significantly higher.

Why is Europe more vulnerable to extreme weather than the United States? I explore the micro-economics of Europe's disaster resilience challenge by first sketching out the statistical learning problem concerning the ever-changing risk geography. Informed decision-makers are more likely to choose safer locations and invest in resilient real estate. On the supply side, Europe's charm and challenge is that so much of its real estate and infrastructure is old, durable capital. Upgrading such capital is costly. If places fail to adapt to resilience risks, then people and firms can migrate to "higher ground." Migration is expensive, and it is especially costly for older individuals and those with lower levels of education. Language barriers and cultural differences can also act as migration frictions.

I discuss the government's role as both "friend and foe" in enhancing weather resilience. Many current European policies are likely to have unintended consequences that hinder resilience progress. I conclude by discussing how spatial resilience competition between European nations and regions facilitates learning through experimentation. Such experimentation is necessary to identify cost-effective solutions that mitigate the impact of extreme weather and climate change on economic growth and quality of life.

THE RISK PREDICTION PROBLEM

In the United States, new firms such as First Street Foundation and Jupiter are now competing against each other in generating geographically downscaled predictions of short-term flooding, wildfire, and extreme heat risks. While these risk maps feature considerable uncertainty, they provide valuable information that alerts decision-makers about the geography of risk. Such maps stretch our imagination and may convert "unknown unknowns" into "known unknowns" as individuals considering buying a home in an area

now invest more time and effort in researching the risks a parcel faces.

I recently co-authored a paper that examines how people searching for housing in the US on the Redfin Internet platform respond to flood risk information (Fairweather et al. 2024). Those randomly assigned to the field experiment's treatment group received information about each property's predicted flood score, based on data from the First Street Foundation. For those who had been searching for homes in high flood-risk areas, the average member of the treatment group subsequently searched for homes in lower flood-risk areas. As climate risk science advances, I envision that these prediction models will enable people and firms in Europe to make more informed locational decisions. Past research set in the Netherlands documents that homes that have been certified as more energy-efficient homes sell for a price premium (Bounen and Kok 2006). Going forward, as European real estate markets incorporate spatial risk data, more resilient properties will sell for a premium. Of course, there must be a trusted entity that can credibly certify that homes claimed to be more resilient are indeed more resilient. A key question in insurance rating and environmental social science is how to substantiate this claim. In the US, the Insurance Institute for Business and Home Safety conducts experiments to test whether a home can withstand a wildfire.

KEY MESSAGES

- Europe lags behind the United States in investing in weather resilience
- Durable real estate capital is at greater risk
- Migration facilitates adaptation
- Government policies often have unintended consequences for resilience
- Need for metrics to benchmark adaptation progress both within and across European nations and over time



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¹ See www.emdat.be.

AVOIDING SUMMER HEAT AND PM2.5 AIR POLLUTION

European summers have become increasingly unpleasant as extreme heatwaves and spikes in PM2.5 air pollution, caused by wildfires, have become more common. The average summer temperature in Paris warmed by 5.5 degrees from 1923 to 2023. As Europeans have grown wealthier, they have demanded more safety and comfort. High summer heat and air pollution spikes pose a threat to both the population's health and comfort.

In this era of real-time big data, researchers now have an increased capacity to use time diaries with geocoded stamps to study how different people spend their days in Europe when it is both hot and polluted. If more people across the socioeconomic spectrum can avoid these disamenities, then the damage caused by these events will decline.

Micro data is needed to measure the demand for resilient European real estate. Consider an apartment in Rome, Italy, with central air conditioning. What price premium do such properties typically command? Do middle-class families have access to central air conditioning, or are they relying on fans? On extremely hot days, how do wealthy people, middle-class people, and poor people avoid the heat and air pollution? Weather forecasters are making strides in predicting short-term weather events. With early warnings of impending heat waves, people can better prepare.

THE CHALLENGE POSED BY DURABLE REAL ESTATE CAPITAL AND INFRASTRUCTURE IN EUROPE

In traditionally mild summer weather places in the US, such as Berkeley, Portland, and Seattle, few of the older homes have air conditioning, while many of the newly built homes in these cities have central air conditioning. All the homes in hot Las Vegas have air conditioning. While relatively little new housing is built across Europe's cities, do these new vintages have central air conditioning in areas where summer heat has increased?

Urban economists have emphasized that durable capital plays a key role in cities, as homes, sewer pipes, and public transit train tracks can last for decades (Glaeser and Gyourko 2005). In slow-growing cities, an even larger share of the capital stock will be old than in a growing city. This means that in many European cities, the capital stock is not optimized for the new weather conditions. The push to engage in historic preservation only accentuates this point. Thus, Europe faces a double challenge: summers are becoming warmer, and the population is aging and living in aging buildings. Exposure to the double punch of heat and ambient particulate matter increases morbidity and mortality risks, particularly for older people, vulnerable populations, and those with chronic conditions.

Research conducted in the United States has shown that air conditioning and the use of air purifiers can mitigate the adverse effects of heat on sleep, schooling, learning, and productivity (Park et al. 2020). More European research on this topic is needed to inform local resilience investment decisions. One example of creative research is a study that examined the quality of chess moves made by players at tournaments in Germany over the years 2017 to 2019 (Künn et al. 2019). This study finds that players make worse decisions when exposed to higher levels of air pollution. This type of empirical research on causal effects is quite useful for establishing the baseline "business as usual" scenario, showing how much damage people will experience if we fail to adapt.

Suppose that air pollution and heat increase during future German chess tournaments. A pessimistic prediction is that the future chess players will make even more mistakes. This prediction is based on a linear extrapolation from the paper cited above. In contrast, I claim that as the outdoor heat and air pollution problems worsen, the chess tournament organizers will invest more in lumpy adaptation (i.e., air conditioners and air purifiers) so that the outdoor challenges cause *fewer* mistakes made by the chess players. This counterintuitive claim can be tested! We are not passive victims in the face of emerging threats to our quality of life.

MIGRATION AS AN ADAPTATION STRATEGY

Both migration within Europe and migration to Europe represent viable adaptation strategies that young people are more likely to engage in. While European citizens have the right to migrate across EU nations freely, their national languages, cultural differences, and differences in religions act as frictions discouraging such migration. Older people are also less likely to migrate than younger people. I raise these points because migration from riskier to safer places is a common adaptation strategy.

If everyone in Europe spoke the same language and shared similar tastes in food, it might be easier for people to relocate. For instance, if a city like Paris fails to adapt to extreme heat and air pollution, residents might move to more resilient cities like Munich or Amsterdam. The United States features many different towns spread out across geographic regions that compete against each other to attract footloose people and firms. For example, suppose crime increases in Chicago, and the city government fails to address the issue effectively. In that case, businesses and residents may relocate, resulting in a loss of tax revenue for Chicago. As I explore in my book *Climatopolis* (Kahn 2010), spatial competition provides an incentive for places to adapt to emerging challenges proactively – just the credible threat of out-migration incentivizes local elected officials to be proactive in investing in resilience.

In recent years, large numbers of people from the Middle East have moved to Europe. The immigration of Syrians into Germany is one prominent example. France has also attracted many immigrants from Algeria and Syria. While the popular media tends to be quick to label such migrants also as “climate refugees,” many of these individuals may believe that Europe offers greater economic opportunity for their families. Immigration raises delicate issues of political backlash and populism in destination nations. Ongoing research on mechanism design is useful here for increasing the likelihood that immigrants are welcomed in their destination communities. The Nobel laureate Al Roth has worked on matching markets for medical residents and kidney transplants. I argue that similar ideas are relevant for facilitating international migration to Europe during a period when Europe’s population is aging and growing at a relatively slow pace.

THE UNINTENDED CONSEQUENCES OF GOVERNMENT POLICIES

Applied microeconomists often test for “Peltzman effects.” These are unintended incentive effects introduced by government policies. If economists can measure these effects and elected officials incorporate these insights into their decision-making, then fewer public policies intended to facilitate resilience will backfire.

THE FLOODING CHALLENGE AND THE CROWDING OUT HYPOTHESIS

Major flood events continue to create significant challenges for communities throughout Europe. Early warning systems are crucial, as residents in older cities with inadequate drainage systems need to be aware of their escape routes. Flood control investments are site-specific and can range from engineering solutions to setting aside land as wetlands.

As governments invest more in flood control, will such protective investments crowd out private self-protection, such that more people will move to the flood zones? In Europe, more research is needed to test this specific Peltzman effect prediction. If an area is perceived to be safe, do more people move there? In spatial equilibrium, the extent of this backfiring effect depends on whether the flood area is a desirable location, features amenities, and is close to highly productive urban areas (Ouazad and Kahn 2025).

FARMING ADAPTATION AND CROWDING OUT BY SUBSIDIES

Basic microeconomic theory emphasizes the importance of dynamic comparative advantage. Given the changing weather conditions in rural Europe, farm-

ers should consider adapting their crop choices to respond to new weather patterns. Farming is highly dependent on external weather conditions, and challenges such as drought, extreme rainfall, and temperature fluctuations have a significant impact on agricultural production. US-based studies have documented that crops such as corn are susceptible to critical temperature thresholds (Schlenker et al. 2009). A global study concluded that farmers can shield themselves from much productivity damage if they switch to growing crops that are better suited to the emerging weather conditions in which they operate (Costinot et al. 2016). If an area is growing hotter in the summer, then some crops are more heat resilient. Generous farming subsidies in Europe are likely to slow down such transitions. US-based research has argued that farmers would be more likely to switch crops if their revenue were tied directly to their production. Government-subsidized insurance thus creates a type of moral hazard effect (Annan and Schlenker 2015).

FREE RIDING AT INTERNATIONAL BORDERS HINDERS RESILIENCE EFFORTS

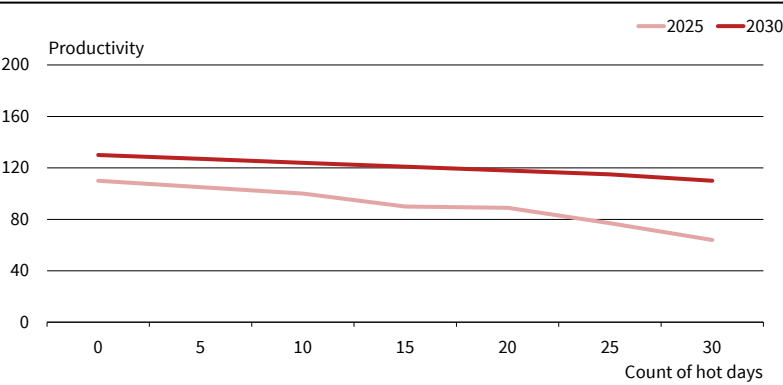
A distinctive feature of Europe is that many countries are situated along major rivers, such as the Danube. These rivers cross national borders, raising interesting questions about international free riding. Do upstream nations have an incentive to take steps to reduce flood risk for downstream nations? How effectively are European nations coordinating the management of shared resources, such as local rivers? Past economic research has documented that water pollution levels are higher at international borders, as upstream nations often place polluting activities near the border, allowing the polluted water to drift downstream to downstream nations (Sigman 2002). Going forward, Europe’s nations will be better able to address regional quality of life challenges if they cooperate effectively.

ARE EUROPE’S DECARBONIZATION EFFORTS CROWDING OUT AVAILABLE FUNDING FOR ADAPTATION?

One European Union document claims that the EU will invest EUR 1 trillion over the next decade to pursue its decarbonization agenda. What is the opportunity cost of resilience for such funds? As Europeans at the personal and national levels spend more money to decarbonize (for example, Europe’s electricity prices are much higher than those in the US), does this crowd out expenditure on adaptation?

While standard free-rider logic would predict that people have weak incentives to reduce their carbon emissions and hence contribute to the global decarbonization challenge, many Europeans and their nations are not engaging in free riding. Europe’s de-

Figure 1
A Graphical Illustration of Adaptation Progress



Source: Author's calculation. © ifo Institute

carbonization effort is pushing ahead. On one level, this is surprising. Europe's overall share of the world's population and GNP is shrinking over time as the rest of the world grows.

Europe's high level of per capita income and strong environmentalism offer two explanations for the continued decarbonization effort. Based on survey data from the World Values Survey and their daily behavior, many Europeans live a low-carbon lifestyle, as they do not drive frequently, have low rates of household fossil fuel consumption, and some are vegetarians. Many European nations are heavily investing in decarbonization policies.

In both the US and Europe, there is limited knowledge about the amount of money people, firms, and governments spend on weather resilience. We have much better data on decarbonization expenditures. This data gap makes it difficult to assess whether Europe's decarbonization focus is overshadowing resilience efforts.

DOES ADAPTATION INVESTMENT CAUSE SIGNIFICANT CARBON EMISSIONS?

Environmentalists often view air conditioning as extravagant, especially in an era focused on decarbonization. This creates a tension between the need to adapt to higher temperatures and the goal of reducing carbon emissions. Air conditioning contributes to greenhouse gas emissions when the electricity that powers it is generated from fossil fuels, such as natural gas or coal. Davis and Gertler (2015) quantified these effects using data from Mexico. As Europe's electricity grid decarbonizes, the emissions resulting from increased summer electricity consumption decrease.

If Europe's cities face increasing summer heat, then their leaders will have strong incentives to experiment with cost-effective adaptation solutions. For example, time use over the day could change so that more firms are open at night when it is cooler, while closing during the hot summer afternoons. In this sense, if a city reduces its crime risk, then more

activity will take place at night. Singapore has a lively nightlife in part because this low-crime city has relatively more pleasant nights.

BENCHMARKING RESILIENCE PROGRESS

Proactive self-protection can significantly reduce the damage caused by flooding, heat waves, and pollution spikes. Of course, richer people and nations have a much greater ability to adapt to these shocks. In contrast, the poor are more likely to work outside and live in lower-quality housing in riskier areas.

Many empirical climate economists use geocoded data to study how people, firms, and places that are exposed to extreme weather conditions perform. Outcome measures include firm productivity, student test scores, corn yields, and morbidity and mortality indicators, among others. Empiricists estimate these reduced-form regressions, which are referred to as "climate damage functions." My interest here pertains to how the shape of these functions changes across time and space.

In Figure 1 I graph firm productivity as a function of summer heat in the years 2025 and 2030.

These reduced-form equations could be estimated using panel data on geocoded firm productivity data at the monthly level. If the productivity/heat gradient flattens over time, this is the empirical benchmark test that firms in different nations across Europe are successfully adapting to the heat. Such a graph does not reveal the costs these firms incurred to achieve this extra resilience. In this sense, policymakers across Europe need to start collecting household- and firm-level data on defensive investment expenditure and the specifics of the investments these decision-makers are choosing. Such data would help inform policymakers as they see how effective private actors have been in protecting themselves. What assistance do they require from the government to expedite the adaptation process?

POLICY CONCLUSIONS

Investments in bolstering Europe's weather resilience will stimulate national economic growth. The nation's people and capital stock would be more resilient to shocks, and tourists would continue to visit Europe, as the local quality of life would remain high.

Given Europe's well-educated population and committed environmentalism, there is the possibility for Europe to become a leader in "resilience tech." Resilience technology focuses on both measuring spatial risk and designing cost-effective solutions that facilitate resilience. The global demand for adaptive market solutions is increasing, stimulating endogenous innovation. Europe stands to benefit from this trend, as the world faces a growing need for cooling, flood prevention, and air pollution protection technologies.

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