
CLIMATE RISKS AND VULNERABILITY OF THE LOCAL ECONOMY OF THE CITY OF SKOPJE

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Abstract: Climate change is a global problem that challenges humanity. Global warming, which is expected to bring extreme weather events, exposes human health, ecological systems, and ultimately the economy to great risks. Although the economy affects climate change, climate change also affects the economy. The effects of climate change on the economy in the short term can be positive or negative, but in the long term there is a consensus that global GDP will on average experience a significant reduction depending on the intensity of global warming. In addition to the small direct impact through disruption of economic inputs, the indirect impact through the transmission mechanism of productivity and investments on GDP is complex.

However, climate impacts are not expected to have an equal negative impact on all economies in the world, and the Republic of North Macedonia is in the group of countries less vulnerable to climate change. In this paper, we will apply the SECAP methodology for assessment of climate risks and vulnerability of the local economy of the City of Skopje. For this purpose, we will do an in-depth analysis of the local economy through the sectoral approach. The City of Skopje is an administrative city, and the sectors that are most vulnerable to climate change, such as agriculture, forestry, fishing and construction, are marginal. An increase in the intensity of the extreme weather is expected, especially the increase in temperatures in all seasons with increased precipitation and flash floods. Therefore, an increase in climatic risks is expected in the local economy in the City of Skopje in relation to the current vulnerability. Although some sectors would be negatively affected by climatic change, the general assessment is that the economy of the City of Skopje will remain moderately vulnerable to future climate risks. It is because of the expectations for strong adaptability of local businesses and change of business models according to the new economic conditions.

Keywords: extreme weather, heatwaves, extreme cold, productivity, investment incentives, climate hazards

1. INTRODUCTION

Climate change has emerged as one of the most pressing global challenges of our time, with far-reaching consequences that extend beyond the realms of the environment. Climate change has far-reaching consequences for various aspects of human life, including the economy. Rising temperatures, changing rainfall patterns, and extreme weather events will impact ecosystems, human health, and economic systems in a variety of ways. Understanding the economic implications of climate change is crucial for policymakers, businesses, and societies to make informed decisions and take proactive measures.

However, the assessment of the impact of climate change on the economy is too complex a task. First of all, there is great uncertainty about the intensity of global warming in the long term, and if the warming is greater, the economic consequences would be greater. In fact, all predictions so far are made in isolated conditions and scenarios for different magnitudes of warming and with different assumptions. Long-term forecasting is also uncertain. There is uncertainty in which direction technological progress will develop and how it could be used in reducing GHG emission and sinking, reducing global warming or in green transition. Almost all countries in the world signed the Paris Agreement and have a national determined contribution (NDC) that provides for mitigation and adaptation measures. And of course, global warming brings opportunities and benefits rather than cost only. The evaluation of the impact of climate change on the economy is full of uncertainties. However, the largest number of studies clearly show that the long-term consequences of climate change on the economy are negative and quite broad. Although some areas of the world would be slightly affected, some countries would have catastrophic economic and other wide consequences.

Global warming is a consequence of anthropogenic greenhouse gas emissions and leads to climate change. These emissions are the result of increased industrialization, which increased employment and led to growth in the income of economic agents. Individuals with increased disposable income increased personal consumption, companies increased investment spending, and increased tax payments increased public spending. The increasing demand for goods and services has continuously greatly increased the transportation of goods and people around the world, using fossil fuels. And it is not only transport that is considered the main source of carbon, but the growing global economy has brought many other sources and extremely increased intensity of greenhouse gases. This has led to an acceleration of post-industrial global warming in recent decades. While the growing economy affected climate

change, now the economy will be affected by climate change. But no single extreme weather event can be the sole cause of a negative impact. The impact of climate change on the economy is too complex, affecting primarily the life and health of people, ecosystems and economic resources and activities.

The impact of climate change on the economy is expressed through an estimate of the eventual loss of GDP. However, this impact is to a small extent direct, and to a greater extent it is realized through a complex transmission mechanism. The two main ways that extreme weather events caused by climate change will affect the economy are productivity and investment. Extreme weather events can lead to damage to the economic resources needed for production and thus directly affect the reduction of GDP. But they can reduce productivity and subsequently investments that are determinants of long-term economic growth. However, climate change also brings many opportunities for businesses, especially in the segments of energy efficiency, green businesses and green transition.

Productivity is one of the key determinants of long-term economic growth. It is actually the volume of goods and services produced by the employed factors of production. Growth in productivity means growth in output with the same engaged inputs, thus growth of the income in the economy and economic growth (GDP growth). The opposite is true for decrease in productivity. Extreme weather events can negatively affect productivity. First of the productivity of the labor force would be affected, which will decrease due to global warming. Labor productivity shows the volume of output that is created in the economy per unit of employed worker. And total factor productivity measures the amount of output that is produced by all the factors employed (labor, capital and land).

Rising temperatures have a direct adverse impact on the workforce. Workers will reduce their labor supply due to the heat wave shutdowns, worker exhaustion, and even death caused by high temperatures. Workers will have to take more frequent breaks in work due to the need for rehydration and cooling. In conditions of high temperatures, the productivity of workers decreases due to reduced performance. Ultimately, this leads to increased mistakes, errors and omissions in operation, and eventually loss in output. However, this will be most true for labour-intensive and outdoor activities such as agriculture and construction, but will not be as typical for office work. Also, the negative effect on productivity will be pronounced in certain locations that are more exposed to heat waves, but would have positive effects for higher places where there are currently low temperatures.

The other key determinant of long-term economic growth is investment. These are the investments of economic agents in fixed assets with which production capacities are created. In the short term, the very act of investment means GDP growth due to the investment consumption component. But in the long term, investments in new production facilities create conditions for future growth in production, employment, and thus ultimately GDP growth. The opposite is true if investments are decreasing. Businesses have the incentive to undertake an investment only if they see profitable opportunities that will bring them future earnings.

Extreme weather events such as storms and floods, forest fires, etc., can lead to degradation, destruction of real estate, plants and equipment and thus directly affect the reduction of production and income in the economy. But if business managers perceive the reduced productivity that we described above, together with the direct destruction of fixed funds, there is a reduction in the incentive to invest and a reduction in GDP. Extreme weather events can erode investors' confidence in generating profits. In particular, investors will withdraw from climate-vulnerable areas and activities. If climate change affects the expected changes in the preferences of buyers, the change in technologies and policies, the lack of inputs for production, but also the possible imposition of new duties such as carbon taxation, will certainly have an unfavorable impact on investments. However, climate change can open up new areas of interest for investors, such as investments in energy efficiency and green businesses.

The effect of climate change is different in the short and long term. While in the short term their impact can be negative or positive, in the long term global warming is expected to have significant negative effects. The reduction in GDP would be due to reduced productivity, reduced investment, reduced household disposable income and reduced consumption. Consequently, there will be reduction in the amount of taxes paid to the government, which will subsequently reduce government spending. Ultimately, there would be a reduction in the three components of GDP: reduced personal, investment and government consumption.

However, research shows that some parts of the planet Earth will have a moderate or no impact, especially the northern parts. Southern parts, especially the African continent and small island countries in Asia are expected to be hit hardest. Ultimately, on average global GDP would decrease to a greater or lesser extent depending on the expected increase in global temperatures.

The impact of climate change is expected to have a different impact on different economic sectors, with the most climate-vulnerable sectors being agriculture, water, forestry and public health. The climate vulnerability of the economy depends on the exposure of the economy to any of these sectors. If the economy is dominated by sectors that are less climate-vulnerable, overall the economy is not very climate-vulnerable in itself. But this claim is subject to a caveat, because the domestic economy may be trade and otherwise dependent on another climate-sensitive

foreign economy, on the international supply chain or transport infrastructure, and thus the climate risks from outside may spill over to the domestic economy.

Impacts on agricultural productivity: Climate change poses significant threats to global food security by altering agricultural conditions. Rising temperatures, changing rainfall patterns, and extreme weather events can lead to reduced crop yields, decreased livestock productivity, and increased vulnerability to pests and diseases. These disruptions have direct economic repercussions, affecting food prices, trade balances, and the livelihoods of millions of farmers and agricultural workers.

Economic costs of extreme weather events: The increasing frequency and intensity of extreme weather events, such as hurricanes, droughts, and floods, have devastating economic consequences. These events result in extensive damage to infrastructure, property, and crops, leading to substantial costs for both individuals and governments. The aftermath of such events often requires substantial investments in recovery and reconstruction efforts, diverting resources from other sectors of the economy.

Disruption of supply chains: Climate change can disrupt global supply chains, particularly in industries heavily reliant on natural resources. For example, rising sea levels can threaten coastal infrastructure, impacting shipping routes and ports. Changes in temperature and precipitation patterns can also affect production and transportation logistics, leading to supply shortages, increased costs, and economic instability.

Impacts on tourism and hospitality: The tourism and hospitality sector, a vital contributor to many economies, is highly vulnerable to climate change. Rising temperatures, changing weather patterns, and environmental degradation can impact tourism-dependent regions, leading to reduced visitor numbers and revenue losses. Additionally, the degradation of natural attractions, such as coral reefs and national parks, can further undermine the economic potential of these areas.

Financial risks and market volatility: Climate change presents significant financial risks, as the potential for physical, regulatory, and societal impacts increases. These risks include increased insurance claims, reduced asset values in climate-vulnerable regions, and the potential for stranded assets in carbon-intensive industries. Moreover, regulatory measures and shifting consumer preferences towards sustainable practices can create market volatility, affecting investor confidence and economic stability. Climate change can have an adverse impact on the creditworthiness of loan users and make them default on their debt.

Adaptation and mitigation opportunities: While climate change poses substantial challenges, it also presents opportunities for innovation, economic growth, and job creation. Transitioning to a low-carbon economy can drive investments in renewable energy, energy efficiency, and sustainable infrastructure, stimulating economic activity and creating new employment opportunities. Additionally, investing in climate adaptation measures, such as resilient infrastructure and agricultural practices, can help mitigate potential economic losses.

The literature reviewed highlights the far-reaching impacts of climate change on the economy, emphasizing the urgent need for proactive measures to address this issue. The economic costs of inaction are projected to outweigh the costs of climate mitigation and adaptation. By recognizing the interplay between climate change and the economy, policymakers, businesses, and individuals can work together to develop sustainable strategies that protect both the environment and economic well-being, ensuring a more resilient and prosperous future.

Climate change will cause income divergence across individuals, sectors, and regions, adjustment in energy markets, increased inflation variability, financial markets stress, intensified innovation, increased migration, and rising public debt (Breckenfelder et al., 2023). According to Mendelsohn et al. (2000), assuming 2°C of warming is reached by 2060, most damages will come from agriculture where OECD economies will gain from warming while the rest of the world will lose. Using the Ricardian model, they predict much smaller losses and gains than the reduced-form model, predicting a cumulative effect of a loss of 0.3% to 2060 GDP levels from 2.0°C warming. In a similar study, Mendelsohn, Schlesinger and Williams (2000) cumulative market impact costs do not exceed 0.1% of GDP in 2100 assuming 2.5°C rise of global temperature. In a very extreme scenario, Stern (2005) assuming global warming of between 2.4°C and 5.8°C costs of extreme weather alone could reach 0.5 - 1% of world GDP per annum by the middle of the century and an average loss of 5% of global GDP per annum over the next two centuries. IPCC (2014) assuming more realistic global warming of approximately 2.0°C, a loss of 0.2% - 2.0% of the global GDP per annum is expected. There are large differences between countries when damage estimates accelerate beyond 3°C of warming. Delaying mitigation efforts beyond those currently in place to 2030 is estimated to substantially increase the difficulty of transitioning to low long-term emission levels. However, Pearce et al (1996) believe that only a fraction of the market economy is vulnerable to global warming, namely agriculture, coastal resources, energy, forestry, tourism, and water. These sectors contribute just 5% of global GDP to which their share is expected to shrink over time (Mendelsohn, 2013). According to OECD (2015) without climate action, the combined effect of the selected impacts on global annual GDP are projected of 1.0% to 3.3% by 2060. Assuming a wider range of 1°C to 6°C, GDP losses could amount to 0.6% to 4.4% in 2060. Kahn et al. (2019) found that persistent increase in average

global temperature by 0.04°C per year, in the absence of mitigation policies, reduces world real GDP per capita by more than 7% by 2100. On the other hand, limiting the temperature increase to 0.01°C per annum reduces the loss substantially to about 1%. These effects vary significantly across countries depending on the pace of temperature increases and variability of climate conditions. NIESR - UNEP FI (2022) report that inflation is expected to rise by 1–3 percentage points than under current policies and to be well above central bank targets in most countries. Batten, Sowerbutts and Tanaka (2020) states that inflationary pressures might arise from a decline in the national and international supply of commodities or from productivity shocks caused by weather-related events such as droughts, floods, storms, and sea level rises. These events can potentially result in large financial losses, lower wealth, and lower GDP.

2. METHODS

Given that there are no statistical data on the local GDP of the City of Skopje, the impact of climate change on the local economy will be assessed using a qualitative approach. This approach is implemented in two steps. In the first step, we will estimate the current vulnerability of the local economy to extreme weather events by applying the matrix shown in Table 1. The future impact of climate risk is estimated based on the estimated current vulnerability and the future expected changes in extreme weather events in terms of their intensity and frequency using the matrix in Table 2.

Table 1. Vulnerability assessment matrix

Class of vulnerability		Adaptive capacity		
		Low	Medium	High
Exposure / Sensitivity	High	Hhigh	High	Medium
	Medium	High/medium	Medium	Medium/Low
	Low	Medium	Low	Low

Table 2. Matrix for future climate risk assessment

Current vulnerability	Expected change in the intensity and frequency of the hazard		
	Decrease	No change	Reinforcement
High	Medium	High	Very High
Medium	Low	Medium	High
Low	Low	Low	Medium

Source: City of Belgrade SEP (2015)

3. RESULTS

Table 3. Assessment of the current vulnerability and future climate risk of the local economy of the City of Skopje

ECONOMIC SECTOR	EXTREME WEATHER EVENT	CURRENT VULNERABILITY	FUTURE CLIMATE RISK
HOUSING	Extreme Heat	High	Very High
	Extreme Cold	Medium	Low
	Extreme Precipitation	Medium	Medium
	Floods	Medium	High
	Droughts	Medium	High
	Storms	Medium	Medium
	Landslides	Medium	Medium
	Forest Fires	Low	Medium
INDUSTRY	Extreme Heat	Medium	Very High
	Extreme Cold	Low	Low
	Extreme Precipitation	Medium	Medium
	Floods	Medium	High
	Droughts	Medium	High
	Storms	Medium	Medium
	Landslides	Medium	Low
	Forest Fires	Low	Low
TRADE (WHOLESALE AND RETAIL)	Extreme Heat	Medium	Medium
	Extreme Cold	Medium	Low
	Extreme Precipitation	Low	Medium
	Floods	Low	Medium
	Droughts	Medium	High
	Storms	Low	Medium

	Landslides	Medium	Low
	Forest Fires	Medium	Medium
CONSTRUCTION AND CIVIL ENGINEERING	Extreme Heat	High	Very High
	Extreme Cold	Medium	Low
	Extreme Precipitation	High	High
	Floods	Medium	Low
	Droughts	Medium	High
	Storms	Medium	High
	Landslides	Medium	Low
	Forest Fires	Low	Medium
TRANSPORT AND STORAGE	Extreme Heat	High	Very High
	Extreme Cold	Medium	Low
	Extreme Precipitation	Medium	High
	Floods	Medium	Medium
	Droughts	Medium	Medium
	Storms	Medium	Medium
	Landslides	Low	Low
	Forest Fires	Medium	Low
TOURISM AND HOSPITALITY	Extreme Heat	Medium	High
	Extreme Cold	Low	Low
	Extreme Precipitation	Medium	High
	Floods	Low	Medium
	Droughts	Low	Medium
	Storms	Low	Medium
	Landslides	Low	Low
	Forest Fires	Medium	Medium

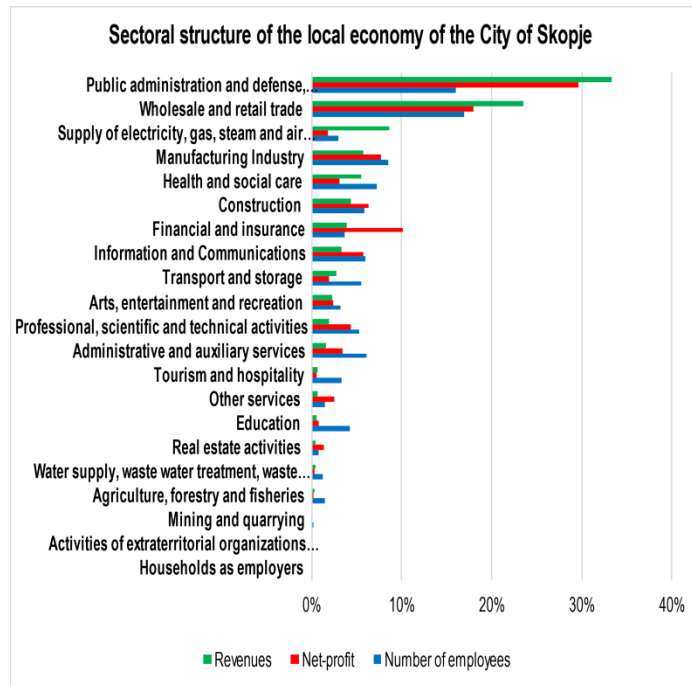
Source: authors own presentation

4. DISCUSSIONS

Assessment of the past and current climate vulnerability of the local economy of the City of Skopje

The only official data on the negative impact of extreme weather conditions caused by climate change was the report of the Insurance Supervision Agency related to the unusual storm that hit Skopje on August 30, 2022. Insurers from the Skopje region reported a total of 349 property losses in all insurance companies after the strong storm. Of all the reported damages, the largest number, ie 215, are on property insured by natural persons. Companies and other legal entities based in Skopje reported 134 property damages as a result of the unprecedented strong storm in the capital, according to data provided by the Insurance Supervision Agency (ASO) from all 11 non-life insurance companies. However, although this is the only one, it is a very scarce data for two reasons: i) this data includes only those who were insured, but not those who were not insured, for whom no one keeps official data even though the number of people in our country is small who voluntarily insure the property; ii) this data does not show us the value of the damaged claims expressed in money.

Source: authors own presentation



There is no such data for the huge storm followed by torrential flood six years before, on August 6, 2016 in the western part of the Skopje valley. In a very short time of just a few hours, several villages were flooded, a large number of people lost their lives, and the material damage was enormous. The damages in the farming and agricultural companies were huge, a large number of companies went bankrupt, thereby defaulting on the loans they had to the banks, and the insurance companies had to pay large damages.

Also a data for forest fires in the City of Skopje are provided, but there are no estimates of the economic damage from this event either.

Apart from these events described above, another frequent extreme event is the heat waves that usually affect the City every year in July and August. It exposes a large number of people to health risk and reduced productivity due to the need for cooling, but also the need for absence from work for chronically ill, elderly and pregnant women. Heat waves have a negative impact in outdoor activities such as construction and agriculture. There, in particular, business process interruptions, business discontinuities and reduced output occur.

Skopje is an administrative city, the capital of the country, which houses the entire state administration, the local administrations of the ten municipalities, and public enterprises. The headquarters of the largest number of companies are in Skopje, especially all financial institutions. Thus, in addition to the state administration, there is a large business administration. Most of the workers in Skopje work in office conditions where people can protect themselves and adapt to extreme weather conditions.

Assessment of the future climate risks of the local economy of the City of Skopje

At this moment there is great uncertainty and we cannot predict with great precision in which direction the local economy of the City of Skopje will change, in which way local businesses will adapt. Assuming that the structure of the economy will remain the same or approximately the same we made qualitative assessment of future economic risks and impact on the different economic sectors. We choose only the dominant sectors in the local economy.

An increase in the intensity of the majority of extreme climate events is expected, especially the increase in temperatures in all seasons, more frequent heat waves, and a decrease in extreme cold days, with increased precipitation and the possibility of flash floods that may become more frequent. Due to the expectations for worsening climatic conditions, an increase in climatic risks is expected in the local economy in the City of Skopje in relation to the current vulnerability. However, the general assessment is that the economy of the city of Skopje will be moderately vulnerable to climate risks in the future. It is because of the expectations for strong adaptability of local businesses and change of business models according to the new economic conditions.

A greater climate risk is expected in the household sector, caused by expected increases in heat waves, but also possible heavy torrential rains. Its consumption would be lower on a short term, due to increased uncertainty, e.g. surrounding housing wealth and future income prospects. But it is expected to be higher on a medium term, due to increased household demand to replace destroyed goods, or hoarding behavior.

Rising temperatures would have a negative effect on industry, especially the construction and agriculture sectors, and other outdoor activities. The need of workers in these sectors for shelter, for cooling, health protection, but also the greater number of work stoppages due to cooling, as well as complete work stoppages, will potentially lead to reduced productivity in the local economy. However, this is not expected to reduce the incentive for entrepreneurs to invest. However, these two sectors have a small relative contribution to the overall economy, especially agriculture, which is a marginal branch in the City of Skopje.

Excessive temperatures can have a negative impact on the incentive of tourists to visit the City of Skopje. It will also lead to potentially increased operating costs of the tourism sector, hotels, accommodation facilities and restaurants.

Rising temperatures would have a potentially high negative impact, but also on interruptions in the transport of goods. Here, there may be increased costs for transportation and storage of the goods, which would negatively affect the profitability of the companies.

Expectations for an increased frequency of torrential rains, floods and strong storms would lead to the destruction of the homes of the population. It would also lead to damage and destruction of the companies' real estate, plants and equipment, and the companies' production facilities. This would lead to business discontinuities until the reconstruction of destroyed real estate, plant and equipment. In the end, the force of the blow may be the complete bankruptcy of some companies, and a large part may suffer great damages. But the effect can spread throughout the economy, primarily on the financial system. Namely, it would have a negative impact on the ability of the companies to return the loans taken from the banks and to default. Through this transmission mechanism, the negative effects will be transferred to the banks, but also to the insurance companies, which would ultimately be called upon to compensate the insured's damaged property. In that way, the climate risk would be transferred to other parts of the economy through several routes and transmission mechanisms.

Ultimately, reduced production, such as industrial production due to the destruction of production facilities, and agricultural production due to the destroyed crop due to floods or reduced crop due to heat waves and droughts,

would have a distortion in the market of goods and services. With unchanged demand, reduced supply would lead to an inflationary effect on certain markets. It can certainly be substituted by imports, but the final effects will depend on the state of the global economy.

5. CONCLUSIONS

The general assessment is that the economy of the City of Skopje is not very vulnerable to extreme weather events. The economy of the city of Skopje is not diversified and there is a large concentration of two low climate vulnerable economic sectors (public administration and trade sector). The largest part of the revenues is realized in public administration (33%) and trade (24%), and the largest number of employees are engaged in trade sector (17%) and public administration (16%). In the public and trade sector, no high climate vulnerabilities have been detected, but they are moderate or low. High vulnerability is assessed in the construction sector to heat waves and extreme precipitation. Agriculture and forestry as the most climate vulnerable sectors are marginal in the City of Skopje. Therefore, focusing on the vulnerabilities of the dominant economic sectors, the eventual conclusion is that the City of Skopje is currently moderately to lowly vulnerable to extreme weather events due to global warming and climate changes.

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