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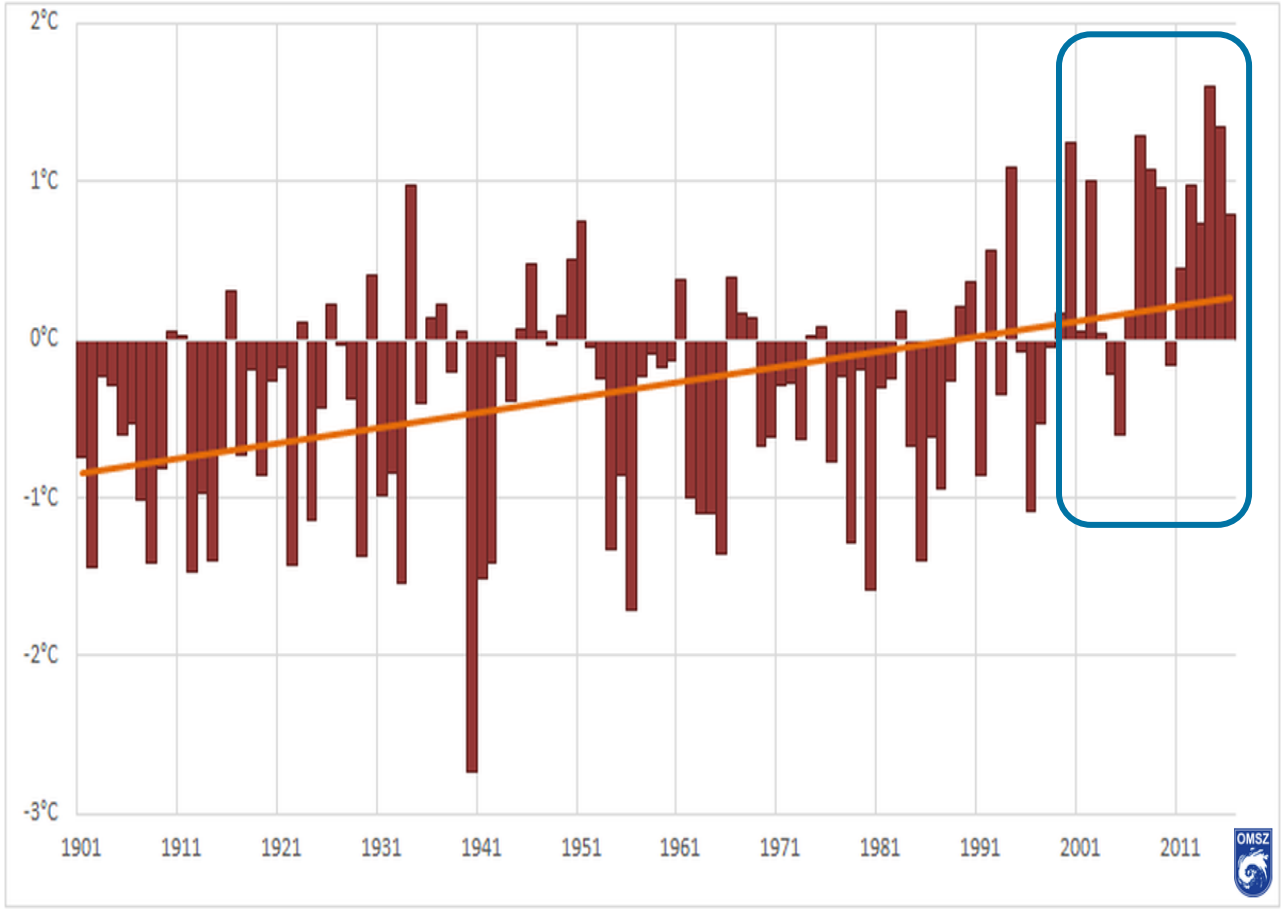
MAIN RESULTS OF THE MAGYAR NEMZETI BANK'S LONG-TERM CLIMATE STRESS TEST

CONTENTS

Source | MNB

IMPACT OF CLIMATE RISKS ON THE FINANCIAL SECTOR

GLOBAL WARMING IN HUNGARY



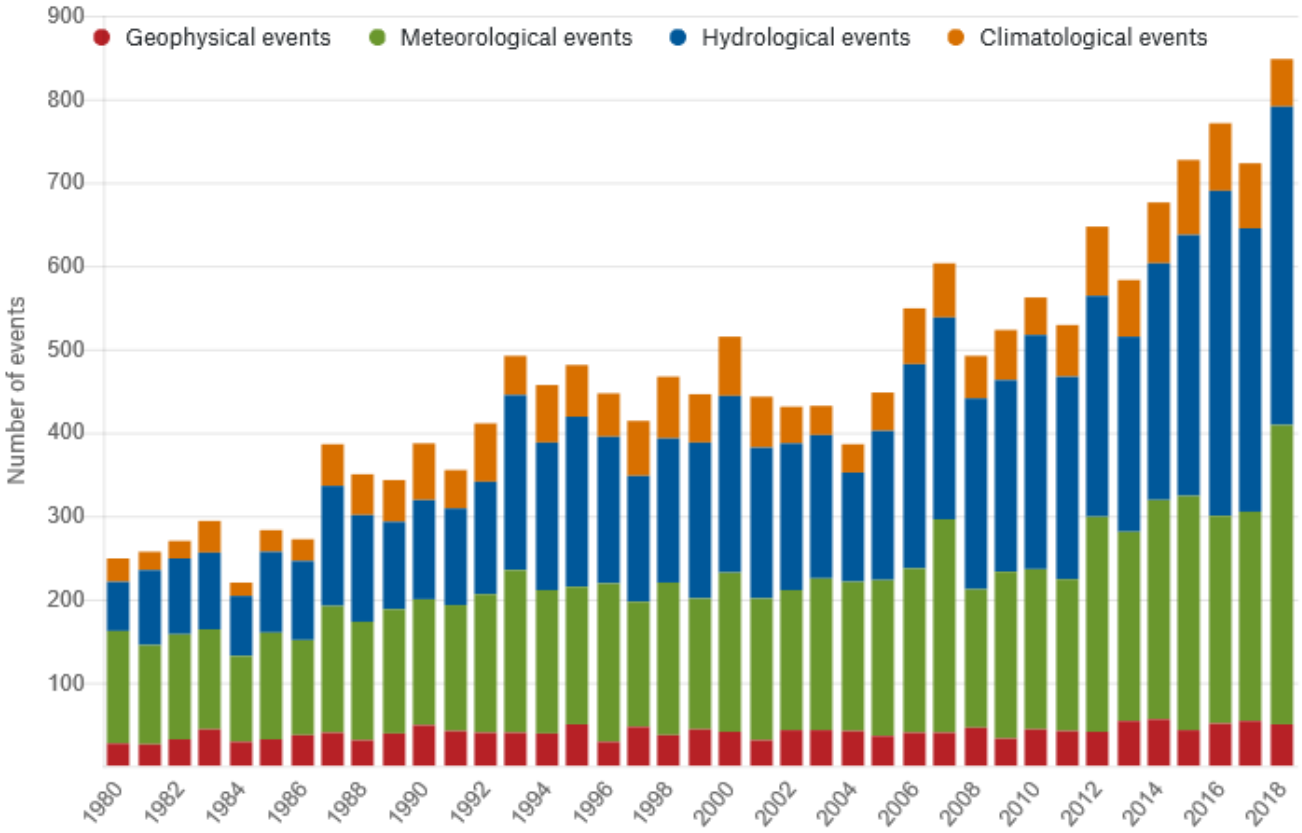
In Hungary, 10 of the 15 hottest years in the last 120 years was after 2000

Globally, average temperature increases by 0.12°C per decade

ANNUAL MEAN TEMPERATURE IN HUNGARY
COMPARED TO THE 1981-2010 AVERAGE

Source | Országos Meteorológiai Szolgálat
(Hungarian Meteorological Service)

INTENSIFICATION OF EXTREME WEATHER EVENTS



The number of claims has tripled in the last 40 years, while it has been above the 1980-2000 average each year

EVOLUTION OF THE NUMBER OF REGISTERED WEATHER AND GEOPHYSICAL INSURANCE CLAIMS WORLDWIDE

Source | Munich Re, NatCatSERVICE

EMERGING NEW CLIMATE RISKS

Physical risks

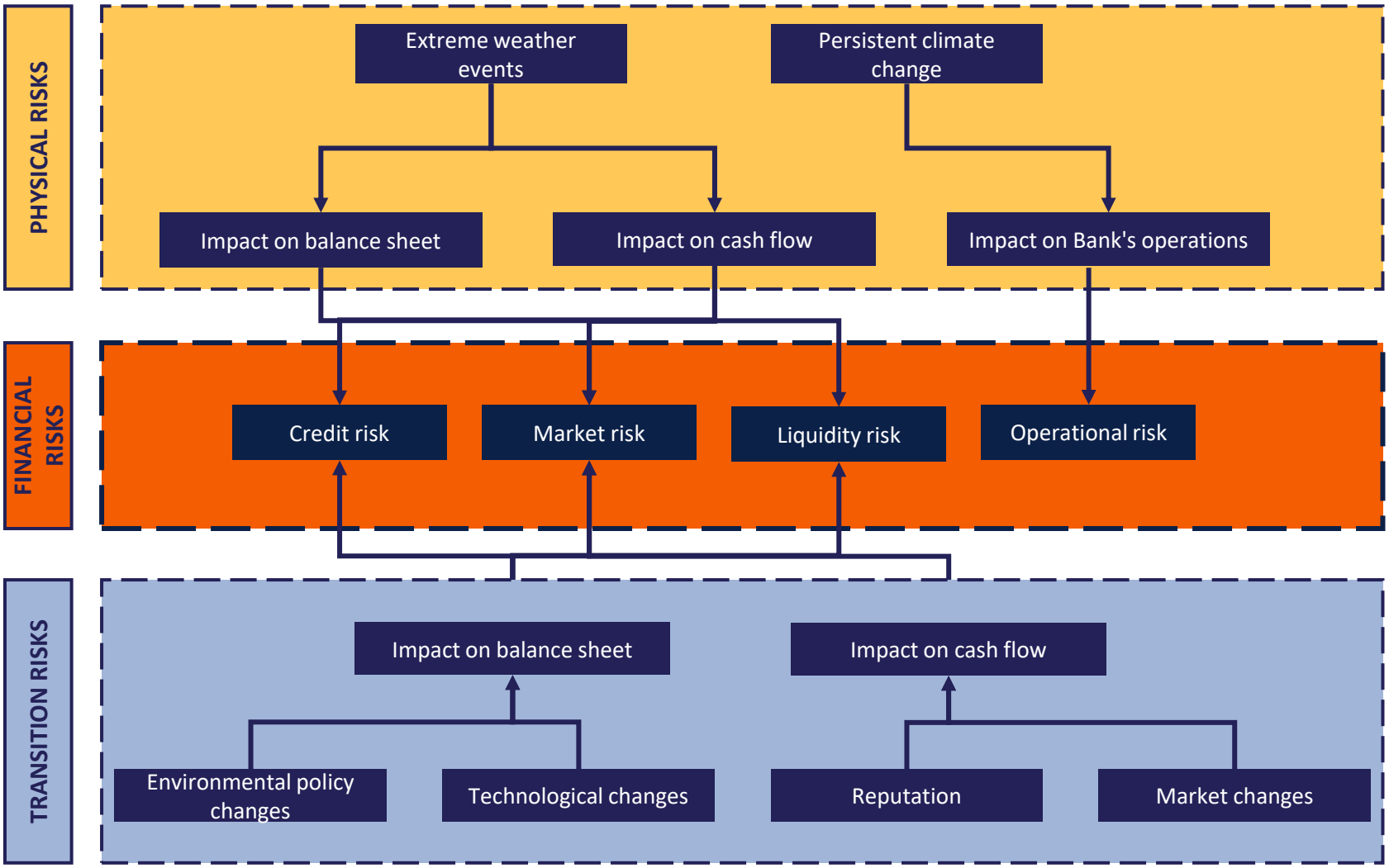
The weather and climate will also change significantly as a result of global warming. There will be persistent negative environmental impacts linked to climate change, such as salinisation, sea-level rise or droughts. At the same time, extreme weather events and their inherent negative anomalies, such as floods, forest fires or heat waves, are becoming more frequent. The impact of these is called physical risk in economics.

Transition risks

To reduce our emissions, the structure of the economy needs to be changed significantly. This can come partly from public actors, for example by banning certain activities or introducing carbon taxes. However, changes in preferences will also have a significant impact on firms. Both investors and consumers take increasingly in account sustainability considerations. The impact of these and the difficulty of technological transitions will also adversely affect some businesses, which will be exposed to transition risk.

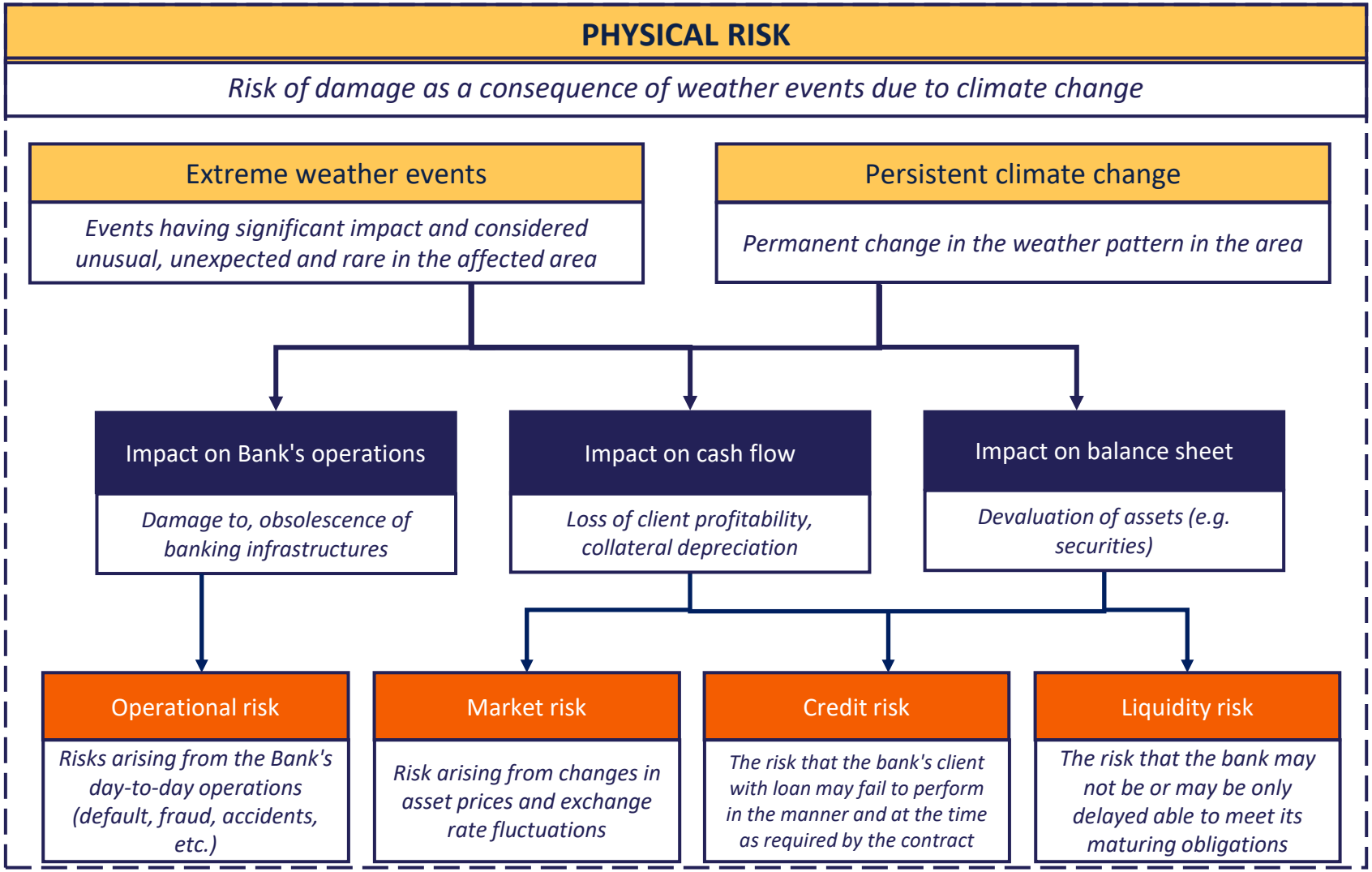
Source | MNB

IMPACT OF CLIMATE CHANGE RISKS ON BANKS



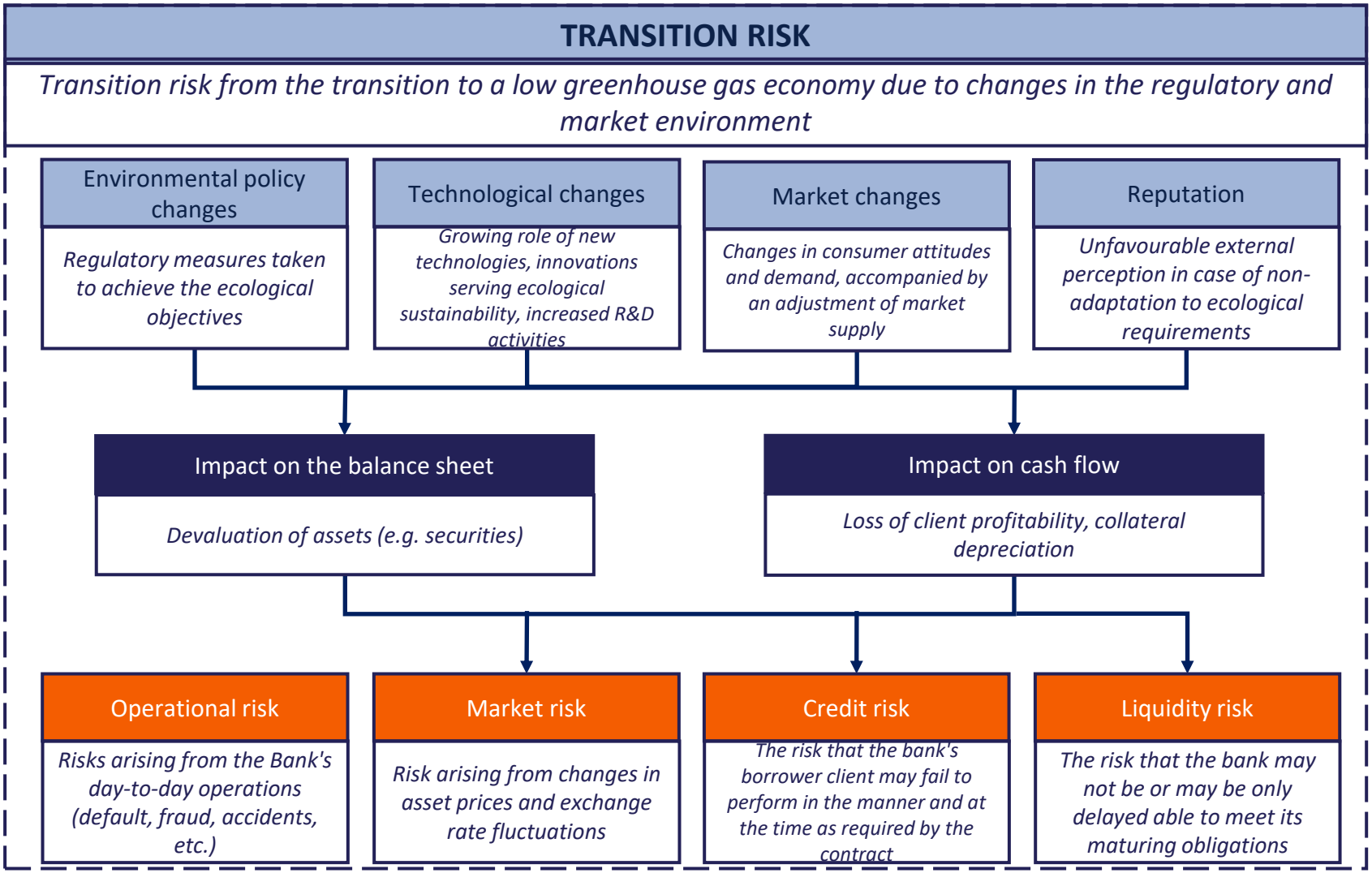
Source | DG Trésor (2017), MNB

IMPACT OF PHYSICAL RISKS ON BANKS



Source | DG Trésor (2017), MNB

IMPACT OF TRANSITION RISKS ON BANKS



Source | DG Trésor (2017), MNB

ROLE OF STRESS TESTS IN IDENTIFYING RISKS

LEGAL ENVIRONMENT

Article 290 of the CRR

*”An institution shall have a **comprehensive stress testing programme for CCR (...).**”*

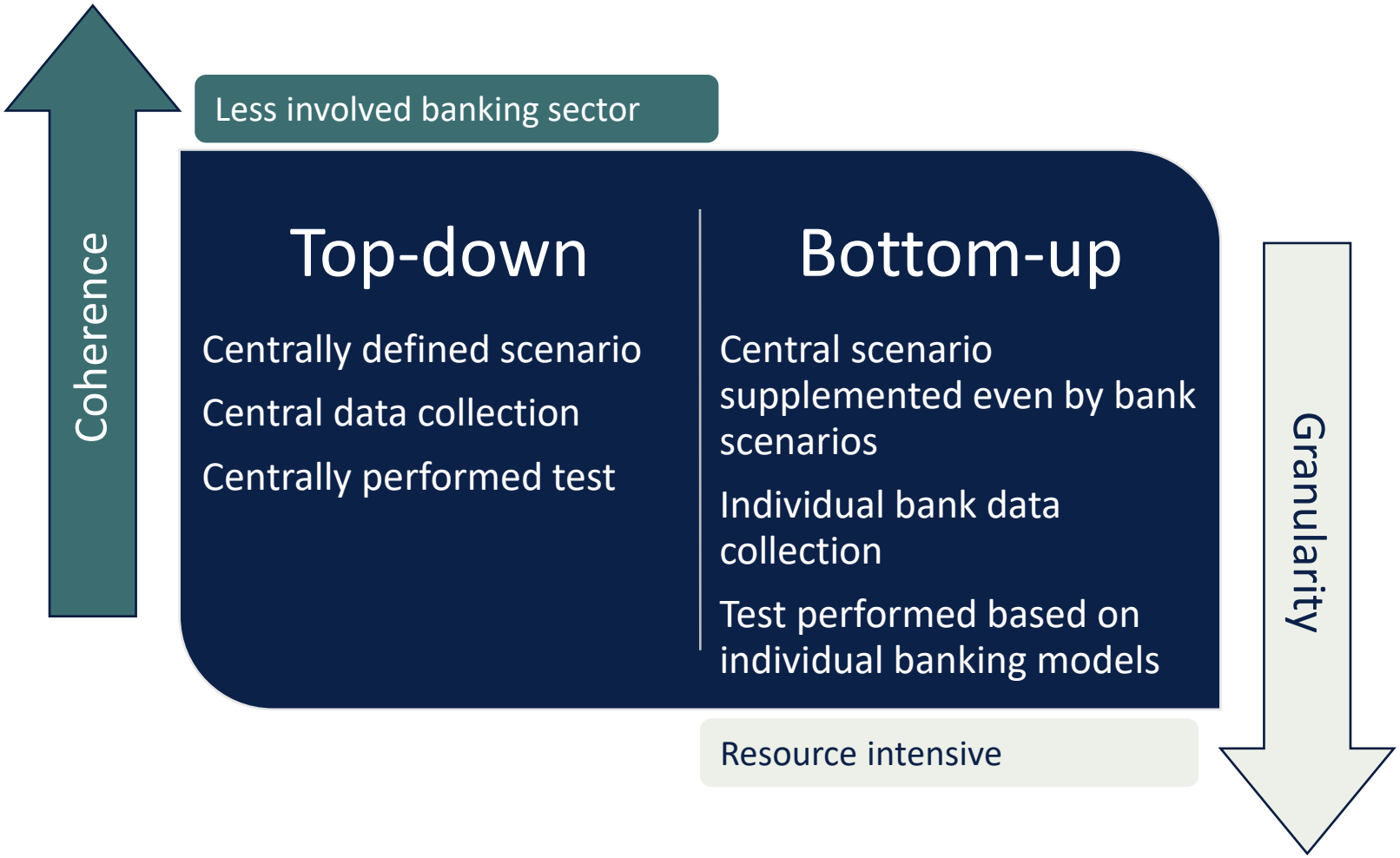
*”It shall **identify possible events** or future changes in economic conditions that **could have unfavourable effects** on an institution's credit exposures and assess the institution's **ability to withstand** such changes.”*

Section 108 of the Banking Act

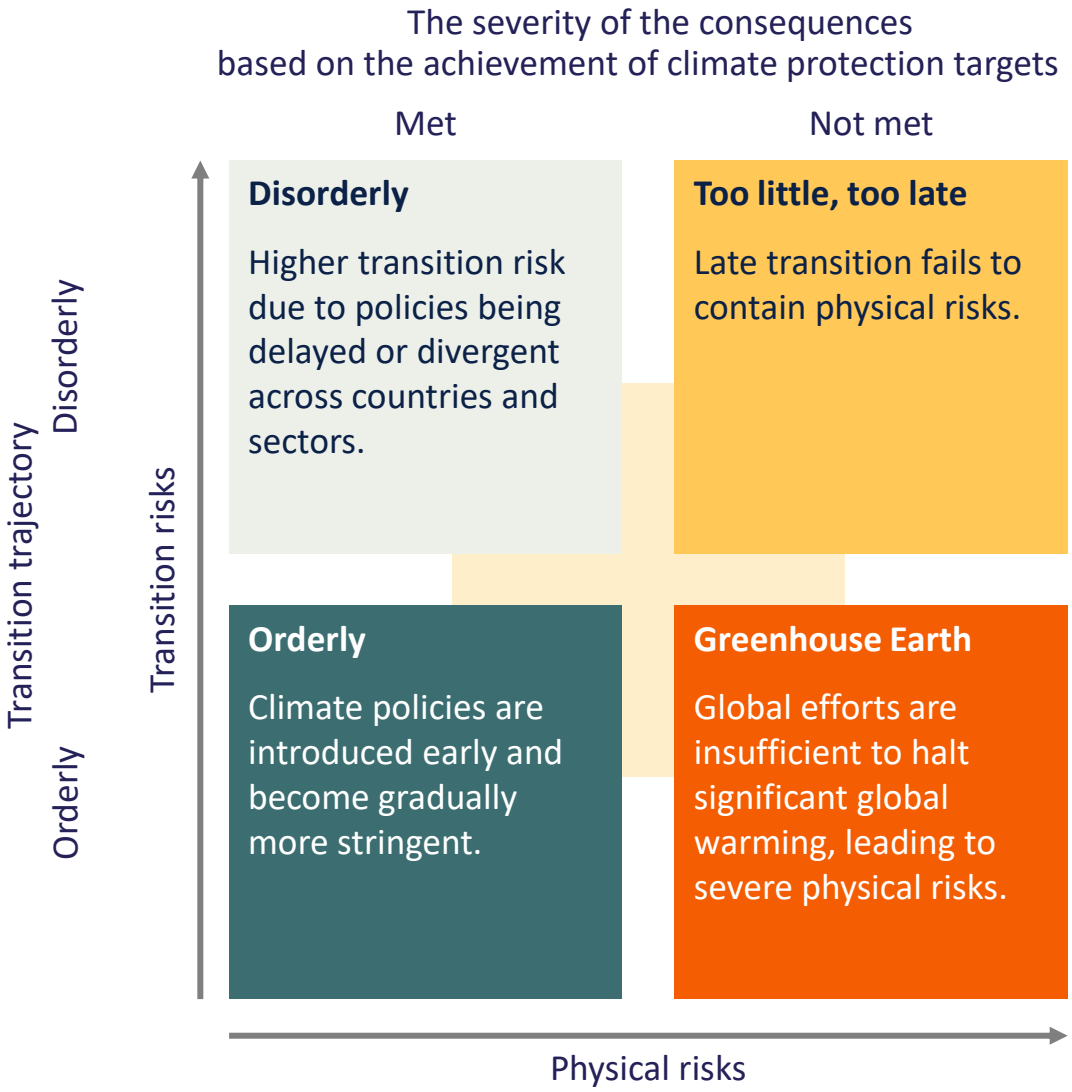
*”credit institutions shall **consider** the potential impact of institution-specific, market-wide and combined alternative scenarios; different time horizons and varying degrees of **stressed conditions** shall be considered”*

Source | MNB

STRESS TEST UNIVERSE



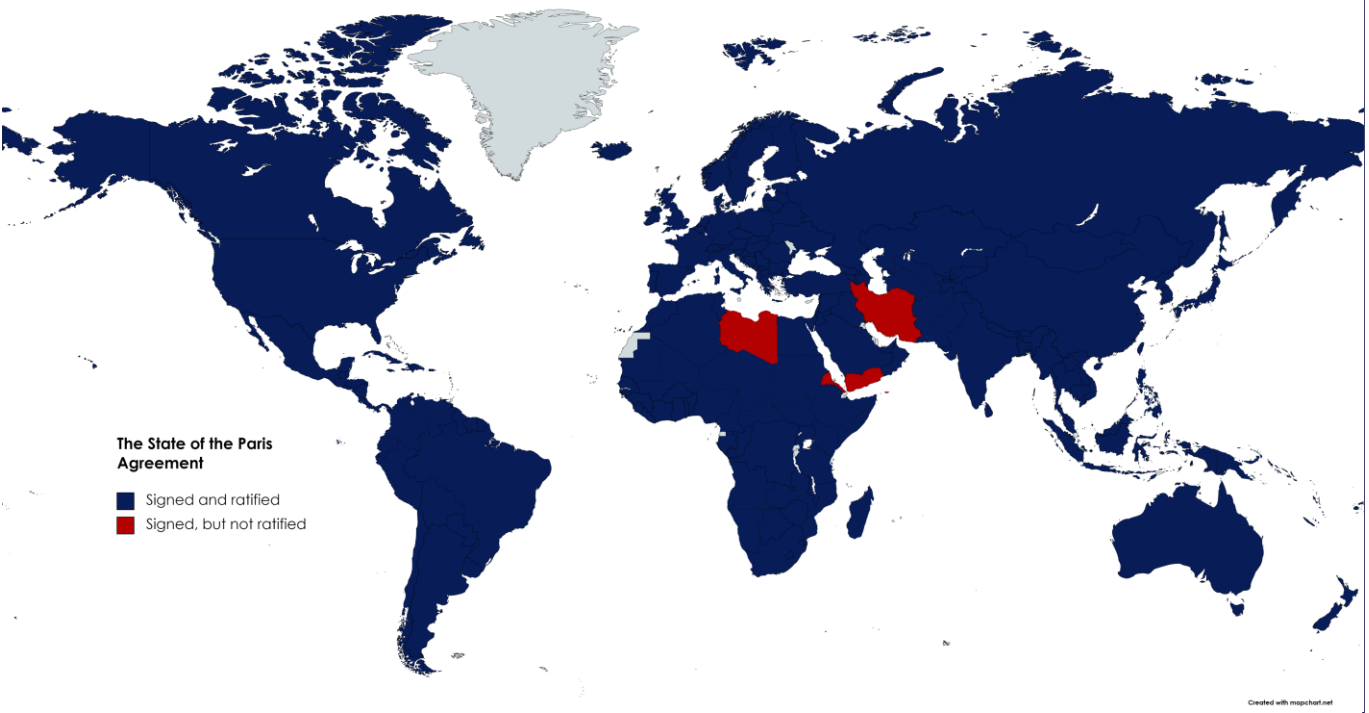
IMPACT OF CLIMATIC STRESS SCENARIOS



Source | NGFS, MNB

CENTRAL CLIMATE POLICY AGREEMENT: PARIS AGREEMENT

COUNTRIES THAT HAVE SIGNED AND RATIFIED THE PARIS CLIMATE AGREEMENT



PARIS AGREEMENT

- By November 2021, signed by 195 countries, ratified by 193 countries
- The main objective is to keep the global temperature increase below 1.5-2°C.
- This requires a rapid reduction in GHG emissions.
- The Agreement provides the basis for orderly transition in climate stress scenarios.

Source | United Nations Treaty Collection, MNB

PREREQUISITE FOR CLIMATE STRESS TEST

A model that can translate

the evolution of global warming drivers (e.g. greenhouse gas concentrations in the atmosphere) into economic consequences,

all at sectoral level, as the involvement of different activities can vary considerably,

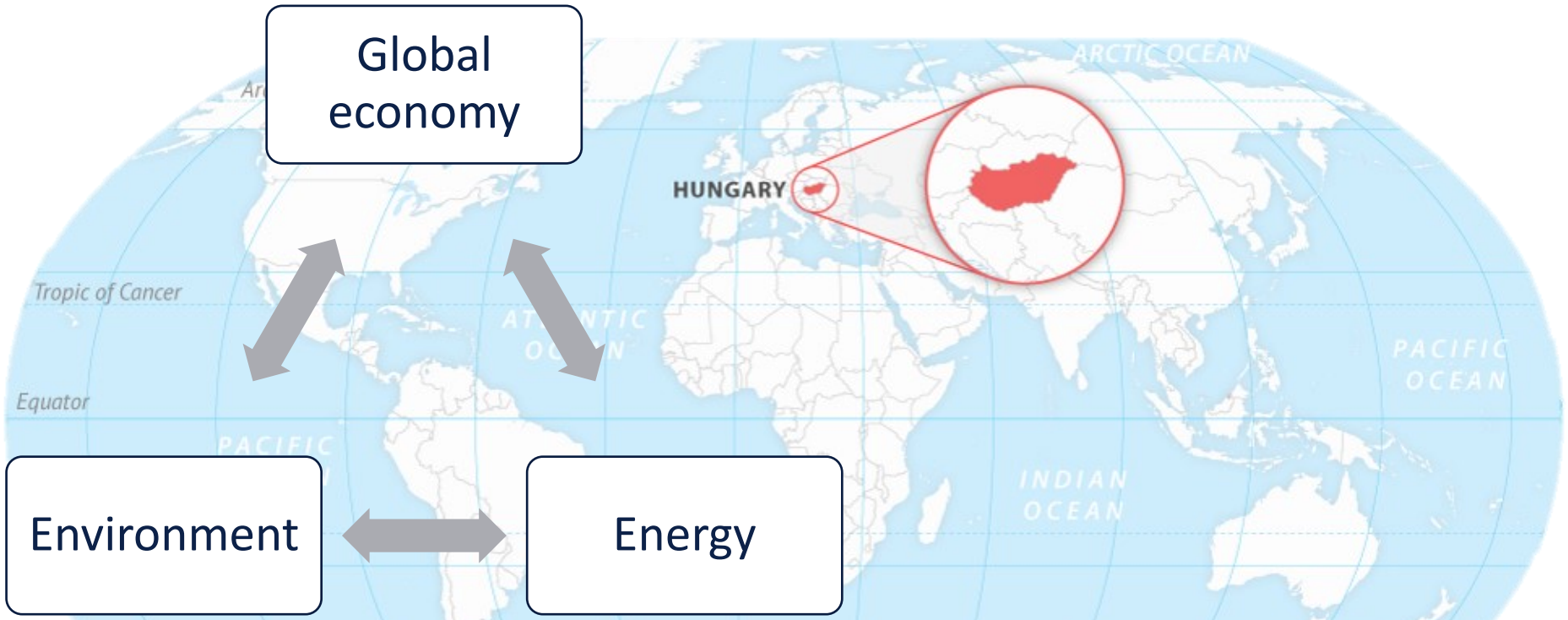
addressing the two-way feedbacks between natural and economic variables, as economic measures affect the evolution of natural variables.

Source | MNB

CAMBRIDGE ECONOMETRICS E3ME MODEL

CAMBRIDGE ECONOMETRICS (CE) E3ME MODEL

Econometric model with complex system of equations: global economy (61 countries/regions: 33 European, 28 other), environmental impacts and energy market, with two-way feedbacks.



Data with annual frequency starting from 1970 projected until 2050

1970 | 1980 | 1990 | 2000 | 2010 | 2020 | 2030 | 2040 | 2050

Source | CE, MNB

CAMBRIDGE ECONOMETRICS (CE) E3ME MODEL – DEMAND-DRIVEN

Demand-driven

The assumption is that supply catches up to the demand.

Free capacities

It allows imperfect capacity utilisation, which is also the typical condition.

Policy measures

Regulatory and policy measures can boost investment, employment etc. and ultimately the output.

Source | CE, MNB

SCENARIOS SIMULATED FOR THE MAGYAR NEMZETI BANK BY CAMBRIDGE ECONOMETRICS

Failed Transition
No additional decarbonization efforts

- Continuation of EU ETS
- Phase out of fossil fuel subsidies (EU, USA, China, Japan)
- Renewables mandates (China, Germany, UK)
- Ongoing (but declining) investment to coal power generating
- Biofuel blending mandates in India and USA

Orderly Transition
Aligning with Paris Agreement

- Ambitious carbon pricing
- Economy-wide energy efficiency programs
- Decreasing demand for fossil fuels, deteriorating economic environment for the related companies
- Direct renewables subsides
- Preventing investment to coal power generating
- Phasing out ICEs

Disorderly transition
Alignment with PE with delayed risk pricing

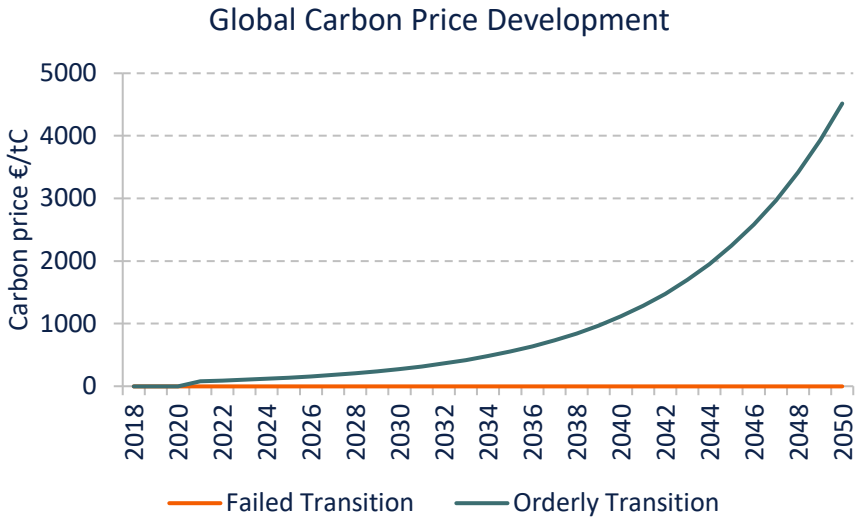
- The regulatory environment is the same as in orderly transition (differing from the NGFS 'disorderly transition' scenario)
- However, it is only after 2025 that financial markets will price climate risks in a swift manner
- Physical risk remain at the level of orderly transition

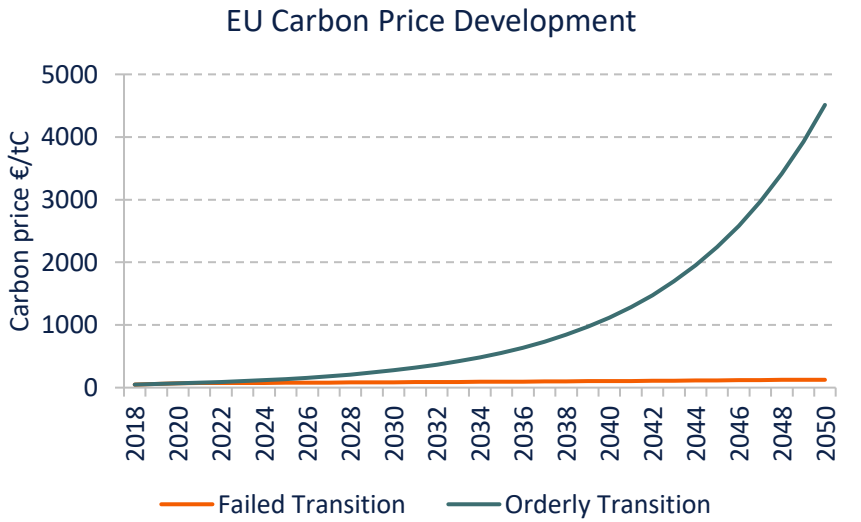
Physical risks

Physical and transition risks

Source | CE, MNB

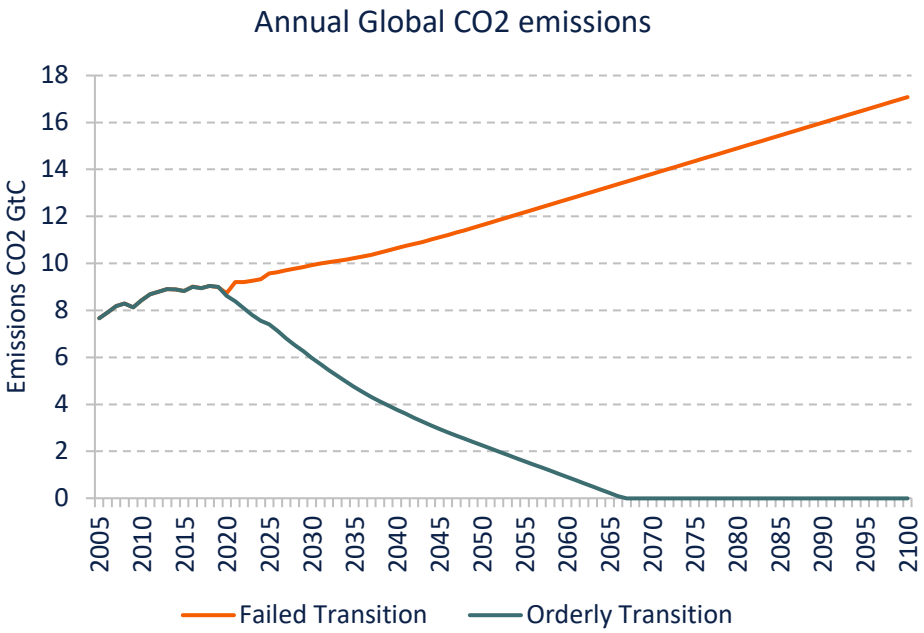
CARBON PRICING – REVENUE NEUTRALITY CONDITION – ECONOMIC CONSEQUENCE

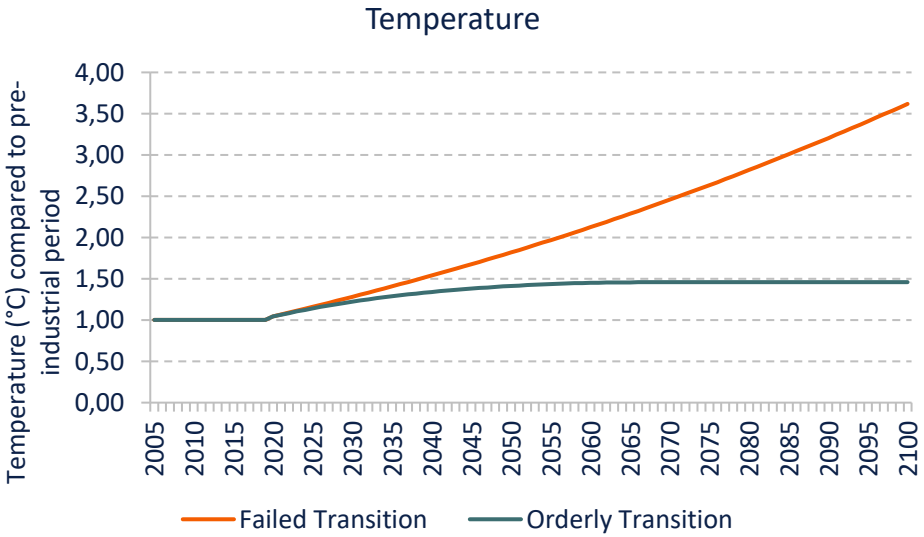




- Ambitiously increasing carbon pricing could generate significant government revenues.
- Assumption: The government's net revenue from carbon tax is zero; consumption tax revenues are decreased at the amount of raised carbon tax revenues.
- Reducing tax burden on consumer goods creates a consumption stimulus (in a competitive environment).
- The consumption stimulus leads to a general stimulus in a demand-driven model (with spare capacity).

Source | CE, MNB





CO_2 EMISSIONS, TEMPERATURE

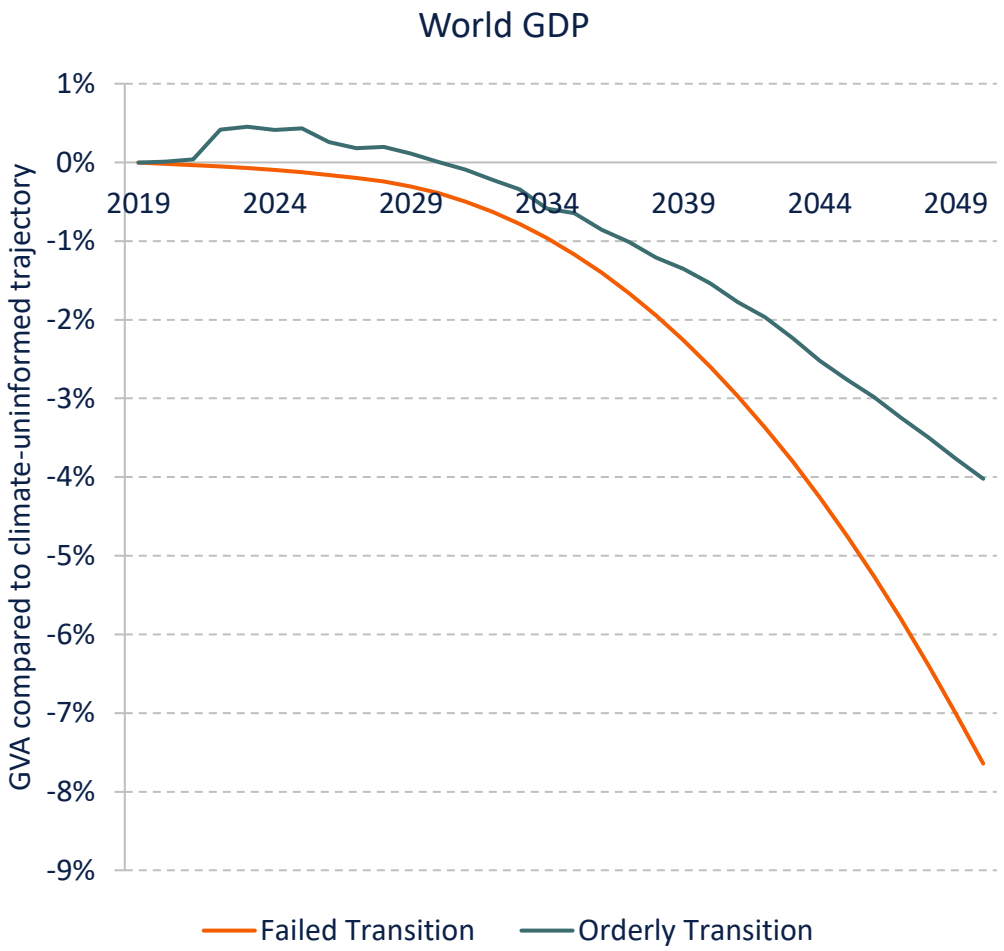
If the transition fails, global CO_2 emissions will gradually increase until the end of the century. With an orderly transition, net zero CO_2 emissions will be reached by 2070.

Compared to pre-industrial times, i.e. the second half of the 19th century, in the case of a failed transition, the Earth's average temperature would increase by 3.5-4 degrees Celsius. If the commitments made in the Paris Agreement are met, global temperature increase will be kept below 1.5 degrees Celsius by the end of the century.

Source | CE, MNB

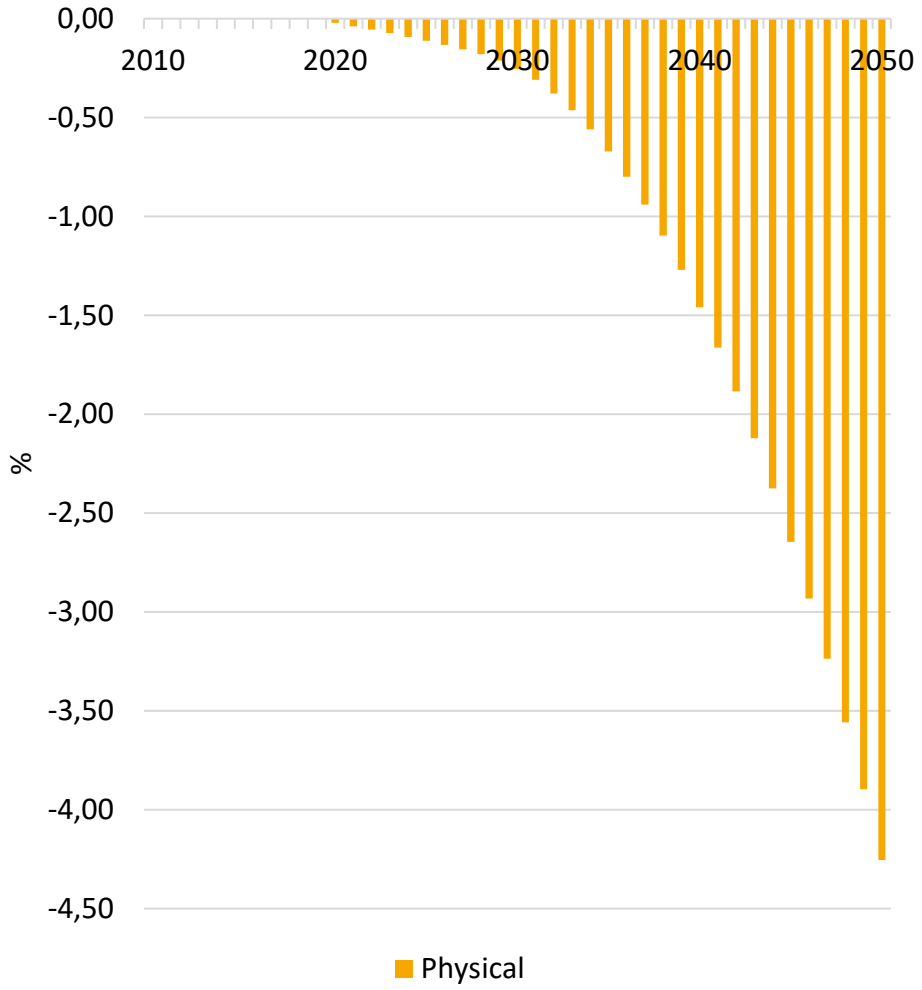
IMPACT OF RISKS ON WORLD GDP

- The Climate-Uninformed Baseline (CUB) represents the imaginary trajectory of failed transition free of physical risks.
- For the world as a whole, even a 1.5-2 degrees Celsius trajectory has negative consequences.
- However, there is a wide variation among countries, not all of them are (directly) affected by sea-level rise, for example.



Source | CE, MNB

IMPACTS OF CLIMATE SCENARIOS ON THE HUNGARIAN ECONOMY



FAILED TRANSITION

GDP-EFFECTS OF RISKS

(DEVIATION FROM CUB LEVEL)

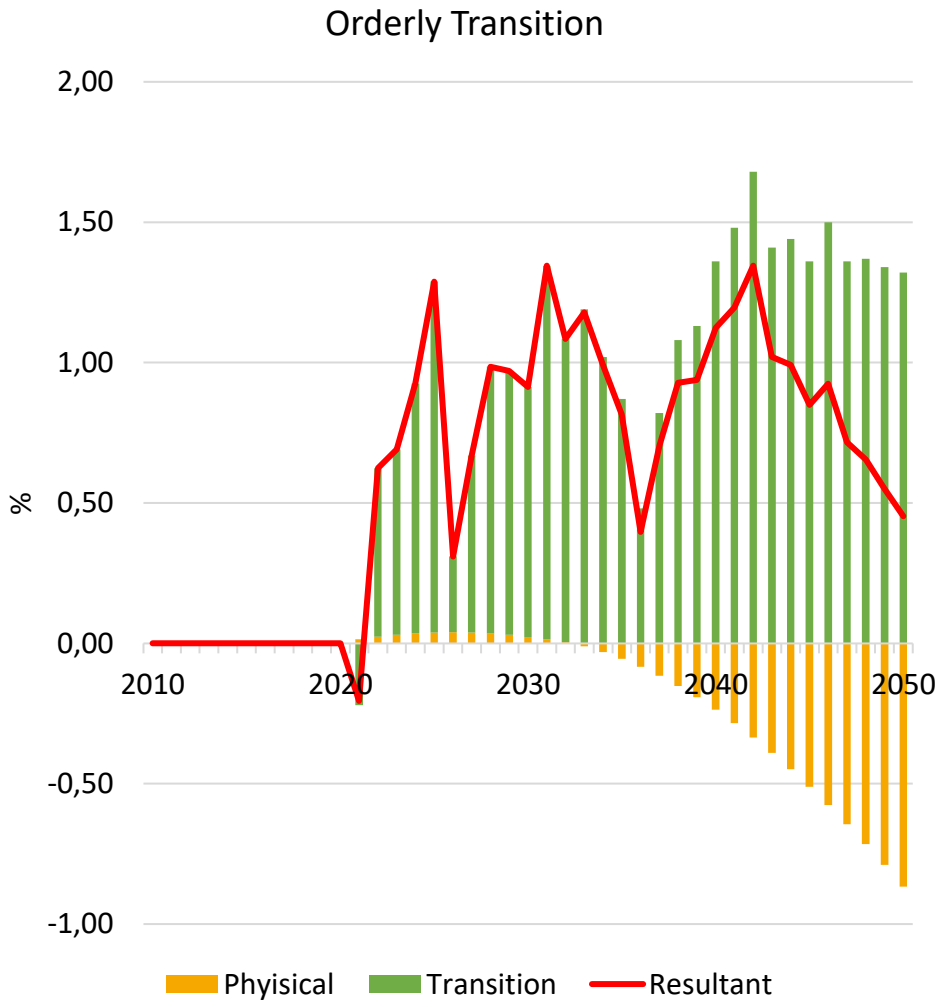
IMPACT OF A FAILED TRANSITION ON THE HUNGARIAN ECONOMY

In case of a failed transition, GDP levels are expected to be 4-4.5 percent lower by the end of 2050 due to the physical consequences of climate change. But the way to get there is just as important, because it is not a one-off negative shock in the distant future, but the fact that compared to the hypothetical baseline trajectory, there will always be less goods to be shared.

Source | CE, MNB

ACTIONS RELATING TO THE TRANSITION YIELD POSITIVE GDP

In orderly transition, the physical impacts will be significantly reduced as global temperature increases more moderately. For the Hungarian economy as a whole, the transition is not a risk but an opportunity, as it will entail surplus in GDP. From a domestic perspective, a world transited to "climate-friendly" operation is therefore highly desirable.



ORDERLY TRANSITION

GDP-EFFECTS OF RISKS

(DEVIATION FROM CUB LEVEL)

Source | CE, MNB

HUNGARIAN ASSUMPTIONS FOR AN ORDERLY TRANSITION

According to the schedule, two new units of Paks II will be started and two existing units will be phased out.

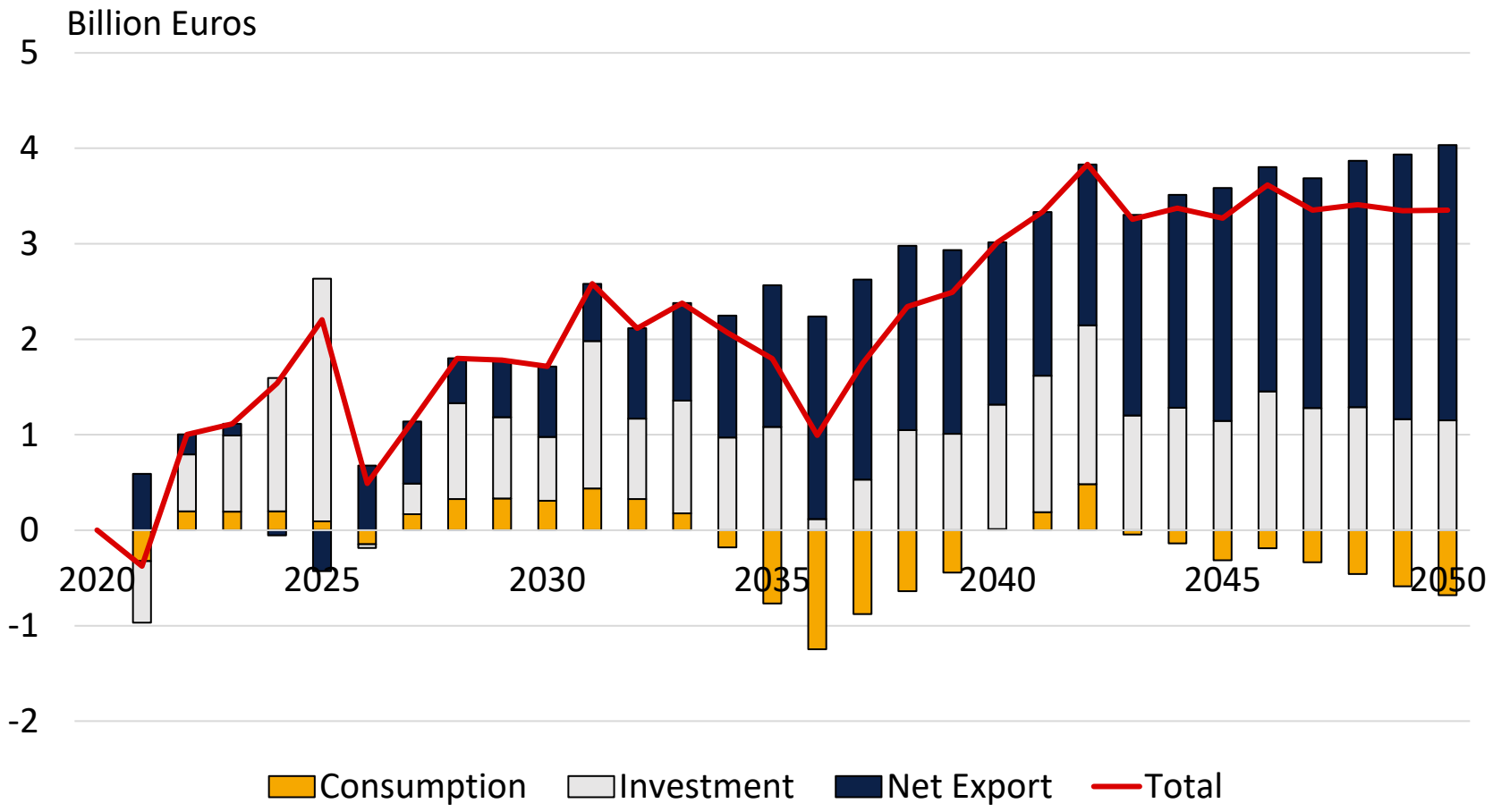
Coal and lignite power plants will be phased out

Solar energy becomes the preferred and subsidised renewable resource

The Hungarian orderly transition scenario was developed by Cambridge Econometrics based on the 2019 National Energy and Climate Plan published by the Department of Innovation and Technology.

Source | ITM, CE, MNB

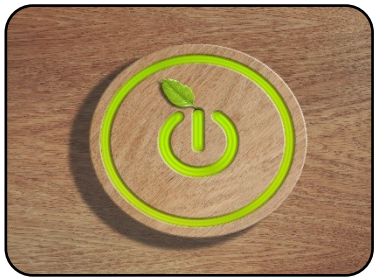
TRANSITION "RISKS": INVESTMENT AND NET EXPORT AS MAIN BOOSTERS



DECOMPOSITION OF GDP EFFECTS OF TRANSITION RISKS (ORDERLY TRANSITION, DEVIATION FROM CUB LEVEL)

Source | CE, MNB

MAIN DRIVERS OF TRANSITION ARE INVESTMENT AND NET EXPORT



Greening energy production

- Investments in key infrastructures that are to be decarbonized, i.e. energy production and transportation, are booming.
- These investments will stimulate the construction, metalworking and electronics manufacturing sectors.

Transition of the automotive industry

- The transition of the automotive industry to more fuel-efficient or electric technologies is also driving investment and net export in related sectors.
- The situation of the sectors extracting and using fossil fuels is deteriorating.

Household's disposable income increase

- The improvement in the external trade balance also due to reduced imports of fuels increases the income that can be spent on other products.
- The increase in disposable income is mainly boosting output in the agricultural, food industry and consumer goods sectors.

Source | CE, MNB

SECTORAL VARIABLES PROVIDED BY CAMBRIDGE ECONOMETRICS

Variables	Time	Transition risks from 2020	Physical risks from 2020
GDP/GVA	1995–2050	●	●
Investment		●	●
Exports		●	●
Imports		●	●
Number of employees		●	●
ULC	2010–2050	●	●

- The variable set shows the set of independent (not derived from each other) variables.
- Physical risks were only available for gross value added (GVA).
- This has given rise to unconventional solutions when using time series.

Source | MNB

NACE REV.2 LEVEL 2

A – AGRICULTURE, FORESTRY AND FISHING

- 01 Crop and animal production, hunting and related service activities
- 02 Forestry and logging
- 03 Fishing and aquaculture

B – MINING AND QUARRYING

- 05 Mining of coal and lignite
- 06 Extraction of crude petroleum and natural gas
- 07 Mining of metal ores
- 08 Other mining and quarrying
- 09 Mining support service activities

The variables provided by Cambridge Econometrics refer to the aggregated groups of 99 NACE level 2 nomenclature (mostly level 1 categories).

⋮

U – ACTIVITIES OF EXTRATERRITORIAL ORGANISATIONS AND BODIES

- 99 Activities of extraterritorial organisations and bodies

Source | MNB, EU

METHODOLOGY AND KEY RESULTS OF THE MNB'S LONG-TERM STRESS TEST

FOCUSING ON NPL RATIO

$$\text{NPL ratio} = \frac{\text{loans with 90+ days past due}}{\text{all loans}}$$ **1.**

Definition of loan:

- Loans, credits, credit type agreements, financial leases (both on- and off-balance sheet items)
- provided by other monetary financial institutions (MNB sector code C) **2.**
- to non-financial corporations with a Hungarian tax number (≈ with NACE classification).

Source | MNB

FOCUSING ON NPL RATIO

A key indicator of financial stability (loan quality) **3.**

There is empirical evidence of its connection with the cyclical situation. **4.**

Relatively less dependent on bank decisions compared to other key variables (e.g. earnings, write-offs, capital). **5.**

Sales to factoring companies were small compared to the banking system in the examined time period. **6.**

Source | MNB

MODELLING FRAMEWORK

1.

Goals of modelling

Conditional forecast of the target variable (NPL ratio) over the time horizon 2020-2050, on the basis of the economic environment already modelled in each scenario.

A total of 54 conditional forecasts:

- For 3 scenarios: failed, orderly and disorderly transition trajectories.
- for 18 sectors: covering the whole economy.

2.

Model estimation

Historical relationship between sectoral NPL ratios and (already forecasted) sectoral economic variables.

'Training' time window is relatively short: 2012Q2 to 2019Q4.

Use of unified models for all sectors.

Same function form and variable set (GVA, ULC, etc.).

3.

Forecast

By feeding trajectories of economic variables into estimated models.

Underlying assumption: the estimated parameters are stable over time.

Physical and transition risks are concentrated in a single variable.

Different GVA trajectories underlie the different NPL ratio projections of scenarios.

Source | MNB

HISTORICAL CORRELATIONS – MODELLING DECISIONS

A single model in each sector

$$NPL_t = \beta_0 + \beta_1 Igap_t + \beta_2 Xgap_t + \beta_3 ULCgap_t + \beta_4 GVAgap_t + \varepsilon_t$$

1.

NPL_t: NPL ratio

2.

Explanatory variables: transformants of interpolated variables

- Frequency conversion from annual to quarterly (Denton-Cholette).
- 'Gap': ratio of deviation from own CUB trend (univariate HP filter)

3.

Default estimation method: OLS.

- In case of negative NPL ratio forecast, TOBIT (for 2 sectors).

4.

Unconventional modelling decisions (frequency conversion, gap instead of lagging) are due to the shortness of the NPL time series.

5.

Source | MNB

CONDITIONAL FORECAST – MODELLING DECISIONS

Assumption on the GVAgap in the forecast:

$$GVAgap = \left(GVA^{scen} - GVA^{cub}trend\right)/GVA^{cub}trend, \quad \textbf{1.}$$

where $scen$ denotes OT, DT and HT scenarios, and cub denotes the climate-uninformed hypothetical scenario.

Point forecast of NPL ratio is prepared for three scenarios per sector. **2.**

The excess of the failed and disorderly transition scenarios compared to that of orderly transition are reported. **3.**

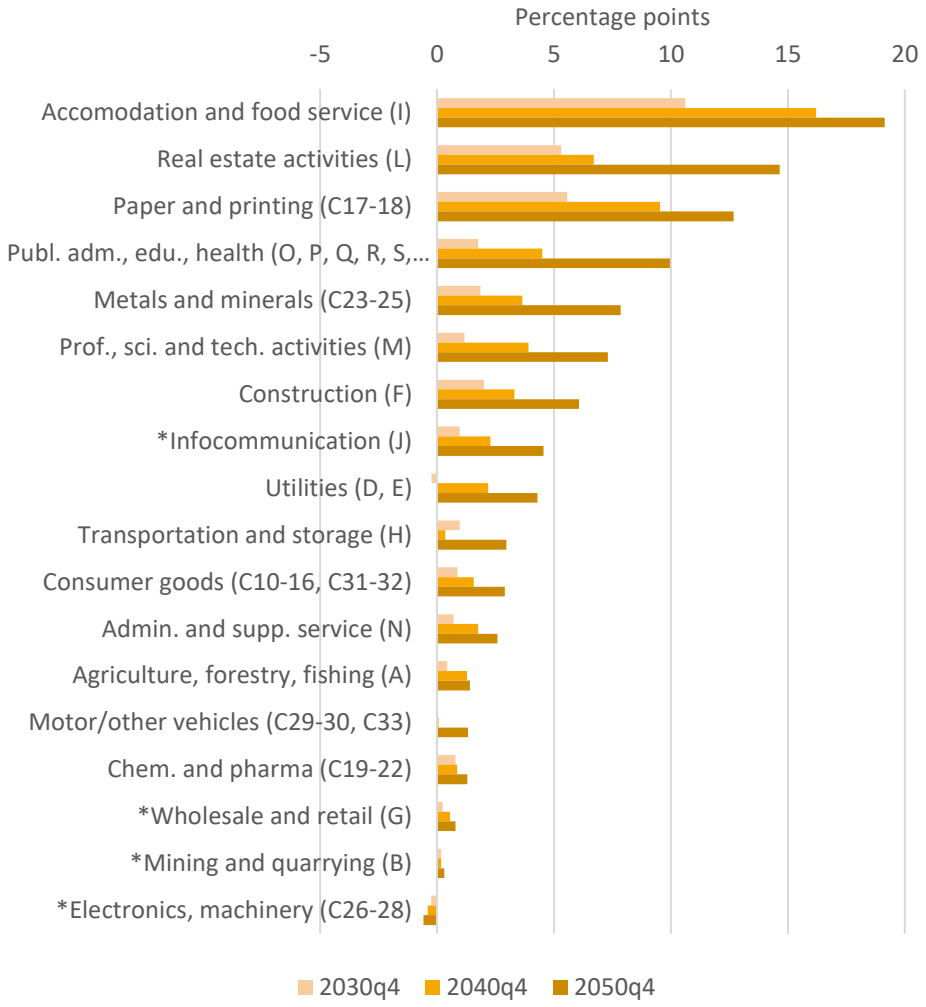
We also monetise this excess on the basis of loans in 2019Q4, assuming its static composition. **4.**

Source | MNB

RESULTS: EXCESS RISK OF FAILED TRANSITION

- The non-payment outlooks show high dispersion over time.
- The differences are due to different physical and transition risks and different cyclical sensitivity.

! The values show the difference between two scenarios.



EXCESS NPL RATIO (BENCHMARK: OT)

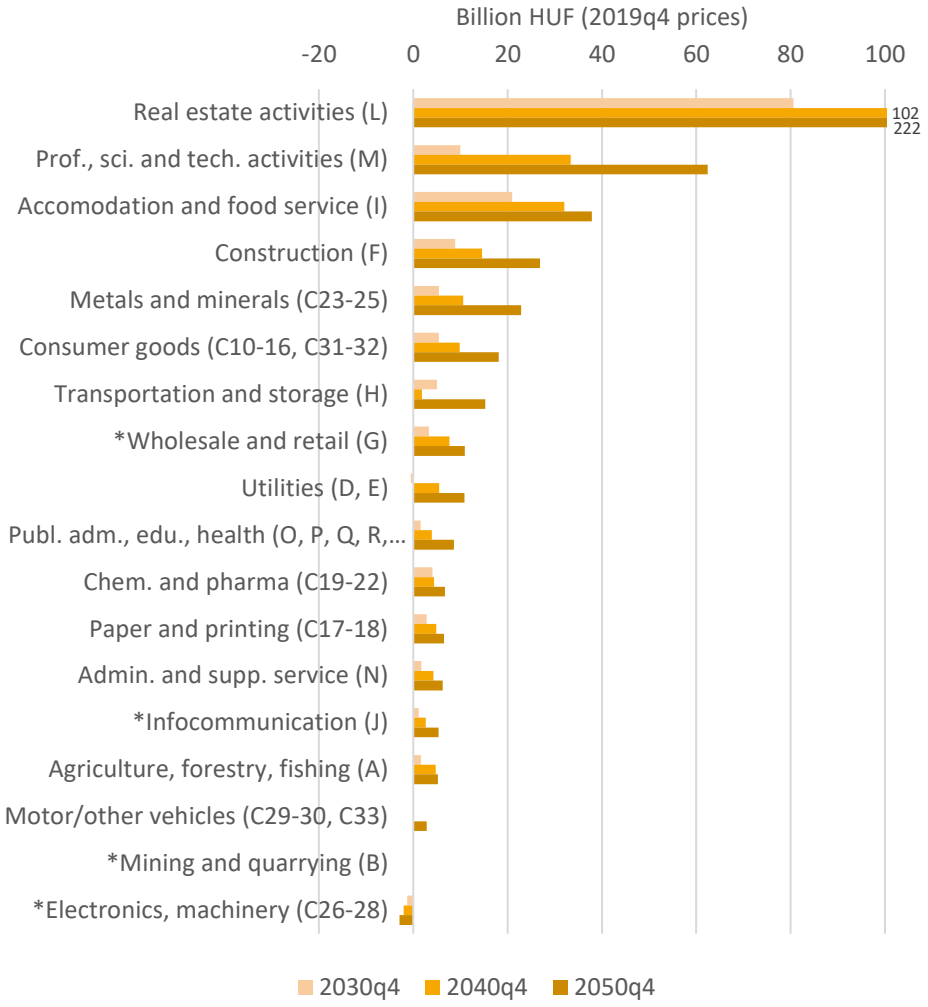
Values of asterisked sectors are statistically insignificant.

Source | MNB

RESULTS: ABSOLUTE VALUE OF THE ADDITIONAL RISK OF FAILED TRANSITION

- The values presented are based on the static loan portfolio of 2019q4.
- Significantly different pairs of sector risk and exposure may, of course, be behind similar values.

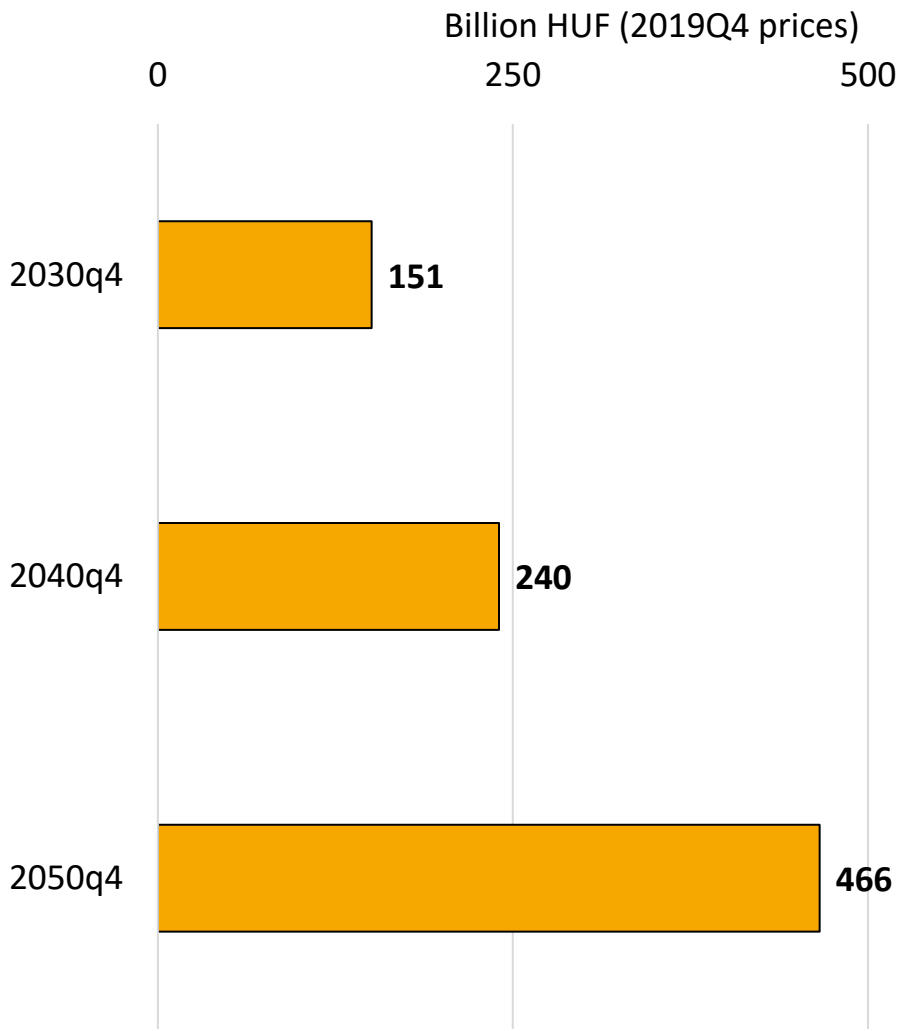
! The values show the difference between two scenarios.



EXCESS NPL IN HUF

Values of asterisked sectors are statistically insignificant.

Source | MNB



EXCESS NPL IN BILLION HUF

TOTAL EXCESS NPL OF FAILED TRANSITION

- The excess NPL of failed transition is nearly half a trillion forints.
- This is a rough underestimate due to the assumption of static portfolio.
- By dynamizing sectoral loans with sectoral GVA growth, the total excess is about 50 percent higher.

! The values show the difference between two scenarios.

Source | MNB

RECOMMENDATIONS FOR THE FINANCIAL SECTOR

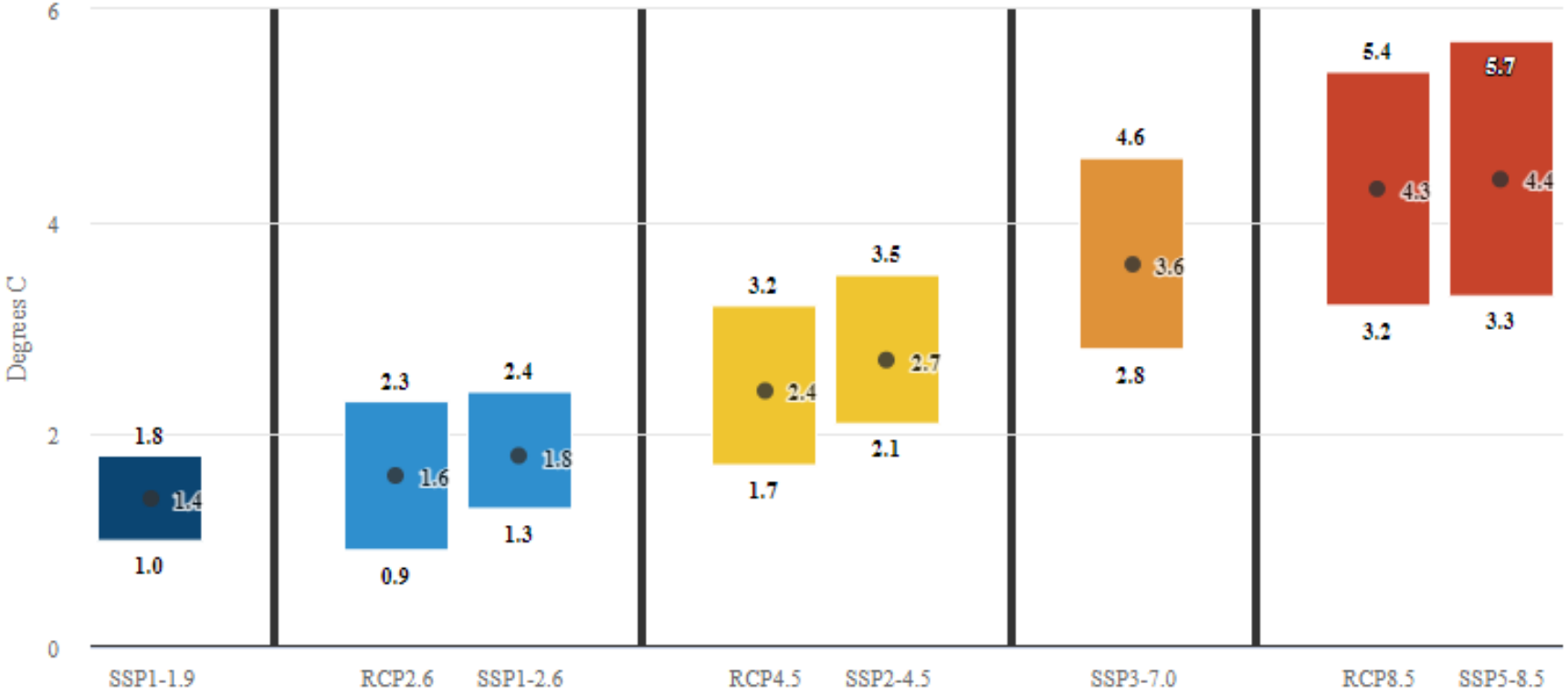
OBJECTIVE OF LONG-TERM CLIMATE STRESS TEST

The current stress test is a pilot project. Its primary objective is to draw the attention of financial sector to the risks and opportunities inherent in climate risks. Through this work, the MNB also aims to promote knowledge building and remains open to knowledge transfer. The information and analysis provided can help to understand the scale and distribution of the risks posed by the new challenges. Although the analysis has a micro-prudential focus, it is not intended to determine capital requirements.

Source | MNB

CLIMATE SCIENCE IS A RAPIDLY EVOLVING DISCIPLINE

Comparing the average temperature trajectories of the IPCC Synthesis Reports 5 and 6, as shown in the figure, the projections can vary over time, but typically show a more pessimistic picture.



Average temperature increase for the period 2081-2100 calculated for each scenario compared to the average temperature increase for the period 1850-1900, in degrees Celsius. The figure shows the forecast bar and point estimate for Synthesis Report 5 (RCP) on the left and for Synthesis Report 6 (SSP) on the right, for each scenario.

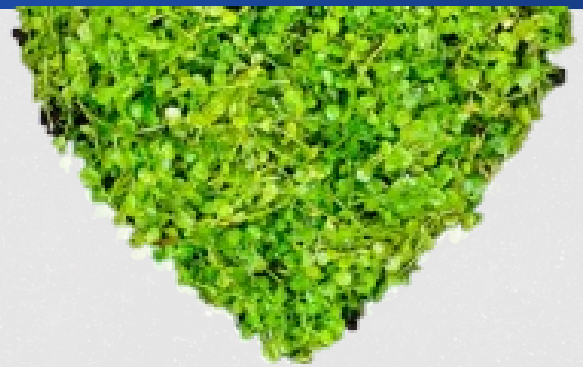
Source | IPCC, Carbonbrief

TRANSITION RISK IS ALSO AN OPPORTUNITY

While there will be victims in the transition to a green economy, the process also offers unique opportunities. According to the model of Cambridge Econometrics, the Hungarian economy is a clear winner of the transition, thanks to e.g. falling energy imports. By becoming pioneers in certain industries, the export capacity of Hungarian companies will also improve significantly. A positive example is the significant investments made by Hungarian water companies in South East Asia and Africa, as well as the establishment of solar parks and solar power plants by several Hungarian companies in neighbouring countries.

Source | MNB

SUSTAINABILITY IS A PRIORITY FOR INDUSTRIES EXPOSED TO CLIMATIC RISK



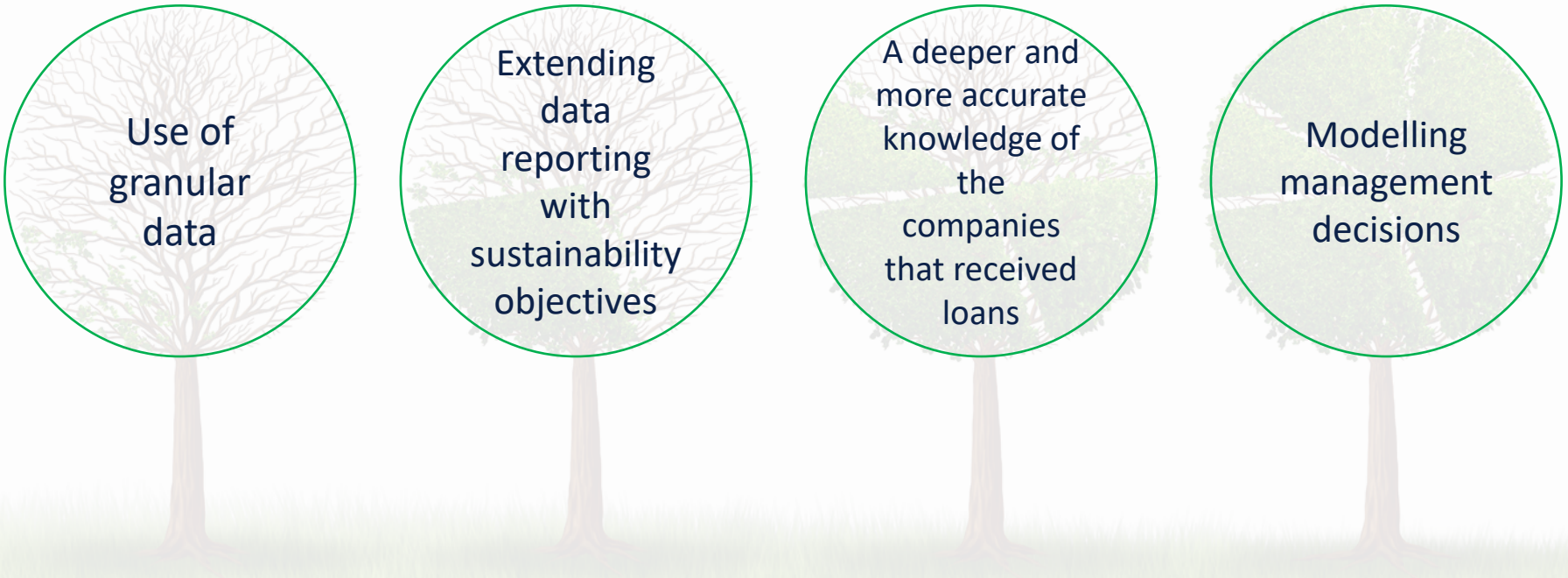
Sustainability is a priority for sectors that are particularly exposed to climate risks. It is important to emphasise that the results of the long-term climate stress test do not imply that financing the most vulnerable sectors inevitably carries significant additional risk for credit institutions, but that in order to minimise this, the sustainability dimension of these projects should be taken into account.

Significant investment is needed to mitigate physical and transition risks, in which credit institutions are – optimally – partners. This is in the interest of both parties.

Source | MNB

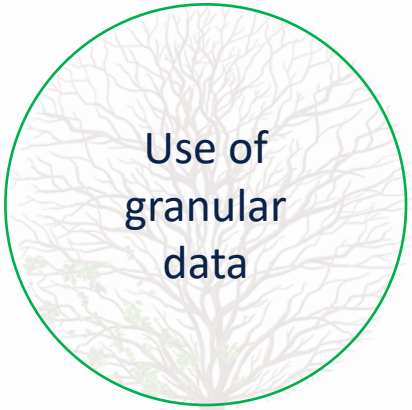
DEVELOPMENT DIRECTIONS

IMPROVEMENT OF DATA ASSETS



Source | MNB

USE OF GRANULAR DATA



There are a number of transaction-level databases available to Magyar Nemzeti Bank, which can be used to further refine the results of the long-term climate stress test. However, their use poses a number of challenges, such as limitations on the usability of data provided by peer authorities. Other challenges include the low frequency, changing composition, high manuality of improving, as well as the extreme human resource-intensity of data reporting. In relation to recognising the importance of data, a number of transaction- and client-level databases have been created, however, currently there are no long enough time series to produce 30-year forecasts. The MNB aims to include new sources of data in the next implementation, such as an analysis of the energy efficiency of commercial real estate or a detailed analysis of the location of the registered offices and premises of companies.

Source | MNB

EXTENDING DATA REPORTING WITH SUSTAINABILITY OBJECTIVES

Extending data reporting with sustainability objectives

The former design of several frameworks and databases did not prioritise meeting the needs of sustainability analysis. One of the most striking examples is the NACE sector breakdown. Within sector code D (electricity, gas and steam supply, air conditioning), the source of electricity generation is not specified, i.e. solar and coal-fired power plants are included in the same sector, although there is a significant difference between the two energy suppliers from a climatic and therefore credit risk point of view. The MNB will therefore also label green loans in its credit databases.

Source | MNB

DEEPER AND MORE ACCURATE KNOWLEDGE OF THE COMPANIES THAT RECEIVED LOANS

Experience to date and consultations with credit institutions have highlighted the need for a more accurate mapping of the businesses that received loans. The NACE codes indicated as the main activity are often inaccurate. Many credit institutions do not know the exact location of the registered office and premises of the companies they lend to. To make full use of these data, significant data cleaning will be required during the next stress test. A further difficulty is to assess the scope of activities of certain holdings and to track mergers.

Source | MNB

MODELLING MANAGEMENT DECISIONS

With the long-term climate stress test, the MNB has taken the initiative step in assessing the physical and transition risks. At the same time, credit institutions are expected to assess these risks and, after modelling the risks, to develop their management actions and adequate responses.

Action plans will be reviewed and modelled quantitatively by the MNB to allow the identification of risks at the institution level. In the future, it assess the further improvement possibilities of the stress test along these efforts.

In the coming years, the financial sector's task is to assess the risks inherent in climate change and the economic potential of facilitating sustainability. The MNB will always be a partner to institutions, through recommendations, incentive programmes and knowledge transfer, supporting the financial sector in reducing its transition risk, while expecting responsible behaviour.

Source | MNB

ANALYSIS OF RETAIL LOANS

Quantifying the exposure of retail products to climate change and transition risks is an even greater challenge for authorities as compared to corporate clients. The MNB is also planning to include this segment, and thus modelling the entire client base, i.e. to follow a more comprehensive approach of financial stability.

Source | MNB