Ökonomie der Anpassung an den Klimawandel

Ulrike Lehr, Anne Nieters, Thomas Drosdowski

Climate change adaptation and the German economy

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1 INTRODUCTION

In the last 15 years, Germany experienced rather severe extreme weather events, particularly river floods and heat waves. Germany's economic dependence on high-tech production sites, and its population density make it highly vulnerable to disturbances and disruptions caused by extreme weather events. If the frequency of occurrence and the severity of such events increase in the future, a need for adaptation measures will arise. Facing such real possibilities, estimates of the damage costs from extreme weather events and the likely benefits from adaptation measures as suggested in the following are relevant to support decision makers to take the appropriate steps.

The economics community has begun to tackle these issues not later than since the Rio conference at the beginning of the 1990s. Accordingly, different models and attempts to quantify economic effects of climate change have evolved. Among these, Integrated Assessment Models (IAM) combine simple economic and earth system models via damage functions and concentrate on economic effects resulting from gradual changes of the global average surface temperature. They rarely consider effects of extreme weather events (Kemfert 2007, Nordhaus and Sztorc 2013, Patt et al. 2010).[1] Disaster Impact Models (DIM) focus on the latter, e.g. on floods, hurricanes or earthquakes on a regional level (Hallegatte et al. 2011, Rose and Liao 2005). A third category comprises flood damage assessment methods, whose focus is on detailed modeling of the physical conditions and spread of river floods. The analysis of economic effects plays only a minor role in this type of models (Rojas et al. 2013, Feyen et al. 2009, Lugeri et al. 2010). In the last years, adaptation to climate change has received increased attention as being a complementary to climate mitigation. Thus, a large knowledge base concerning adaptation costs is available. Some of the IAM are hence extended to integrate this aspect (e.g. AD-DICE). However, they do not capture it in full, again focusing on gradual temperature changes and not on extreme weather events and the adaptation to them (de Bruin et al. 2009, Agrawala et al. 2011). This contribution takes a different approach and enhances a simulation tool, which up to now has been used for climate mitigation modeling rather than climate change simulations. The paper shows the challenges in modeling and provides simulation results.

The remainder of this paper is organized as follows: The next section describes the changes needed in the modeling framework and defines the scenarios for (a) frequently recurring extreme weather events (river floods and heat waves) and (b) adaptation measures. In the following section, results are presented in terms of effects on the German economy as a whole and on individual economic sectors until 2050. The last section concludes and gives an outlook.

[1] FUND 3.17 for example is one of the few models dealing with this topic (Anthoff and Tol, 2013).

2 FLOODS AND HEAT WAVES IN A INDUSTRIALIZED ECONOMY – THE MODELING CHALLENGE

2.1 ADAPTATION OF THE MODEL – MODELING ADAPTATION

In this paper, an input-output based macroeconomic model is extended to allow for the modeling of damages resulting from extreme weather events and modeling of adaptation measures. A detailed documentation of the model used, PANTA RHEI, can be found in Ahlert et al. (2009) and Lehr et al. (2012). So far, PANTA RHEI has been used to analyze the impacts of environmental and climate change policies, for instance, to analyze employment effects of renewable energy expansion in Germany (Lehr and Ulrich 2014) and of increasing investments in energy efficiency (Lutz and Lehr 2014). The focus of these studies is on the effects of changes in prices or investment decisions and on the respective economic adjustment reactions. In the model, each of the industries of the German economy is described in detail and macroeconomic variables are aggregated bottom-up. The demand side of the economy is econometrically estimated, based on time series data. These construction principles are maintained in the new modules, which contain the impacts of extreme weather events and adaptation measures. However, no time series exist concerning extreme weather events in Germany; therefore cost and damages of river flood events and heat waves were primarily derived from the impacts of the Oder/Elbe flood in 2002 and the heat wave in 2003, functioning as reference events or benchmark. Data on costs of adaptation measures stem from cost estimations of selected adaptation projects found in the literature.

Extreme weather events do not affect all industrial sectors in the same way; therefore, it is necessary to model damages at the level of individual economic sectors. Moreover, companies located next to rivers may be forced to reduce or even interrupt production, if severe flood events cause damages to production sites. The situation can be even worse, if flood-related damages to transport infrastructure impede the transport of intermediate goods, because not only companies in the flood zone but also companies depending on intermediate goods from the flood zone are affected. In case companies are insured against floods, they only have to bear a part of the costs necessary to remedy damages to production sites, while the remaining costs will be accepted by insurance companies. Heat waves affect particularly companies depending on the cooling of their processes, for instance power plants, since environmental protection laws restrict withdrawal of water and the emission of used cooling water into the river, if stream water temperature exceeds a certain threshold. This leads to reductions or even losses in production.

Extreme weather events act as shocks to the model and previous economic interdependencies are temporarily overridden. Capital stock, for example, has over decades served as a production factor depending on the expected demand and market signals. Severe extreme weather events create a different situation: parts of a company's production sites and facilities may be destroyed and its capital stock reduced, even if the demand for (intermediate) goods is the same as before the event. This damage results in substitution of domestic products with imports in the short-run. To model flood damages to production sites, for instance, capital stock of machinery is reduced. The damage estimate is taken from the literature including coverage of large river floods from the past in Germany. Modeling damages to properties and transport infrastructure, or impacts on industrial and agricultural production (the latter with respect to both flood events and heat waves) follows a similar approach. Effects of heat waves are modeled by considering impacts on energy production, labor productivity and transport by ship. A reduction in energy production is compensated by rising energy imports if domestic energy demand exceeds domestic energy supply. Ship transport companies suffer from low river water levels and have to shift to other means of transportation. In terms of modeling, this means that production output of the sector land transport becomes lower. As a result, unit costs and therefore prices rise.

Adaptation measures prevent or reduce impacts of extreme weather events, but require up-front investments. Adequate adaptation strategies directed at river flood events are the creation of additional retention areas and the reinforcement of dikes. Power plants depending on cooling may adapt to heat waves by installing cooling towers. Companies prevent heat-related reductions in labor productivity by greening roofs and installing air conditioning.[2] These measures are represented in the model as increasing building investments, whereas the costs and damages resulting from extreme weather events simultaneously decrease over the years. Adaptation therefore takes place gradually, because the adaptation measures are implemented over the years. Some of the cost bearing institutional sectors (households, companies, government etc.) may currently be financially incapable to invest in adaptation measures; others may not be aware of the vulnerability to extreme weather events and postpone investments. Generell werden innerhalb der Formatvorlage die Überschriftenebene 1 bis 5 unterschieden, wobei innerhalb des Discussion Papers nur drei Überschriftenebenen Anwendung finden sollten. Für Discussion Paper ist keine Kurzusammenfassung vorgesehen. Die beiden dem Abkürzungsverzeichnis nachgelagerten Abschnitte „Zusammenfassung“ und „Summary“, welche dem Kapitel 1 „Einleitung“ noch vorgelagert sind, sind nur für den Research Report zu verwenden.

2.2 SCENARIOS – EXPLORING CONSISTENT FUTURE DEVELOPMENTS

To track the response to exogenous changes from the simulation results of a model we need to compare at least two scenarios. The differences between central modeling results can be attributed to the exogenous changes, all other things remaining unchanged, i.e. ceteris paribus.

Usually, one designs a base line or reference scenario, which describes the future development of the economy based upon past developments, including past structural adjustment and structural changes. In this case, the reference is a development not considering damages from extreme weather events, as they have not been damaging or frequent enough to be relevant for the economic performance in the past, nor they are assumed to be in the future.

The first scenario, which differs from the reference explicitly, includes damages from ex-

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2 Due to the fact that air conditioning has a large potential for GHG emissions, the former measure is preferable. Air conditioning as an adaptation strategy is considered in this paper, provided that environmentally friendly air conditions are installed and energy from renewable sources is used.

treme weather events, particularly heat waves and river floods. The second scenario adds adaptation measures to the damages caused by extreme weather events. Differences in the model variables then show economic effects, since they reflect economic impulses triggered by the modeled shocks representing extreme weather events.

Scenario comparison shows differences in a large set of economic indicators, including Gross Domestic Product (GDP). Although one can argue that GDP is not useful as a comprehensive welfare measure, it does reflect the economic activity and growth of a country. Employment is often used as a variable to reflect the social aspects of a future development, given that unemployment reduces social participation and inclusion. Private consumption reflects individual well-being to a certain extent and production indicates the opportunities and activities of a country's industry. The latter is more meaningful if we look at it in more detail, i.e. on the sector specific level.

PANTA RHEI is a simulation tool, which is relying on past observable economic reactions. Therefore, it has to be stressed that the accuracy of the simulation results of PANTA RHEI is diminishing the longer the simulation period is, meaning that the simulation results for the first decade are more precise than for the last one. Simulation results are only intended to give an idea of possible economic effects of extreme weather events and corresponding adaptation measures in Germany, with the main conclusions to be drawn from the signs and direction of the effects observed.

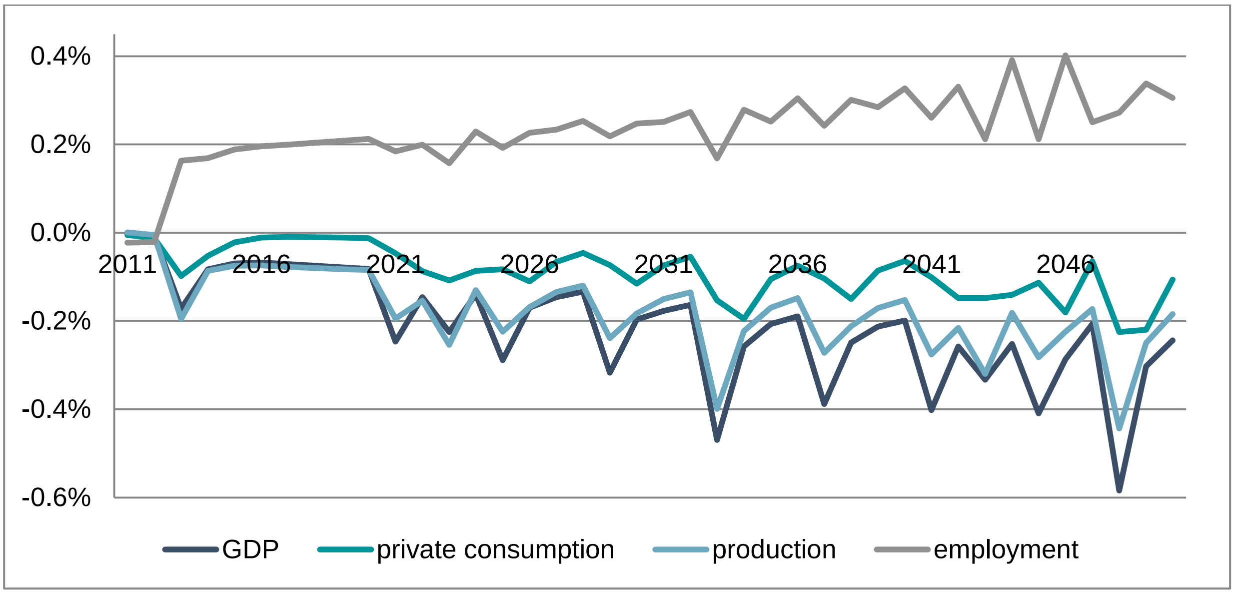
3 RESULTS

3.1 DAMAGES FROM EXTREME WEATHER

Damages from extreme weather have effects beyond the sector which is hit, and they are farther- reaching than the immediate vicinity of the damage. The German economy, especially the producing sector, is intertwined to an extent that carries these effects across half of the economy.

Simulation results indicate that overall economic effects of recurring heat waves and river floods are moderate in Germany until 2050. Figure 1 shows the development of the four indicators described above – gross domestic product, private consumption, production (all price adjusted) and employment – in the extreme weather scenario in comparison to the reference scenario. The lows (respectively the peaks in the case of employment) show the years with the weather extremes. Overall, the data show a negative effect of weather extremes on the economy, albeit on a very low level. In monetary values, private consumption is annually between 1 and 3 bn., production between 3.5 and 30 bn. and GDP between 1.75 and 19.5 bn. Euros lower than in the reference. Only employment "benefits" from extreme events. This positive development can be attributed to two effects: firstly, production shifts from capital-intensive sectors to labor-intensive sectors, as capital is destroyed by the flood and production goes down in some capital-intensive sectors, whereas employment in the construction sector grows. Secondly, the increase is due to falling productivity, which is compensated by the model with businesses hiring more personnel, whose wage incomes have become smaller. More employees striving to keep their living standard are hence needed to generate the same output.

Figure 1: Economic development, price-adjusted differences (in %)[3], extreme weather vs. reference scenario



Own results.

The number of events occurring during a decade certainly has an impact on deviations from the reference run. However, PANTA RHEI is not the right model to forecast extreme weather. Results also show that, irrespective of the number of extreme events that are modeled in a given decade, the effect is slightly intensifying over time: In the decade from 2031 to 2040, average effects are higher than in the following decade, even if less events occur. Hence, effects seem to be lasting, and the predicted increase in the number and intensity of extreme weather events in Germany may challenge its economic development in the future.

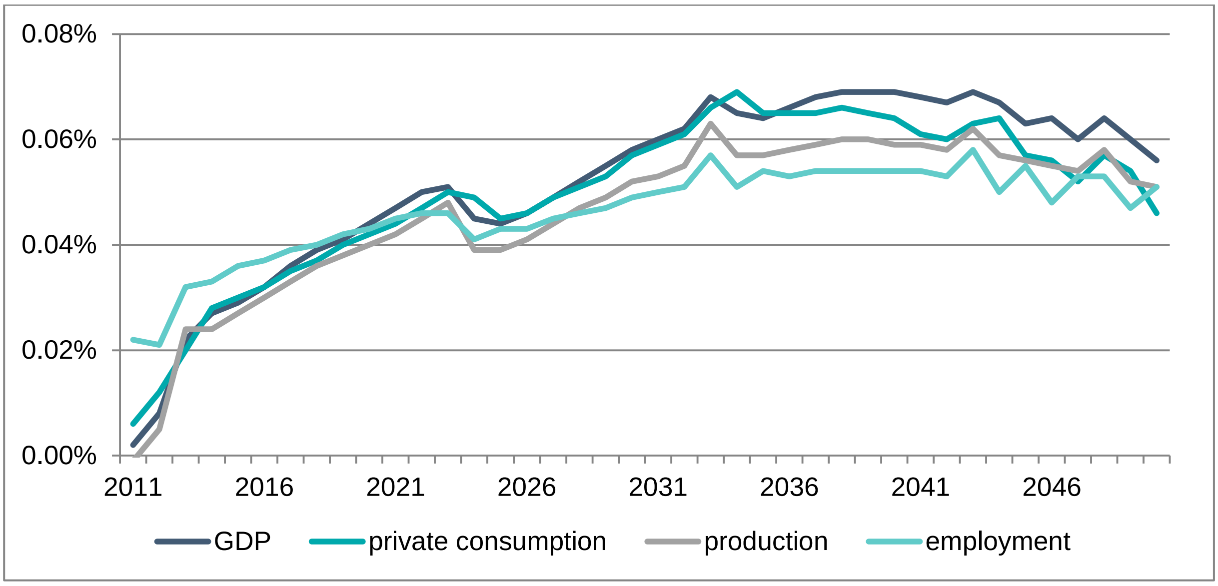
3.2 ECONOMIC EFFECTS FROM ADAPTATION

Economic effects from adaptation are twofold. Firstly, they prevent or reduce extreme weather damages and, secondly, they induce economic activity in the construction sector, in transportation and in the production of adaptation goods. Adaptation measures require up-front investments of companies or the government. Simulation results reveal that the German economy is better off adapting to extreme weather events, because investment triggers positive economic effects. As presented in Figure 2, all four indicators are slightly larger in the adaption scenario in comparison to a scenario considering extreme weather events without adaptation. The effect is increasing over time, which is due to the fact that, firstly, the impacts of extreme weather events are rising as well. Secondly, adaptation measures are undertaken gradually. Hence, the more adaptation measures are undertaken, the more damages are avoided. However, the lasting positive deviation is decreasing

[3] Price adjustment does not refer to employment which is given in 1000 persons.

in the last decade. This development results from rising costs accompanying some of the adaptation measures.

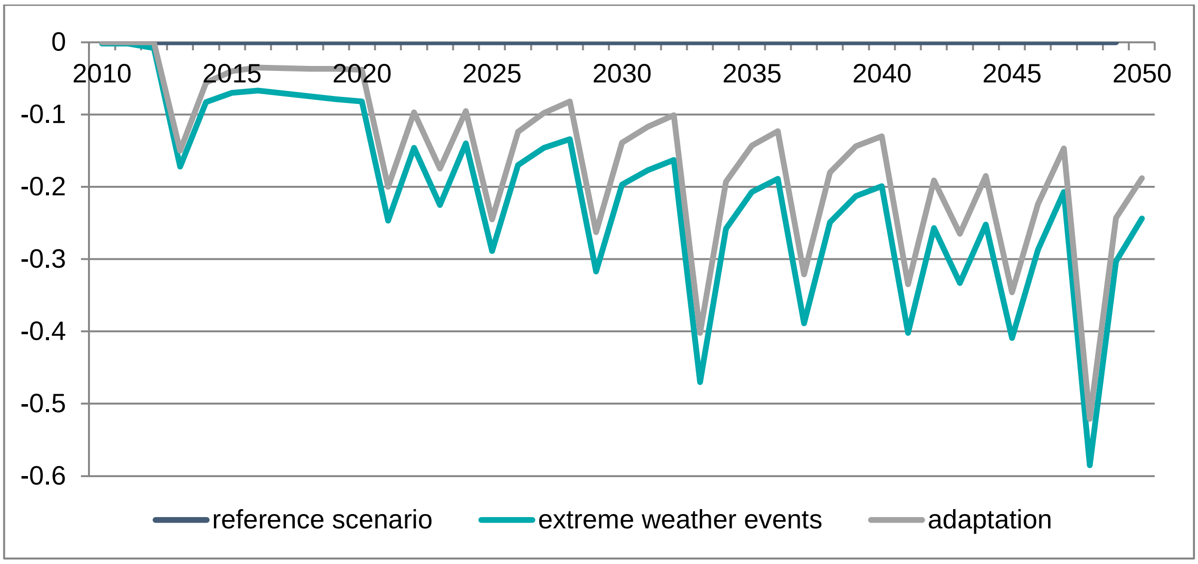
Figure 2: Economic development, price-adjusted differences (in %), extreme weather vs. adaptation scenario



Own results.

Figure 3 shows the development of GDP in the extreme weather and the adaptation scenario until 2050 in comparison to the reference scenario. It easily can be seen that the selected adaptation measures reduce the negative effects of extreme weather events. However, in both scenarios the German economy is worse off in comparison to a scenario without extreme weather events.

Figure 3: GDP, price-adjusted differences (in %), reference vs. extreme weather and adaptation scenario



Own results.

3.3 A MORE DETAILED PICTURE – EXTREME WEATHER AND ECONOMIC SECTORS

How are individual sectors affected by extreme weather? Are there winners and losers in the economy? The contribution of sectors to the aggregate changes can differ markedly. Since the analysis of aggregate effects may underestimate the effects on individual economic sectors, sector-specific effects have been included in the analysis. Instead of a detailed description of single effects of extreme weather events and adaptation measures on the economic sectors, an overview of the most and least affected industries is given. We look at the contribution of individual sectors to total Gross Value Added (GVA), which is corresponding in its magnitude to GDP. In 2014, GVA in Germany amounted to roughly 2.5 tr. Euros. As presented in Table 1, the most important sectors with respect to economic performance are "other services" (administrative and support service activities, public administration and defense, education, social activities and health and other) recording a GVA of 1.25 tr. Euros. The next largest sector is manufacturing (535 bn. Euros), as well as trade, maintenance and repair of motor vehicles (250 bn. Euros).

Table 1: GVA at the sectoral level in 2014, in bn. Euros

economic sectors	GVA in 2014 in bn. Euros
agriculture, forestry and fishery	20
mining and quarrying	7
manufacturing	535

Own results.

Comparing the reference and the extreme weather scenario (see Table 2) we find only small deviations from the reference scenario. An exception is the transport sector with percentage changes between 0.4 and 0.5 per decade. The most negative development can be observed in the sector mining and quarrying with deviations between -0.2% and -0.3%. This development is due to the negative development in the manufacturing sector amounting to between -0.1% and -0.3%, since the mining and quarrying industry requires a range of intermediate products from the manufacturing sector for the production. Supply shortages, thus, force companies in the sector mining and quarrying to reduce production. However, the sector mining and quarrying only contributes little to total GVA.

The response of the sector mining and quarrying to the reduction in produced output of the manufacturing sector reflects a weakness of the model. It can be assumed that the imports of equipment required by the mining and quarrying sector rise after an extreme event, if supply shortages in Germany exist. However, intermediate input linkages of the sector mining and quarrying are, to a large extent, constant in the future, which means that a model-intrinsic adjustment to the consequences of an extreme weather event, e.g. by companies sourcing abroad, is not possible in PANTA RHEI. Transport and communication services show the largest effects with an average increase in GVA of 0.5% in the period between 2021 and 2030 and 0.4% in the other decades. The construction sector follows with deviations amounting to values between 0.1% and 0.3%. Striking are the simulation results for the agricultural sector, indicating a slightly positive effect, as far as average deviations per decade are considered. It is hard to understand why an industry that is particularly challenged by inundation, heat and drought may “benefit” from these events. The reason is that Table 2 and Table 3, indeed, gives an overview of the extent to which an economic sector is affected, but obscures heavily fluctuating annual deviations.

Table 2: GVA, average deviations per decade (in %), extreme weather vs. reference scenario

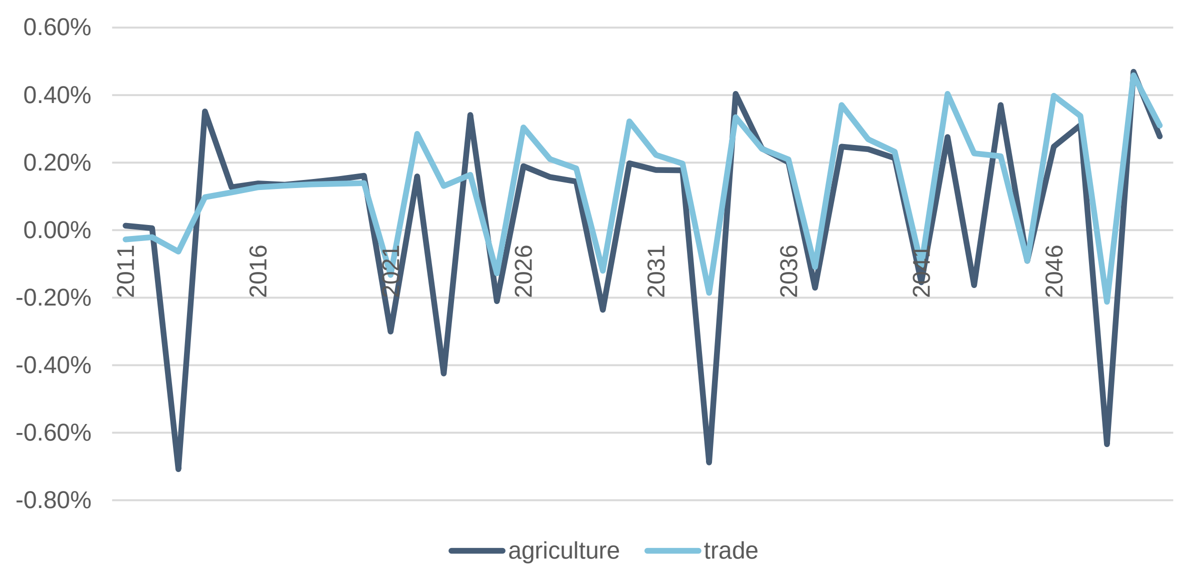
economic sectors	2011-2020	2021-2030	2031-2040	2041-2050
agriculture, forestry and fishery	0.07%	0.01%	0.11%	0.09%
mining and quarrying	-0.17%	-0.31%	-0.27%	-0.28%
manufacturing	-0.07%	-0.22%	-0.19%	-0.28%
energy and water supply	-0.04%	-0.09%	-0.13%	-0.16%
construction	0.14%	0.21%	0.28%	0.29%
trade; maintenance and repair of motor vehicles	0.08%	0.12%	0.18%	0.20%
hotel and restaurant industry	-0.04%	-0.14%	-0.14%	-0.17%
transport and communication services	0.43%	0.48%	0.43%	0.38%
financial intermediation	0.06%	0.07%	0.10%	0.09%
other services	-0.02%	-0.08%	-0.09%	-0.11%

Own results.

The same is true for the trade sector. Figure 4 presents annual deviations from the reference scenario in the sectors agriculture and trade (in percent) and makes clear that the total effect on these sectors, positive in both cases, does not reflect their vulnerability.

Simulation results indicate both years with negative and years with positive effects. Even if the negative effect on GVA in the agricultural sector is quite strong (-0.71%) on an annual basis in comparison to the other sectors, the overall effect on the sector is positive, meaning that negative impacts in the years in which extreme events occur are overcompensated by positive effects in the years in between. The same is true for the trade sector: negative effects are observable but positive effects predominate. This means, the stronger the impact, the stronger is the counter-reaction in the years following extreme weather events. An increasing number of extreme events may challenge particularly the agricultural sector. The relatively “strong” counter-reactions are caused by price increases after an extreme weather event because of a likely massive crop loss. Higher prices in years following an extreme event may compensate farmers for the previous losses, leading to an increase in GVA.

Figure 4: GVA of the sectors trade and agriculture, annual deviations (in %), extreme weather vs. reference scenario



Own results.

Agriculture and trade are not the only sectors characterized by fluctuating deviations from the reference scenario. Similar patterns are observable in other sectors as well. To give an idea of the fluctuations, Table 3 summarizes the standard deviations of the industries in intervals of ten years. Besides the sectors agriculture and trade, the manufacturing sector shows strongly fluctuating deviations of GVA. Fluctuations are increasing over time, which could be the consequence of missing price adjustments.

Table 3: Standard deviation of sectoral GVA

economic sectors	2011-2020	2021-2030	2031-2040	2041-2050
agriculture, forestry and fishery	0.27%	0.25%	0.30%	0.32%
mining and quarrying	0.05%	0.14%	0.14%	0.14%
manufacturing	0.07%	0.21%	0.26%	0.30%
energy and water supply	0.02%	0.03%	0.05%	0.07%
construction	0.10%	0.05%	0.07%	0.06%
trade; maintenance and repair of motor vehicles	0.08%	0.17%	0.17%	0.23%
hotel and restaurant industry	0.03%	0.03%	0.07%	0.07%
transport and communication services	0.02%	0.15%	0.12%	0.16%
financial intermediation	0.05%	0.03%	0.04%	0.05%
other services	0.02%	0.02%	0.04%	0.03%

Own results.

Overall, the most striking developments take place in the sectors agriculture, manufacturing, construction, trade and transport, where the strongest deviations from the reference and the strongest fluctuations of the deviations are observable.

3.4 EFFECTS OF ADAPTATION TO EXTREME WEATHER EVENTS ON ECONOMIC SECTORS

In the adaptation scenario, governments and companies undertake investments to adapt to river floods by extending retention areas and reinforcing dikes. Impacts of heat waves on labor productivity and on power plants are prevented by investments in green roofing, air conditioning and cooling towers. Table 4 shows the average deviations per decade of GVA on the sectoral basis, comparing the reference and the adaptation scenario. Simulation results of the latter reflect a combination of both impacts of extreme weather events and adaptation measures. This is because, firstly, undertaking adaptation measures does not mean that all impacts of extreme weathers are avoided at once. This is happening incrementally. Secondly, not all of the modeled impacts can be reduced by the selected adaptation measures: whereas it is assumed that all effects of river floods can be avoided by the end of the simulation period, the selected measures are, for example, not suitable to adapt to low river water levels during a massive heat wave.

Table 4: GVA, average deviations per decade (in %), adaptation vs. reference scenario

economic sectors	2011-2020	2021-2030	2031-2040	2041-2050
agriculture, forestry and fishery	0.12%	0.05%	0.15%	0.16%
mining and quarrying	-0.03%	-0.17%	-0.13%	-0.16%
manufacturing	0.00%	-0.15%	-0.11%	-0.19%
energy and water supply	0.00%	-0.02%	-0.03%	-0.05%
construction	0.28%	0.47%	0.68%	0.81%
trade; maintenance and repair of motor vehicles	0.11%	0.16%	0.23%	0.24%
hotel and restaurant industry	0.01%	-0.06%	-0.05%	-0.10%
transport and communication services	0.05%	0.12%	0.10%	0.10%
financial intermediation	0.09%	0.11%	0.15%	0.13%
other services	0.00%	-0.04%	-0.04%	-0.06%

Own results.

Also in the adaptation scenario ship transport companies have to shift to other means of transportation to deliver (intermediate) goods and raw materials. The differences in GVA between the reference and the adaptation scenario are similar to the results obtained by comparing the extreme weather and the reference scenario. Effects are small and some of the sectors may benefit from adaptation measures, whereas others may suffer reductions in GVA. In all sectors (an exception is the sector transport and communication services) the positive effect in some sectors is intensifying in the adaptation scenario, whereas negative effects are diminishing (see, for comparison Table 2). In most of the sectors, this development can be attributed to avoided damages. The manufacturing sector, for example, faces lower damages to buildings and properties, since communities gradually invest in additional retention areas and dike reinforcement. Average deviations per decade from the reference scenario amount to between -0.11% and 0.19%. Hence, the sector mining and quarrying records lower deviations as well. An increasing number of utility companies does not need to reduce or even cease energy production in case of heat waves due to the installation of cooling towers. Therefore, reductions in GVA decrease and amount to between -0.02% and -0.05%.

The sectors already "benefitting" from extreme weather events (decade averages) show even higher values in terms of GVA in the adaptation scenario. This is because there is a combination of extreme events and adaptation measures in this scenario. While, for example, the agricultural sector is less affected by river flood events, it simultaneously benefits from compensating payments for the creation of retention areas. Investments in dike reinforcement, green roofing or air conditioning lead to a rise in GVA in the construction sector in comparison to the reference and as well as to the extreme weather scenario. The transport sector, in turn, benefits from the positive development in the trade and construction sector. However, in comparison to the extreme weather scenario, the deviation from the reference run is decreasing. This is because only the demand for construction material increases in comparison to the extreme weather scenario and the reference, implying an increased need for transport services. The demand for disposal of rubble, and for machinery and other equipment in affected regions is lower than in the extreme weather scenario, since damages are lower.

Overall, all sectors benefit from adaptation measures, even if this involves financial burdens for companies and the government. Some sectors (agriculture, construction, trade and others) benefit from extreme weather events when focusing on GVA and decade averages. However, investments in adaptation measures intensify the positive development. At the same time, adaptation to extreme events diminishes negative effects resulting from these events. The sector transport and communication services is the only sector not following a similar pattern. It benefits from adaptation measures in comparison to the reference scenario but compared to the development in the extreme weather scenario it performs worse.

4 CONCLUSIONS

The analysis has shown that extreme weather events have only a slightly negative effect on the German economy. Is this a call to sit back and relax? Quite the contrary – for three reasons. Firstly, despite the impression that the German economy might be quite resilient towards extreme weather events, the analysis shows an intensification of the impacts on economic sectors and the economy as a whole in the future, thus, recurring extreme weather events have the potential to weaken Germany's future economic performance. Adaptation measures, secondly, not only reduce negative effects on the German economy, but also add economic activity and might lead to development of products, which are demanded on international markets, too. Thirdly, the results hold without taking climate change effects on other countries into account. Certainly, the decline or loss of production sites in other countries hit more severely by climate change leads to losses in Germany. For example, summer temperatures and precipitation patterns in Southern Europe will change to the effect that today's cultivation of fruits and vegetables in in this region will no longer be possible, influencing consumers and particularly the manufacturing industry, which may suffer from supply shortages and/or potential higher prices when being forced to obtain foodstuffs from suppliers overseas.

On a sector-specific level, manufacturing as well as mining and quarrying are the most heavily affected industries with respect to GVA when comparing the extreme weather and the adaptation scenario with the reference scenario. The transport sector benefits the most from extreme events. However, its economic performance diminishes in the adaptation scenario. The construction sector responds more positively than average to adaptation measures. For future research, this detailed sector specific analysis needs a detailed regional analysis, too. Not only industries differ in their vulnerability to extreme weather events, but also the individual regions in Germany. Reductions in agricultural production, for example, will have stronger impacts on the economy of Schleswig-Holstein than on North Rhine-Westphalia, since agricultural production in Schleswig-Holstein plays a more important role for the value added in that region than in North Rhine-Westphalia. Regarding this issue, further research is necessary to gain a more comprehensive insight into the impacts of extreme weather events and, thus, adaptation measures in Germany. Detailed knowledge about a region's vulnerability to extreme events is decisive with respect to adaptation strategies. Within a regional approach, the burden sharing process will gain more relevance. Although the effects spread over the whole economy, the local or regional effects on individual households might be much larger. These aspects escape a macro-modeling exercise. Moreover, some responses of the economic sectors to extreme events and adaptation measures reveal weaknesses underlying input-output-based macroeconometric models when analyzing effects of extreme weather events. Further adjustments are needed to capture modified economic relationships resulting from extreme events unhinging preliminary relationships and their interdependencies.

The access to more comprehensive and more detailed data on damages and costs resulting from extreme weather events and costs associated with concrete adaptation measures in Germany will improve simulation results. A program for further research therefore has to meet the threefold challenge of a wider regional focus, including trade and international value chains, a narrower regional focus within Germany and the need for more accurate, sector (and region) specific data on damages from all kinds of extreme weather and temperature increases.

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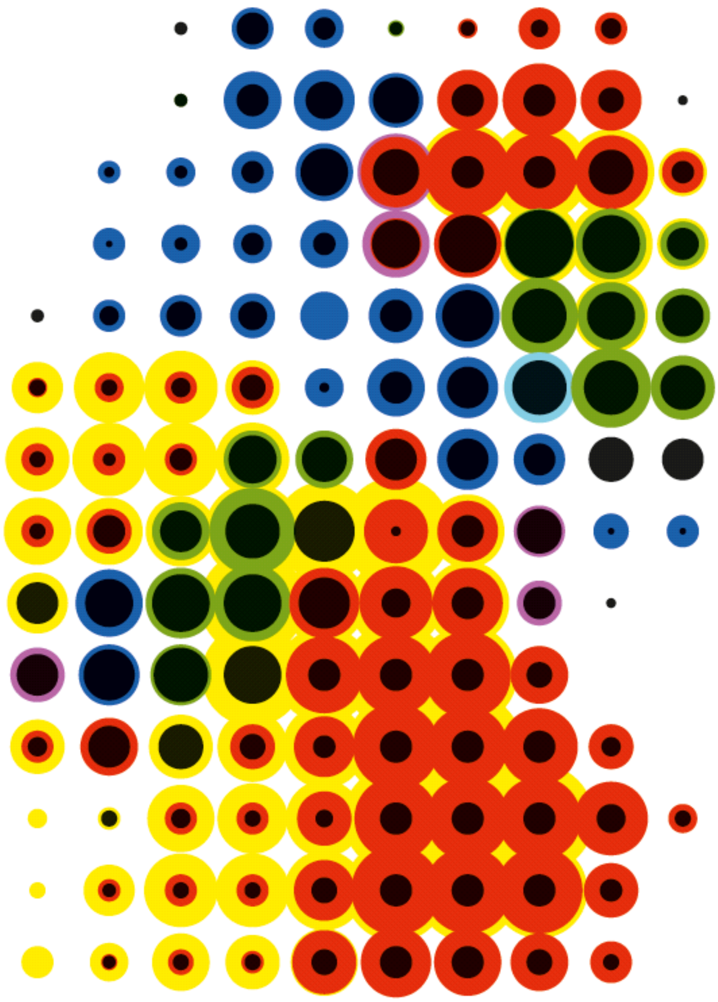

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