CORVINUS UNIVERSITY of BUDAPEST

Essays on Economic Implications of COVID-19

PhD Thesis

Bence Kiss-Dobronyi

Doctoral School of Business and Management
Institute of Operations and Decision Sciences
PhD in Business Economics

Budapest, February 2026

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Co-authorship declaration

I (We), the undersigned co-author(s), hereby give my (our) consent,

Chikán, A., Kiss-Dobronyi, B., Homoki-Szabó, E., and Molnár, B. (2024), "Government influence on national competitiveness (evidence from the COVID era)", Competitiveness Review, Ahead-of-print.

that our joint scientific results in our publications (named above) can be used in his/her doctoral thesis by PhD candidate

Bence Kiss-Dobronyi

I (we) further declare that the share of the contribution of the PhD candidate to our joint results is **40**%

Date: May 23, 2025

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Co-authorship declaration

I (We), the undersigned co-author(s), hereby give my (our) consent,

Kiss-Dobronyi, B., Fazekas, D., and Pollitt, H. (2021), "Macroeconomic assessment of possible Green Recovery scenarios in Visegrad countries", Society and Economy, 43 (2021) 3, pp 227–252. that our joint scientific results in our publications (named above) can be used in his/her doctoral thesis by PhD candidate

Bence Kiss-Dobronyi

I (we) further declare that the share of the contribution of the PhD candidate to our joint results is **60**%

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Abstract

This dissertation is an article-based thesis that ties together four independent articles with underlying research between 2020-2025. Three of the articles have been published in peer-reviewed journals, while one has been released as a working paper. They all analyse different aspects of the economy related to the COVID-19 pandemic. Inevitably, the pandemic and the research topics of the papers have shaped the overall dissertation as well.

The COVID-19 pandemic in 2020-2021 was a defining moment of the decade, as the world has grappled with a health and economic crisis that has been unprecedented in our generation. Economies have suffered from simultaneous supply- and demand-shocks as health policy, that was saving lives, was necessarily reducing economic activity. *Resilience* has become an important question of these times, as people, organisations, as well as nations, have tried to adapt to a new reality.

This thesis analysis the layers of this economic resilience and adaptation, exploring the various levels of the economy and their interlinkages. The thesis contains four main chapters, each a published or presented study on its own, which cover both the microeconomic level impacts of the pandemic (employees and firms) and the macroeconomic level (nations and recovery).

The first two chapters focus on Hungary, and employ primary data collection (surveys) before and during the pandemic, to highlight factors that have influenced resilience and performance of firms and employees during this trying time. Both chapters employ quantitative, econometric methods, namely probit and ARIMA estimations and Fisher's exact and Cochran-Armitage tests to explore and test influencing factors and test for differences between entities with differing performance.

The second two chapters have a more broad geographical focus. The third study focuses on the resilience of national competitiveness in relation to long-term government policy directions during the pandemic, exploiting the global IMD database. Meanwhile, the fourth study looks forward and explores possible recovery scenarios using macroeconomic modelling for the countries of the Visegrad region, and investigates what factors shape the pace and structure of a possible recovery. These studies employ quantitative methods as well: the third study uses econometrics and clustering, focusing on differences between clusters of country groups; while the fourth study employs the E3ME macroeconometric model, to simulate future scenarios of recovery.

In the thesis the framework of firm and national competitiveness, developed by Chikán (2008) is used as an underlying concept, that is used to link together several layers of the economy. This framework links together the welfare and productivity of people with the performance of firms, and eventually the performance of firms with national competitiveness. It also posits the importance of institutional factors, which the thesis directly analyses in its fourth chapter. The conclusion of the dissertation also draws out common insights from these studies, focusing on how building resilience

can create value rather than incur costs, how building resilience can bring various co-benefits and in general, how thinking focusing strictly on efficiency can lead to an underestimation of risks and dire consequences, through high reliance on vulnerable parts of processes and systems.

Keywords: COVID-19, resilience, firm performance, managerial behaviour, competitiveness, institutions, recovery, Hungary

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Acronyms

ARIMA	Autoregressive (AR) integrated (I) moving average (MA). *(p. 40)*
ARIMAX	Autoregressive (AR) integrated (I) moving average with exogenous (X) variable. *(p. 40)*
ARMAX	Autoregressive (AR) moving average (MA) model with exogenous (X) variable. *(p. 40)*
BIC	Bayesian Information Criterion. *(p. 40)*
CBA	Cost-benefit analysis. *(p. 88)*
CEDEFOP	European Centre for the Development of Vocational Training. *(p. 22)*
CEO	Chief Executive Officer. *(p. 37, 43, 46, 50, 51)*
CGE	Computable general equilibrium. *(p. 73)*
COICOP	Classification of Individual Consumption According to Purpose. *(p. 73)*
CRC	Competitiveness Research Centre. *(p. 1, 16, 24, 34, 37–40, 43, 44, 47, 50, 51, 53)*
CZ	Czech Republic. *(p. 77, 78, 80)*
DiD	Difference-in-differences. *(p. 62, 63, 65)*
DMP	Bank of England Decision Maker Panel. *(p. 75)*
ESCO	European Skills, Competences, Qualifications and Occupations. *(p. 24)*
ESR	Effort Sharing Regulation. *(p. 69)*
EU	European Union. *(p. 70, 73, 79, 91)*
FTE	Full-time equivalent. *(p. 78)*
FTT	Future Technology Transformations. *(p. 74)*
GDP	Gross Domestic Product. *(p. 8, 11, 20, 77, 80, 81, 92)*
GFC	Global Financial Crisis (2007-2008). *(p. xvii, 8, 9)*
GRP	Green Recovery Program. *(p. 68, 69, 75–83)*
HCSO	Hungarian Central Statistical Office. *(p. 37, 39, 41, 42)*
HICP	Harmonised Index of Consumer Prices (EU). *(p. xviii, 93)*
HU	Hungary. *(p. 77, 78, 80)*
ICT	Information and Communication Technology. *(p. 36)*

IEA	International Energy Agency. *(p. 70, 72, 76)*
ILO	International Labour Organization. *(p. 8, 20)*
IMD	Institute for Management Development (Lausanne). *(p. viii, 54, 56–59, 63, 65)*
IMF	International Monetary Fund. *(p. 20)*
IPCC	Intergovernmental Panel on Climate Change. *(p. 76)*
KPI	Key Performance Indicator(s). *(p. 46, 48)*
NACE	Classification of economic activities in the European Union (EU), from the French *Nomenclature statistique des activités économiques dans la Communauté européenne*. *(p. 37, 73)*
OECD	Organisation for Economic Co-operation and Development. *(p. 73, 74)*
PL	Poland. *(p. 77, 78, 80)*
PV	Photovoltaic. *(p. 76)*
RES	Renewable Energy Sources. *(p. 70, 77, 78, 80, 82, 83)*
RRF	Recovery and Resilience Facility. *(p. 67)*
SARS	Severe acute respiratory syndrome. *(p. 7)*
SK	Slovak Republic. *(p. 78, 80)*
UN	United Nations. *(p. 73)*
US	United States (of America). *(p. 91)*
WEF	World Economic Forum. *(p. 56)*
WEO	World Economic Outlook (IMF publication). *(p. 91, 92)*
WFH	working from home. *(p. xviii, 4, 5, 19–31, 33, 89, 92, 93)*
WHO	World Health Organization. *(p. 7)*
WIIW	Wiener Institut für Internationale Wirtschaftsvergleiche (The Vienna Institute for International Economic Studies). *(p. 70)*
WWF	World Wildlife Fund. *(p. 69)*

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Introduction

1.1 A personal introduction

The COVID-19 pandemic has changed many lives, we can probably say everyone's life in one way or another. At the time the pandemic started I had been working for about two years for the consultancy, Cambridge Econometrics, focusing on macroeconomics and climate policy consulting, and research. But due to my interest in Business Economics and academia, after graduating from my masters I have kept in contact with some of my former professors and have continued to contribute to research[1] of the Competitiveness Research Centre (CRC) and was teaching together with Attila Chikan in the Rajk and Heller Colleges for Advanced Studies.

When the pandemic hit, in early 2020, suddenly a lot has happened. Interest in areas that were close to my work has peaked: in CRC research it became a focus point to say something about firm-resilience, while in Macroeconomics the consequences of the economic shock that COVID-19 meant and possibilities for recovery have been the most crucial topics. I was trying to contribute both of these topics: first, given that data were scarce/ not timely at the micro-level we have launched an independent survey with Zoltan Bakonyi[2] to try to understand the impact on employees (this research is the basis of Chapter 2). Second, building on our ongoing work on firm competitiveness with Attila Chikan, Erzsebet Czako and David Losonci we have started to look into how resilient firms are and what makes them such (this is the basis of Chapter 3). Meanwhile, with colleagues at Cambridge Econometrics we have started to investigate the macroeconomic consequences and the possibilities for recovery; this work too has yielded multiple important publications[3] (one of these, focusing on Visegrad countries[4], is the basis of Chapter 4).

Research into these questions, as much as the ongoing collaboration with both researchers at the

[1] Some of this early work has culminated in the publication of *Chikán, A., Czakó, E.,* ***Kiss-Dobronyi, B.****, & Losonci, D. (2022). Firm competitiveness: A general model and a manufacturing application. International Journal of Production Economics, 243, 108316. https://doi.org/10.1016/j.ijpe.2021.108316*

[2] A Hungarian language summary of some of our early findings that was disseminated can be found here; an article that Zoltan authored summarising some of our findings for the national news site *Index* can be found here

[3] These include, e.g., *Pollitt, H., Lewney, R.,* ***Kiss-Dobronyi, B.****, & Lin, X. (2021). Modelling the economic effects of COVID-19 and possible green recovery plans: A post-Keynesian approach. Climate Policy, 21(10), 1257–1271. https://doi.org/10.1080/14693062.2021.1965525*

[4] The Visegrad region consists of four countries who share historical and cultural similarities: Hungary, Poland, Czechia and Slovakia. This group was selected because while they share certain similarities, their economic structures are different enough to highlight the differing impacts of recovery policies.

Corvinus University of Budapest and in other institutions have prompted me to consider furthering my education and applying for PhD studies. While initially, my proposed topic has focused on linkages between firms, society and macroeconomics, the emergence of the COVID-19 phenomena have given my research a bit different direction. The research remained focused on these linkages, but I also amended it with a stronger focus on resilience and the common characteristics across planes of the economy that support or jeopardize resilience.

Personally, this period, starting in 2020, was alongside the virus was often turbulent for me as well. Even though at the start of 2020 I was living in Budapest, Hungary in August of that year I have moved to Brussels, Belgium to take part in a 9-month-long mission. The plan was for me to work with Cambridge Econometrics' Brussels office and to cooperate with various European agencies and directorates. Due to COVID-19 much of this has not materialised. While my possibilities were limited, I did try to use my time there wisely. Of course, I have discovered the COVID-regulated version of Brussels without tourists, but I also spent a lot of time to try and understand the economics of COVID-19 and engage with research.

Therefore, when I moved back to Budapest in 2021, and all of these different research avenues — although all of them somehow related to COVID-19 — were still going on with various partners, I decide to try to connect this work and to build a PhD dissertation around it, in which I can consider these many aspects of how COVID-19 has caused the global and the Hungarian economy to react and to change on many levels. As COVID-19 took two years of my life, not just in a personal, but also in a professional manner, I decide to chronicle and research at least some of the things that we have learned from this situation about economic behaviour — one might even say as a silver lining.

All this led me to start my PhD studies at the Corvinus University of Budapest in 2021, with what was called at the time the Institute of Business Economics. Erzsebet Czako and David Losonci became my supervisors, continuing some of the research that we have started together. Attila Chikan has also supported this process with ideas, advice and active contribution to research questions. During the period 2021-2023 I have completed my academic obligations and my final exam in the university, while I have continued to work with Cambridge Econometrics and author research focused on a variety of topics including COVID-19 impacts, but also climate policy and Business Economics (for a list of my publications see Chapter 7). Then the period 2024-2025, has — once more — brought important changes in my life: while I have been working on completing my dissertation I have been invited to join the World Bank in Washington, DC in a consulting role. This is where I am finishing writing my dissertation now. In August 2025, I was able to already present a draft version of this dissertation to my supervisors and reviewers, who suggested some modifications and provided valuable feedback. This has led to changes that are documented in Chapter 7.

As it is discussed in the various chapters and in the conclusion: what I found to be the most important lessons from grappling with the pandemic is — given the lack of major shocks at the end of the 20^{th} century — how the global economy prioritised *efficiency* over *resilience* and how, in the case of a shock, having good systems that care about people (be it at the firm or at the national level) can actually pay off.

This dissertation, therefore, builds on research that I did related to COVID-19 in the period of my PhD studies in 2021-2025, although some works build on research that has started earlier than that. The four chapters of the dissertation correspond to three peer-reviewed papers and one working paper. The respective works are discussed at the beginning of the chapters, while my a list of my other publications and major conference presentations is provided to the dissertation as Chapter 7.

1.2 A general overview of the thesis

This thesis focuses on the economic implications of the COVID-19 pandemic, which started in 2020 and induced both a health and an economic crisis in the world. The thesis is comprised of four chapters, each chapter being a study on its own. This is the format of the 'article-based' dissertation where the overall thesis is comprised of at least three published papers, which are linked together through a common topic, methodology or underlying framework. This, inevitably means that the published articles - and feedback received in the process of publishing them - shape the resulting dissertation.

Three of the studies presented have been published in peer-reviewed journals, while the fourth one is a working paper, that I presented in conferences. My goal with the thesis is to provide a rather broad view of how the COVID-19 induced crises has impacted the economy. The first two studies focus on the microeconomic level, they use primary data collection to ask questions about the situation of individual employees and of firms during the pandemic, these studies focus solely on Hungary. Meanwhile, the latter two studies focus on the macroeconomic level. The first study investigates the relationship between national competitiveness and government policies, while the second - the only study with a forward-looking perspective - presents possible recovery scenarios for the countries of the Visegard region.

Chapter in the thesis	Original title	Description	Author contribution (CRediT)	Methodology	Publication status
2. Employees	Working from home in the midst of COVID-19: occupations and performance Evidence from Hungary	Analyses factors influencing working from home (WFH) possibilty and performance in WFH	Conceptualization, Methodology, Formal analysis, Investigation, Writing - Original Draft, Visualization	Primary data collection (survey) analysed with quantitative methods	Working paper, presented at multiple conferences
3. Firms	Management practices and changes in turnover of domestic firms during the Covid-19 economic shock	Analyses factors influencing firm revenue resilience during the pandemic, including managerial practices and firm characteristics	Conceptualization, Methodology, Formal analysis, Writing - Original Draft, Visualization	Primary data collection (survey) based database analysed with quantitative methods	Published in Economic Review / Közgazdasági Szemle (MTA A)
4. Nations	Government influence on national competitiveness (evidence from the COVID era)	Clusters nations based on the perception of their government policies and analyses whether certain long-term policies have provided better resilience during COVID-19	Conceptualization, Methodology, Formal analysis, Writing - Original Draft, Visualization	Secondary global database analysed with quantitative methods	Published in Competitiveness Review (Q1)
5. Recovery	Macroeconomic assessment of possible Green Recovery scenarios in Visegrad countries	Assesses ex ante recovery scenarios through macroeconomic modelling, that can contribute to recovering from the current shock and building resilience towards future shocks	Conceptualization, Methodology, Software, Writing - Original Draft, Visualization	Forward looking macroeconomic scenario modelling, based on international data	Published in Society and Economy (Q3)

Table 1.1: *Studies presented in the thesis. Source: own work.*

The thesis integrates these studies into a framework, based on the work of Chikán et al. (2018) and Chikán (2008). It uses the framework to show that those examples of economic shock and resilience that it uncovers and presents are interlinked through the complex system of the economy. I present the framework in detail in Section 1.5 and applied directly in Chapter 4. Through this approach, I intend not just to present a broad view of the economic impacts at various levels, but also to shed some light on the common patterns across varying layers and the interlinkages across the entities in different spaces.

Through the individual studies presented in the thesis I put forward the hypothesis that actors who were not focusing solely on maximizing efficiency, but also have built resilience through various ways, have benefited from this during the pandemic shock.

This is important because pursuing efficiency and building resilience can be conflicting goals. This, actually, is observed across various systems from biology (Inouye et al. 2021) to network theory (Brede et al. 2009) and to business (Martin 2019). As Inouye et al. (2021) writes:

> *In general, keeping resources in reserves may increase robustness or resilience to future perturbations, but prevent current performance from being maximized* - (Inouye et al. 2021, p.2183)

While in view of this a balanced approach - both considering efficiency and other goals, that helps build resilience - would be beneficial, it is observed that the focus, especially in the economy, has shifted towards efficiency in this century. This is highlighted by the spread of practices that focus on efficiency, while framing resilience and especially redundancies and buffer strategies as "unnecessary costs" and inefficiencies (Martin 2019; Ruiz-Benítez et al. 2018; Karakoc et al. 2021; Berbés-Blázquez et al. 2022; Staveren 2023; Landau 1969).

In a world without high-risk events, without uncertainty, with reasonable stability, redundancies and resilience building can truly be an unnecessary cost (Staveren 2023; Martin 2019; Landau 1969). However, if we accept that there are unknown unknowns, true uncertainty, that can affect the economic system then resilience building becomes a precautionary necessity. Through this thesis I explore, how ways of resilience building and focusing on goals that are different from efficiency have created better outcomes during a shock period.

These thoughts can be summarised as general research questions that are examined in this thesis through the chapters focusing on the separate levels, but also on commonalities across the discussed layers of the economy:

- R1 What are characteristics and behaviours that support resilience at the level of employees, firms and national economies? Both pre- and post- crisis.
- R2 Are there more general commonalities in these behaviours?
- R3 How do these behaviours relate to performance in a non-shock environment?
- R4 How recovering from shocks relate to this resilience and how recovery can enable future resilience?

The structure of the thesis from here on is the following: the rest of the Introduction presents an overview and timeline of the COVID-19 pandemic (Section 1.3), with a special focus on Hungary, as three of the studies focus on the country; still in this chapter, this is followed by a general definition of resilience (Section 1.4) as a key idea linking the studies together; and a description of the framework describing the economic linkages between the layers studied (Section 1.5). This is followed by the four chapters, that are based on the published studies: first, Chapter 2 focuses on the working from home (WFH) experience of employees during the pandemic; second, Chapter 3 focuses on the resilience of firms based on their behaviour and characteristics; third, Chapter 4 focuses on the resilience of competitiveness in relation to government policy; and finally, Chapter 5 focuses on possible recovery scenarios, that boost resilience in the future against other shocks. After the studies, Chapter 6 is comprised of two sections: Section 6.3 describes the economic developments since COVID and shows some permanent changes, while Section 6.1 draws out insights about resilience and efficiency that are common in the studies. In this section I conclude by providing remarks on what can be taken away from these examples and the experience that we have lived through in order to be better prepared in the future. The pages following the last chapter include an alphabetic index of selected topics, to orient the reader.

The document also includes four individual appendices preceded by a list of my relevant published works and a list of changes to this document since the thesis draft debate. Following the list of references, Chapter 7 provides a list of the author's relevant publications and selected conference presentations. Chapter 8 provides a table of changes to the dissertation between the draft stage and the current stage. Meanwhile, the four appendices, A-D, correspond to the chapters of the thesis providing further calculations, figures as well as methodological details (e.g., survey questions used).

1.3 COVID-19

This section reviews how the COVID-19 pandemic has impacted the world and Hungary beginning 2020. The pandemic and its consequences are reviewed and discussed, as they provide the context for my research presented in the subsequent chapters. First, the section provides a general, global overview of developments, followed by a discussion of its emergence and consequences in Hungary.

The COVID-19 pandemic was a defining moment of the years 2020-2021. Initial reports of an unknown respiratory virus in China as early as the beginning of the year 2020 were followed by the rapid spread of the virus. Nevertheless, it took until January 20 for the Chinese public health officials to acknowledge that the world is facing a new communicable disease. While this was followed by an eventual quarantine of about 650 million people, the virus has already been transferred outside of China, therefore beginning its rapid global spread. (Wright 2021)

Most infections of COVID-19 are generally asymptomatic or very mild, with limited symptoms. Given this, healthcare workers have only seen about one in every two hundred infections (Wright 2021). COVID-19 was spread by people who were infected, but does not necessarily show any symptoms, in most cases - without testing - they were not even aware of their own infection. This, combined with a quick transmission and an initially delayed response from the Chinese side has led to a situation by early 2020, where classic methods of quarantining and contract tracing proved to be very difficult, if not useless at all (Wright 2021). By 2020 March the WHO has declared a global pandemic (World Health Organization 2020). The seriousness of the situation is shown by a conversation reportedly originating from the environment of deputy national security advisor of the US at the time, Matt Pottinger:

> *Pottinger asked, "Is this going to be as bad as SARS?" "Don't think SARS, 2003. Think flu, 1918," the doctor said. "SARS had 9,600 cases. Only one was ever shown to be asymptomatic. In China, 50 percent of the cases of this new disease are asymptomatic. And they spread."* - Wright 2021, p.78

This prediction, unfortunately, proved accurate. The Spanish flu of 1918 estimated to have infected about 500 million people, with suspected deaths in the range of 25-50 million (Wikipedia contributors 2024; Taubenberger et al. 2006). COVID-19, over the course of 2020-2022, in five subsequent waves[5] (Jassat et al. 2022; Suligowski et al. 2023; Boriani et al. 2023) has infected over 700 million people and has caused 6-20 million deaths (Mathieu et al. 2020; Dattani et al. 2024).

While vaccination has become a possibility by the end of 2020 (Abbas et al. 2021; Dattani et al. 2024) in most of 2020 and - while vaccinations were underway - much of 2021 there was no cure nor medical defence against the virus. Given the lack of a cure, or readily available vaccinations, public health officials and governments have looked for other solutions to curb the spread of the virus. These have included various lockdown regimes, restrictions on travel, closures of schools as well as 'non-essential' activities (Wright 2021; Hummelen et al. 2021; Financial Times 2021; Dattani et al. 2024). Notably, many of these measures have stayed in effect up until the second half of 2022 (Financial Times 2021; Dattani et al. 2024).

[5] This differs somewhat by country and region, but *at least* five waves were generally seen and document in many countries, even if their timing has varies somewhat.

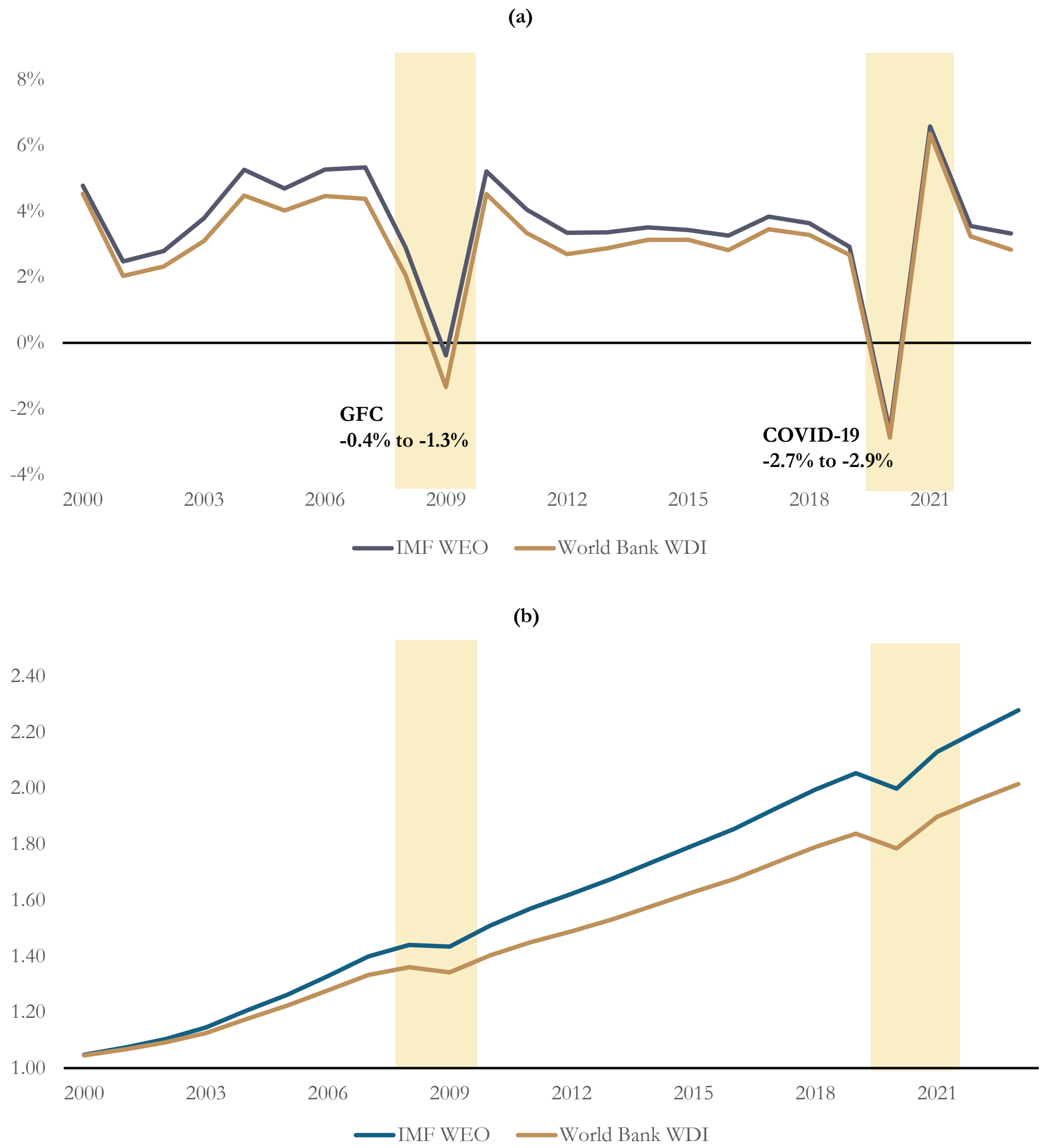


Figure 1.1: ***GDP growth during the GFC and COVID-19 crises.*** *(a) GDP growth year-on-year, annual %, World, (b) GDP growth, index, 2000 = 1.0, World, Source: own work, based on World Bank 2025; IMF 2024.*

Nevertheless, this has also meant practically 'shutting-down' large parts of national economies in countries applying these measures, resulting in a reduction of economic activity not seen since the 1930s Great Depression. Estimated effects of the crisis on global economic activity were between -2.7% to -2.9% (IMF 2024; World Bank 2025) in 2020 (see Figure 1.1 panel a).

While since then we have observed a large rebound of national economies, the economic crisis thought to have some lingering effects and scarring growth for the subsequent years in many economies (Pollitt et al. 2021; Kiss-Dobronyi et al. 2023; Alexandri et al. 2024; Hsu et al. 2024; Barrett et al. 2023; Cerra et al. 2021; Brunnermeier 2021, shown on Figure 1.1 panel b).

This economic crisis, has placed a significant strain on labour markets as well. Basically, the restrictions in many areas of national economies have meant that people were either unable to work or had to significantly change how they work. During the pandemic ILO estimated that about 18%

of global working hours were lost in the second quarter of 2020, with annual losses amounting to about 8.8% in the same year (ILO 2021). This translates to about 255 million full-time jobs, or four times as many jobs as were lost during the GFC.

1.3.1 The pandemic in Hungary

As two of the three chapters focus on samples collected in Hungary, I find it important to present an overview of how COVID-19 has impacted Hungary. Figure 1.2 gives a full overview of the pandemic waves, number of cases, deaths and vaccination ratios, alongside the most important events in Hungary. It follows the definition of ”waves” by Horváth et al. (2022). In the following section, I also provide a brief overview of the events and their economic consequences.

The first COVID-19 case was reported on March 5, 2020 in Hungary. In the so-called ”first-wave” of the virus Hungary (2020 March - June) had a generally low per capita mortality rate, but a high mortality-to-infection rate (Merkely et al. 2020) and a low overall infection rate (Merkely et al. 2020; Horváth et al. 2022; Deme 2020). Initially, as the pandemic emerged the government has decided to announce a state of emergency, which led to travel and activity restrictions and eventually a shelter-in-place order at the end of March (IMF 2020; Index.hu 2020). Nevertheless, after a nationwide testing has indicated low overall infection, in 2020 May the government has decided to re-open the economy gradually (IMF 2020; HVG 2020).

Despite this relatively well contained first wave, in August the number of cases rapidly started to increase. The government has responded with closing down the borders first and then reinstating the state-of-emergency: opening hours were constrained, a curfew was imposed (IMF 2020; Spirk 2020; Horváth et al. 2022). The wave was eventually diminishing by November 2020, but cases started to rapidly rose again in February 2021, as a new, more contagious variant of the virus has emerged - beginning the third wave of the infection (Horváth et al. 2022; IMF 2020).

In this wave, despite general vaccination starting in January 2021 (Horváth et al. 2022), Hungary has experienced a very high rate of mortality. It eventually became the country with the highest per capita mortality rate due to COVID (IMF 2020; Mathieu et al. 2020). Nevertheless, with the growing number of vaccinations, as the country was reaching a vaccination rate of about 20% by May 2021 (IMF 2020; Mathieu et al. 2020), most restrictions were lifted (Horváth et al. 2022). Subsequent waves (4^{th} and 5^{th}) while have seen relatively high infection rates, were much less lethal than the waves before vaccination.

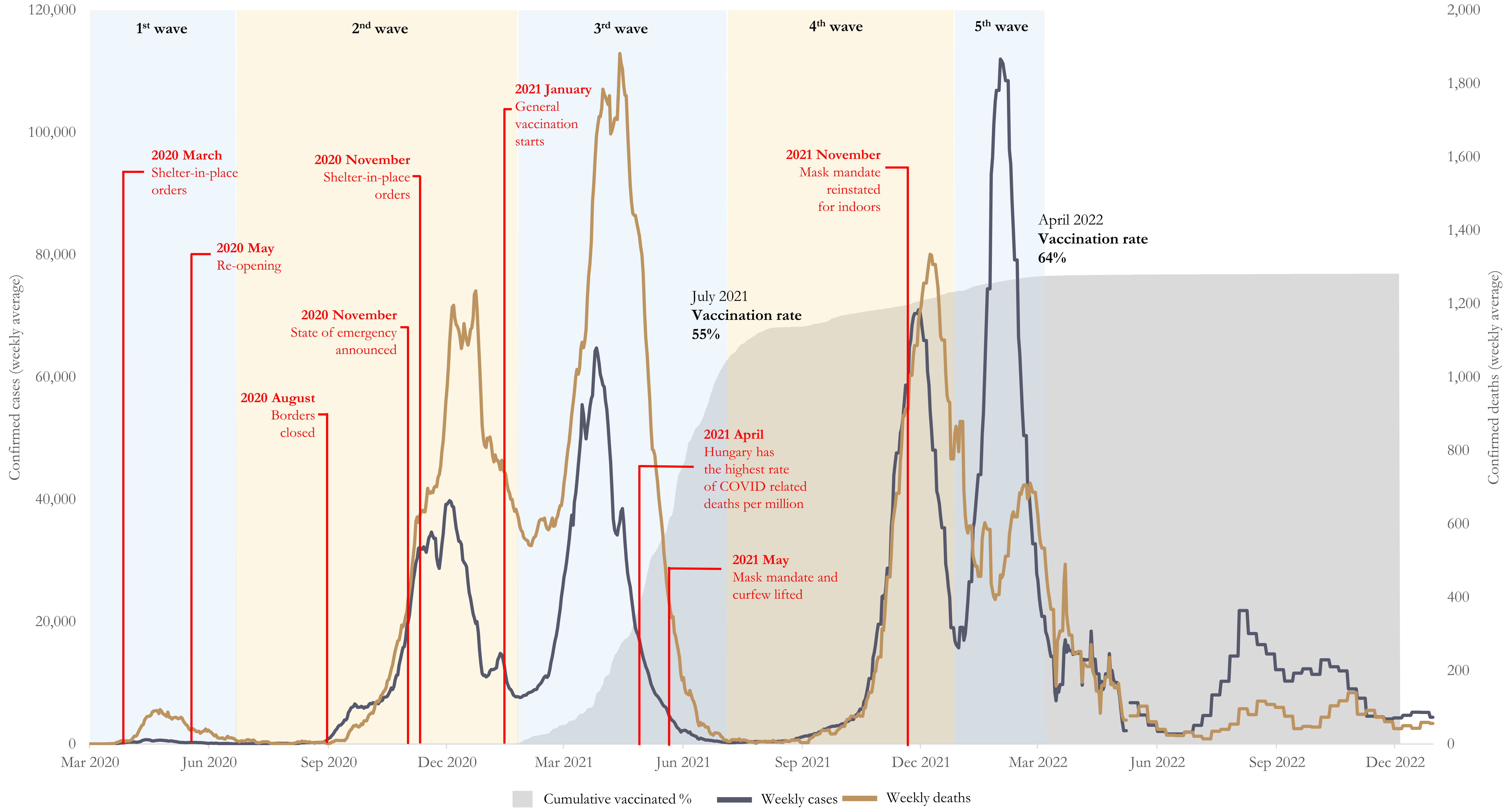


Figure 1.2: ***COVID waves and events in Hungary.*** *Reported weekly cases, deaths, and cumulative rate of vaccinated population alongside designated waves, important events in Hungary. Source: own work, based on IMF 2020; Horváth et al. 2022; Mathieu et al. 2020; World Health Organization 2023.*

While in health policy terms, therefore, the 2^{nd} and 3^{rd} waves were the most critical in economic terms a different pattern has emerged. Figure 1.3 shows indexed values of key economic indicators in Hungary, including GDP, economy-wide employment and consumer prices. As shown in the figure, economic activity has shrunk the most during the first wave, reaching a -13.7% decrease compared to 2019, but gradually rebounded by 2021Q2. Employment followed a similar pattern, although the decrease was lower in relative terms, only -1.8% at its peak, but it has proved to be more permanent - up until 2021Q2 employment levels were consistently -1.2% to -1.8% lower than in 2019.

Meanwhile, prices have followed a pattern characteristic of "normal" times, i.e., prices have increased year-on-year about 3% in 2020. This can be explained by the simultaneous demand and supply shock (Pollitt et al. 2021), which led to a normal price trajectory (Palócz 2022). Nevertheless, towards the end of the 4^{th} wave and into 2022 prices rapidly started to increase. Post-COVID inflation has been a global phenomenon, with its drivers still debated, increased government spending to counter the downturn caused by the pandemic and other demand-side factors (Bianchi et al. 2021; Giannone et al. 2024; Palócz 2022; Brunnermeier 2021) or supply chain disruptions and tight labour markets (Blanchard et al. 2024; Palócz 2022) are seen as primary suspects. However, especially in Hungary, there were other contributing factors as well: the war between Russia and Ukraine that has escalated in 2022 contributed through higher energy and commodity prices (Hartvig et al. 2024; Varga et al. 2024).

Overall, in 2020 especially during the 1^{st} wave, we observe a picture, where strict government measures (Horváth et al. 2022; IMF 2020) has resulted in reduced activity levels among the population (Google 2022). This in turn caused reduced economic activity (indicated by GDP) and reduced employment (both a result and driver of reduced activity). Concurrent demand and supply shocks (Pollitt et al. 2021; Hummelen et al. 2021) caused a drop in economic activity, without putting a pressure on prices (Palócz 2022).

The following 2^{nd} and 3^{rd} waves have shown very different patterns - and different government reactions. In the 2^{nd}, likely considering the economic effects of the implemented measures of the 1^{st} wave, stricter government regulations came much later than in the 1^{st} wave. By the time state-of-emergency was announced in the 2^{nd} wave, the infection numbers and confirmed deaths were about 30-times and 4-times, respectively, as much as they were during the peak of the 1^{st} wave (World Health Organization 2023; Mathieu et al. 2020). Nevertheless, economic impacts then were much more limited, amounting to only about 2% of pre-COVID GDP in the 2020 Q4 quarter. Or to put it in another light; about 14% growth compared to the height of the pandemic in the 1^{st} wave.

The 3^{rd} wave showed similar economic characteristics, with the economy gradually rebounding again, yet infections were still on the rise. Importantly, in both the 2^{nd} and the 3^{rd} wave the population was still restricting their retail and recreation activity to levels similar to the 1^{st} wave, but they have started to go back to work. This can be observed based on activity data of different functional spaces, that has been published by Google during the pandemic (Google 2022). Figure 1.4 shows the evolution of activity over time in Hungary, according to the function of the area where the activity was recorded. It can be observed that e.g., workplace activity was much higher than during the 1^{st} wave in the 2^{nd} and 3^{rd} waves. This can explain the lack of strong economic impacts, as well as the high infection rates, despite retail and recreation activity behaving similarly. We can assume, that people who were able to work-from-home had switched to that (hence the higher residential activity, through the whole time-frame). But also that even though in the 1^{st} wave there was a strict constraint on employment, this was much less the case in the 2^{nd} and 3^{rd} waves. In this period, it is also likely that many businesses were already able to adapt somewhat to the new reality of the pandemic.

I can conclude that while from a health policy perspective the 2^{nd} and 3^{rd} waves of the pandemic might have been the most important in Hungary, in an economic sense, the 1^{st} wave brought the most immense challenges. It truly acted as a double-sided economic shock, with restrictions both on the demand and supply sides (Hummelen et al. 2021; Pollitt et al. 2021), businesses, employees and governments facing an unexpected situation, which they did not immediately have answers to.

1.4 Resilience

In this dissertation what I am interested in is what different entities - people, firms, governments - have done in order to reduce the burden of this initial economic shock. I am largely focusing on characteristics of these entities, that enabled them to withstand the economic shock better than others did. But I first need to be able to define the concept of *resilience*, focusing on both resilience in general and on economic resilience.

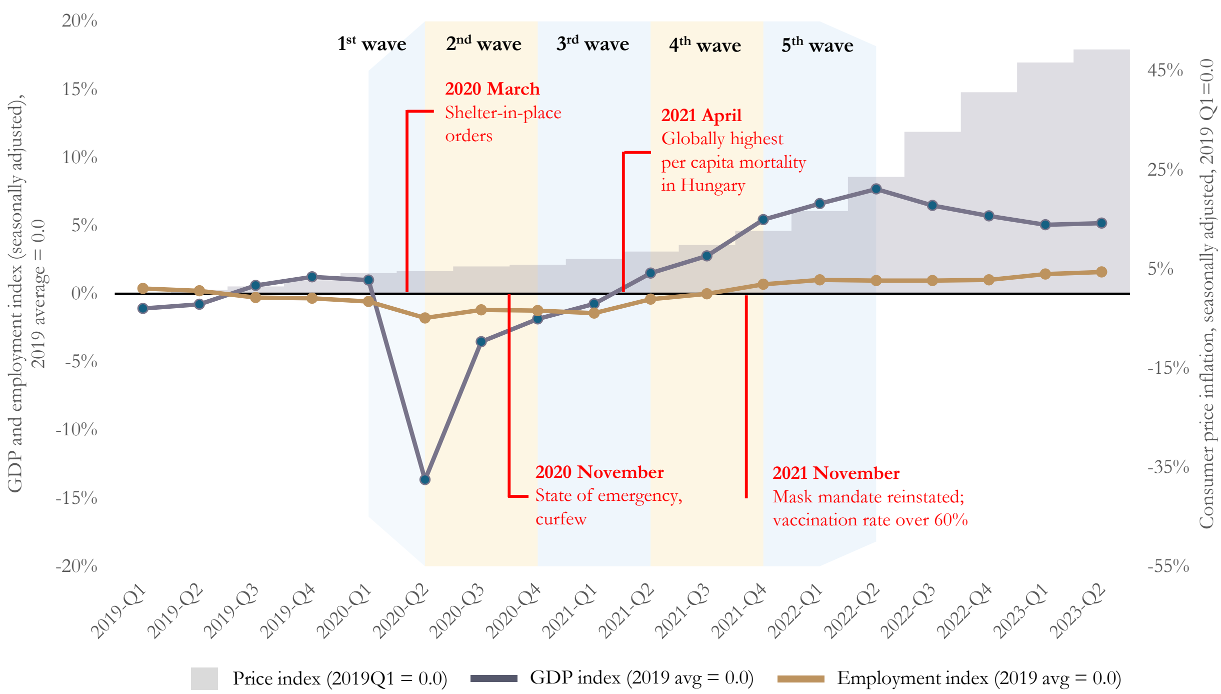


Figure 1.3: ***Key economic indicators during COVID in Hungary.*** *Quarterly GDP, employment and price index alongside designated waves, important events in Hungary. Source: own work, based on IMF 2020; Horváth et al. 2022; Eurostat 2024b; Eurostat 2024c; Hungarian Central Statistical Office 2024.*

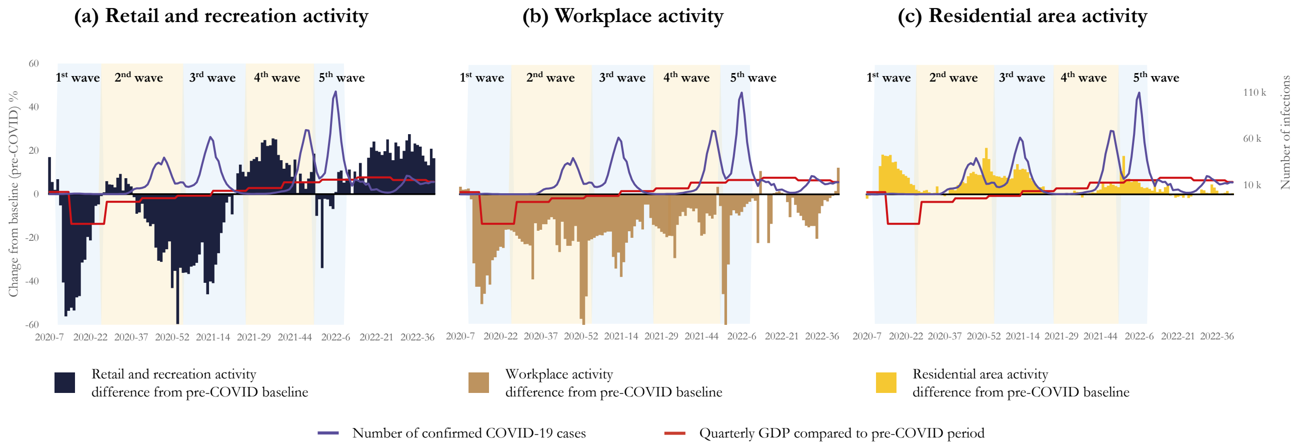


Figure 1.4: ***Activity in different functional areas in Hungary during COVID.*** *Activity in retail and recreation, workplace and residential areas, based on Google Mobility data, 2020-2022, Hungary. Source: own work, based on Horváth et al. 2022; Eurostat 2024c; World Health Organization 2023; Google 2022.*

1.4.1 Defining resilience

Brunnermeier (2021) in his book *The Resilient society*, defines ***resilience*** multiple ways: we can think of resilience as the *"ability to rebound"* (p.8) or more formally it can be thought as an ability for *"reversion back to the mean"* (p.16). Resilience is dependent on the ability to adapt and change (Brunnermeier 2021). Resilience can be and is defined on different levels of analysis. Individual, firm-level, societal or global resilience (Brunnermeier 2021; Enthoven 2023) means different things on a practical level, but carries the same notion.

Enthoven (2023, pp.26-27) and Nyikos et al. (2021, p32) both have collected various definitions from the literature; here I provide a selection of what they have reported:

Authors	Context	Definition of resilience
Holling (1973) in Nyikos et al. (2021)	Ecological systems	The measure of the persistence of systems and of the ability to absorb change and disturbance and still maintain the same relationships between state variables.
Carpenter et al. (2001) in Nyikos et al. (2021)	Socio-ecological	The magnitude of disturbance that a system can tolerate before its transition into a different state that is controlled by a different set of processes.
Rose–Krausmann (2013) in Nyikos et al. (2021)	Engineering resilience	'hastening the speed of recovery from a shock'
Nyikos et al. (2021)	Regional economics	refers to the speed at which a network returns to its equilibrium after a shock and to the perturbations/shocks that are absorbed
Christopher & Peck (2004) in Enthoven (2023)	System	It is the ability of a system to return to its original state or move to a new, more desirable state after being disturbed.

Table 1.2: ***Table of resilience definitions in various contexts.*** *Source: own work, based on Enthoven (2023) and Nyikos et al. (2021).*

There are common elements across the definitions, regardless of the unit of analysis and the context: (1) resilience is generally defined as an ability, (2) first to absorb impacts and (3) second to

Authors	Context	Definition of resilience
Blackhurst et al. (2011) in Enthoven (2023)	Firms	It is the firm's ability to absorb disruptions or enables the supply chain network to return to state conditions faster and thus has a positive impact on firm performance.
Lengnick-Hall et al. (2011) in Enthoven (2023)	Firms	A firm's ability to effectively absorb, develop situation-specific responses to and ultimately engage in transformative activities to capitalize on disruptive surprises that potentially threaten organisational survival.
Ruiz-Martin et al. (2018) in Enthoven (2023)	Organisations	The measurable combination of characteristics, abilities, capacities or capabilities that allows an organisation to withstand known and unknown disturbances and still survive.

Table 1.3: ***(cont'd) Table of resilience definitions in various contexts.*** *Source: own work, based on Enthoven (2023) and Nyikos et al. (2021).*

recover from (4) an unknown / unexpected shock.

Brunnermeier (2021) also provides a good analogy for resilience, highlighting its trade-offs too:

> [. . .] *consider an electric circuit with numerous light bulbs. The most cost-efficient way to set this up would be a series circuit like those used in old-style Christmas tree lights. In this case, if one light bulb failed, the entire Christmas tree would turn dark. A more resilient alternative is a parallel circuit. In this case, each light bulb is connected to a main circuit* [. . .] *The total cost of the wiring is higher because more wire is needed, but the parallel circuit is more resilient. -* Brunnermeier 2021, p.9

Importantly, I do not use the distinction that Brunnermeier (2021) uses to distinguish between *resilience* and *robustness*. He defines *robustness* as a concept different from resilience:

> *Robustness, unlike resilience, is about the ability to resist shocks without adapting. A robust system performs well and continues to operate as normal - in most circumstances. -* Brunnermeier (2021, p.19)

While this distinction is certainly appealing, the issue is that in practical analysis - without high-frequency data - it is very hard to distinguish between these two effects. Given an interval of time after a shock, two different entities might have different behaviours: one absorbing the shock due to *robustness*, while the other adapting to it due to what Brunnermeier calls *resilience*, but their observed outcome at the end of the period can be still equal. This practical consideration leads us to adapt the above definition, which merges both of these behaviours into the concept of *resilience*.

Another interesting distinction, is mentioned by Enthoven (2023): he discusses a subdivision of the concept of resilience into *proactive* and *reactive* resilience. In this interpretation *proactive* resilience focuses on building capabilities before a disruption occurs, while *reactive* resilience focuses on post-disruption capabilities. It is easy to draw a parallel with Brunnermeier's robustness and resilience. I partially take this distinction into account in the subsequent analyses, given that focus on pre-shock characteristics that *enable resilience*. However, these characteristics again can lead to both absorption of impacts and adaptation, which we cannot differentiate between.

Importantly, as Brunnermeier (2021) or Chikán et al. (2022b) highlights, production systems in the last few decades have increasingly moved towards "just in time" principles: minimizing stocks, implementing lean practices, relaying on the ever-available transnational stock flows. Resilience, in these production systems, but also in general, in contrast to this encourages redundancies and safety buffers (Brunnermeier 2021). And indeed, for example in Hungary, during the COVID-19 induced supply chain disruptions firms started to leverage inventories as a buffer to mitigate shocks (Chikán et al. 2022b). Inevitably, building resilience diverts the focus from cost-efficiency and efficiency to stability and safety, which - ironically - can prove to be more cost-efficient if a shock actually strikes.

In conclusion, the definition that I adapt through this dissertation focuses both on *withstanding* and *adapting to* shocks and makes no distinction between the two. It focuses on an ability, but given the empirical nature of the work, which works with outcomes, it proxies ability with 'realised ability'. And importantly, I consider resilience of the different entities in the context of COVID-19, which is - as I have discussed it earlier - a largely unexpected and rapidly evolving shock, with origins outside of the economic and business systems. Therefore, I can summarise my adapted definition of *economic resilience* as ***the ability of various entities to adapt to and/or withstand shocks and maintain and/or increase their performance***.

1.4.2 Economic resilience

Of course, this being a dissertation focusing on economics, I apply these definitions in the economic space. Crucially, this does not change what I expect resilience to be, but it does point to certain units and outcomes that I should observe if I am looking for *economic resilience*. Enthoven (2023), as shown above, already discusses some relevant units of observation in the economic system: firms and organisations, while Brunnermeier (2021) talks about individual, societal (national) and global levels. Hallegatte (2014) and Rose et al. (2013), adapting a more general approach, talks about *microeconomic* and *macroeconomic* resilience.

The unit of analysis then drives the relevant outcomes as well. The survival of a unit (e.g., firm) is definitely a common outcome of interest (Enthoven 2023). However, there are also less drastic outcomes that worth looking at: Hallegatte (2014), considering mostly the macroeconomic level, focuses on variables such as loss of output, loss of income or loss of employment (and of course how much of these losses can be avoided). While at the microeconomic level variables of interests are stock returns (Essen et al. 2015; Cheema-Fox et al. 2021), employment losses (Essen et al. 2015; Köllő et al. 2021), revenues (Köllő et al. 2021; Lamorgese et al. 2024).

In the Chapters of this thesis I explore *economic resilience* across multiple units of analysis connected with multiple outcome variables, the table below provides an overview of this:

Chapter in the thesis	Unit of analysis	Outcome variables
2. Employees	Employees	Employee productivity
3. Firms	Firms	Firm revenue
4. Nations	Nations	Competitiveness score
5. Recovery	Nations	GDP, employment

Table 1.4: *Unit of analysis and outcome variables in the studies. Source: own work.*

1.5 A framework of the economy and competitiveness based on Chikan's (2008, 2018) concept

I have so far reviewed the impacts of COVID, with a focus on Hungary as well and have discussed how we can understand and define resilience, now, as a context to the subsequent chapters that look at different levels of the economy, I offer a framework of the economic system that link these levels together. My adapted framework builds on Chikán (2008) and Chikán et al. (2018) and I directly use this framework in the fourth chapter to discuss national competitiveness. The framework is intended to capture how national competitiveness is formed, but it also provides a good basis for a general understanding of economic linkages, including the role of households and institutions.

Chikán (2008) and Chikán et al. (2018) are two seminal papers of the same research program (many aspects of the research program are documented in Chikán et al. (2019)), which has been maintained for many years by the CRC. Chikán (2008) provides the initial framework and idea for defining and linking firm-level and national-level competitiveness. Importantly, it highlights the idea of double value creation as the main process of the economy and prescribes the national goal of increasing the welfare of citizens, while increasing productivity sustainably. Meanwhile, Chikán et al. (2018), building on this, consolidates a fundamentally Microeconomics-based model with the ideas of Institutional Economics and the resource-based view of the firm.

The framework, shown in Figure 1.5, is built up as follows: the intersection of supply and demand is where value creation happens. In the tradition of Chikán (2008) value creation is seen as a two-sided process , i.e., when demand is matched to supply, it creates material well-being and shareholder value. Material well-being being the satisfaction of customers, while shareholder value is the realised profit of the enterprise. Now, if we look at the demand and supply sides in detail: supply is what firms (can) produce, it is dependent on factors conditions of the firm (i.e., employees / labour and resources, that are natural and produced capital) and the productivity of the firms.

On the firm side: firms have to manage all their processes in the business environment, that is shaped by not just the available resources, but the other firms in the economic system as well as the regulatory environment, altogether this creates the *market environment* of the firm. Here, the regulatory environment, in turn, is heavily dependent on policies of the government as well as institutions in a broader sense (as in (Acemoglu et al. 2005)).

Now, on the demand side, we find households, who have subsistence and discretionary consumption demand, which, when fulfilled through the process of value creation, becomes well-being for these same households. I note that value creation, as defined by Chikán (2008), has a *"double"* character: it simultaneously creates *societal* value, i.e., well-being for consumers and shareholder value.

In the interpretation of Chikán (2008) there are two final outputs of the framework, the well-being of the society and productivity. He also argues that increasing productivity is eventually what means the growth of social well-being possible.

In Figure 1.5 I also position the four studies: my second chapter is related to employee productivity (2), my third is to firm capabilities (3), while my fourth and fifth is to the general institutional environment (4) and government actions (5).

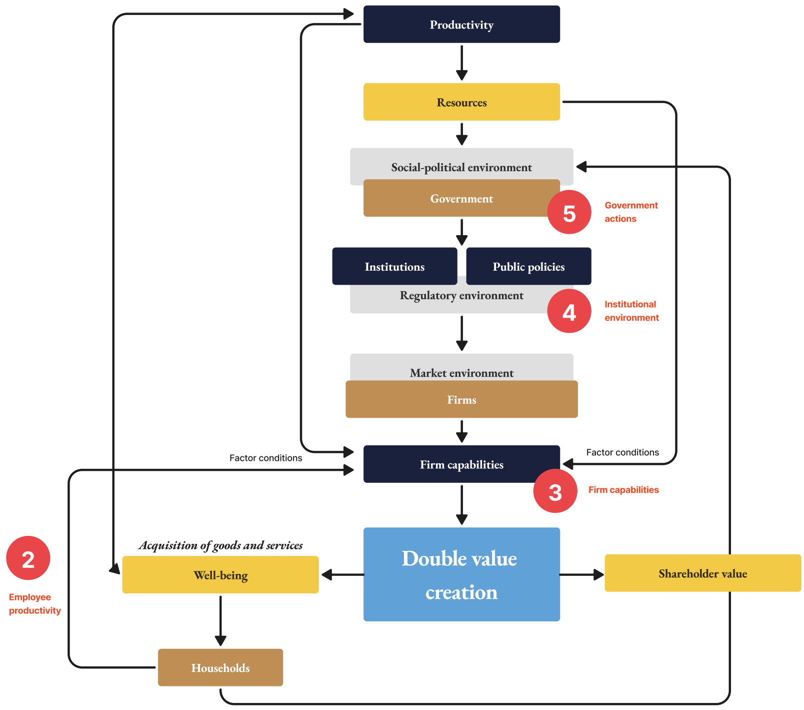


Figure 1.5: ***Framework of economic value creation and the articles in the PhD dissertation.*** *Source: own work, based on Chikán (2008) and Chikán et al. (2018).*

1.5.1 Understanding the impacts of COVID in this framework of the economy

There are many aspects, how COVID impacted national economies and how different entities in the economy were able to withstand these effects or bounce-back, due to their resilience. Earlier in this dissertation some global economic effects of the pandemic were shown (e.g., Figure 1.1) and it was discussed how COVID meant a demand and supply shock at the same time (Pollitt et al. 2021) and how it has impacted employees and consumers through various ways. I have also shown (Figure 1.3,Figure 1.4) and discussed some economic impacts that were specific to Hungary. Now, I ask the question of how this relates to the framework that I have just described?

First, I need to note that there are many impacts of COVID that *could be* captured in this framework that I, unfortunately, do not discuss, just a few from the many, e.g.:

- how investment trends were impacted by COVID and related uncertainty,
- how shareholder value and capital returns have changed,
- how resource use has changed

What I *do discuss* are three areas, fitting into the framework presented above, based on Chikán (2008), where I believe pre-COVID practices and resilience can have a major role. These three areas are, as shown on Figure 1.5, which map them into the defined framework:

1. Stability of employee productivity in the midst of the COVID induced shocks
2. The resilience of firms' performance based on their pre-COVID practices

3. The resilience of nations' competitiveness based on their long-term government practices

Crucially, as I will discuss in the conclusion, these areas are linked together through various channels, as indicated by the framework. Furthermore, they also share bits of logic and methods of operation that are common between the these layers. Through the channels, these logics can easily spread up and downwards, shifting the economic-societal system towards certain behaviours. Accordingly, it is important to see these separate layers in a common framework (such as the one presented above) and to be able to understand the commonalities that transcend across these levels of the economic system.

Note that all three topics are focused on resilience, while they investigate vastly different *levels* of the economic system. These topics are presented through three studies that make up the following three chapters of the dissertation. These are research papers that were published, in different versions, either as journal articles or as working papers. However, the versions that I present here carry substantial extensions compared to some of the published works, highlighting commonalities between the reactions of the different levels and mechanisms carrying the impacts from one to the other. Two of the papers focus on Hungary, and specifically the year 2020, given that the economic shock of the pandemic has been the heaviest then, as it was discussed earlier (see page 11). Meanwhile, the third paper focuses on a more global picture, comparing the resilience of countries with different policy / government / institutional directions.

2

Within a Firm: Employees and Management Issues in the Pandemic

The chapter introduces how the COVID-19 pandemic has disrupted normal work processes in the early days of 2020 March. Importantly, this chapter starts our investigation from as close to the micro level of the economy as possible - on the level of the actual employees and people. The chapter discusses what were the instant and most crucial effects of COVID-19 and related government measures on how people were working. It builds on primary research carried out during the earliest periods of the pandemic (starting March 2020), the background of the research will be discussed in the next section. Material presented in the chapter has been published as a working paper: *Kiss-Dobronyi, B. and Szekeres, M. (2021), "Working from home in the midst of COVID-19: occupations and performance Evidence from Hungary"*[1] and has been submitted for publication. The dissertation author's contributions were (CRediT): Conceptualization, Methodology, Formal analysis, Investigation, Writing - Original Draft, Visualization.

2.1 Background of the chapter

This chapter builds on research that has begun in early 2020. The author has organized research efforts in the early days of the COVID pandemic to collect primary data on employee behaviour, working from home possibilities, as well as other factors, connected to the crisis influencing how work was disrupted in this period. The research has focused on primary data collection through internet-based surveys and the analysis of the resulting datasets.

Much of the work has carried out with the support of Zoltan Bakonyi and later with Marton Szekeres (both of Corvinus University of Budapest). While at the time the resulting insights were not published academically, we have made sure to (1) share the anonymized data with interested researchers, (2) provide updates about one sample of the Hungarian labour force based on the collected data, (3) discuss the results in both academic and professional settings.

Our research has led to the publication of multiple non-academic news articles[2], but has also inspired academic work (Kazainé Ónodi et al. 2020; Kupa et al. 2022; Olasz 2022; P. Juhász et al.

[1] Deposited to Corvinus Research.
[2] See at Index.hu or G7.hu, in Hungarian.

2021) and was reviewed by both Hungarian[3] and EU authorities[4]. Furthermore, the authors have presented about the research on multiple occasions: forum of HR leaders (Budapest, 2020. Sept. 30.), Poznań University COVID-19 economics conference (2021. Dec. 2.).

2.2 Introduction

At the beginning of 2020, the COVID-19 crisis had put governments into an uneasy position: in order to curb the spread of the pandemic, most of them have implemented strict measures asking or forcing residents to adopt social distancing and stay-at-home measures whenever they can. But these measures had adverse effects on national economies - restrictions were imposed on a substantial part of the labour force. This, as people were unable to work, have created a supply shock in the economy. At the same time, the same restrictions and behavioural responses have created a demand side shock as people significantly reduced their movements and have severely reduced their spending in many areas (e.g. tourism, transport, entertainment) (OECD 2020a) .

By now we have seen and understand some aspects of the overall economic effects COVID-19 and these measures. According to calculations by the International Monetary Fund (IMF) the global economy has shrunk by about -3.1% (in GDP) (IMF 2021). Meanwhile, given that adverse impacts were often hurting vulnerable and low-income groups the most, global employment has decreased by -3.5% according to the International Labour Organization (ILO) (ILO 2021). Although the magnitude of these effects at the country and regional levels have been influenced by multiple factors, it is still reasonable to say that for the supply shock two factors were probably among the most important drivers. The length and level of lockdown measures is one of these, while the other is the amount of supply substitution possible through working from home (WFH). Furthermore, what we see in terms of WFH adaptation can have long-term consequences as well, as many people experienced WFH for the first time. If it deemed feasible for jobs, where it was not standard practice before, it could lead to more widespread use. Nevertheless, if it is perceived as causing a performance issue among employees it can seriously hinder its adaptation in the future.

2.2.1 Review of the literature

Literature quickly emerged when the COVID-19 pandemic and restrictive measures struck. Many of the studies focused on the potential rate of WFH across the economy. Starting with Dingel et al. (2020) multiple studies (Rio-Chanona et al. 2020; Koren et al. 2020) have used the O*NET database for estimating the potential number of jobs that can be done from home either as a result or as an input to further modelling. Their methods have relied on programmatic and manual classification of occupations and industries, based on their main tasks and activities, to arrive at a score reflecting the plausibility of working from home. Results have ranged between 34%-44% for labour force in the US economy.

For countries other than the US Fadinger et al. (2020) have investigated the effects of costs and benefits of home office measures in Germany. They found, based on Eurostat data, that 42% of jobs can be done from home, putting their estimate in the range of US estimates. Adams-Prassl et al.

[3] State Audit Office of Hungary, 2021, ”Teleworking, working from home, opportunities, risks”, link to the document.
[4] European Parliament, 2020, ”Public Opinion Monitoring”, link to the document

(2020) reported, based on a recently conducted survey, that the average percent of tasks can be done from home differs quite significantly across occupations, ranging between about 20-70% in both the US and UK.

While in developing markets, Saltiel (2020) have shown, based on the STEP survey, that WFH rates can be significantly lower, with large country differences. His definition of WFH follows Dingel et al. (2020), ruling out WFH:

> "*if workers either (not) use a computer at work, lift heavy objects, repair electronic equipment, operate heavy machinery or report that customer interaction is very important*"
> (Saltiel 2020, p. 150)

His results show that on average 13% of jobs can be done from home in the studied countries, ranging between of 5.5% in Ghana and 23% in some Chinese provinces. This slightly differs from survey results from China - Zhang et al. (2020), based on a survey conducted in February, have reported that 38% of their respondents have worked from home, however their sample was not representative of the Chinese population and most of their respondents had completed tertiary education.

With the exception of Zhang et al. (2020), these studies focus on the potential for WFH, as their main question is usually the adverse supply shock that can be mitigated by substituting normal work practice to a WFH setting. However, it is not trivial to understand how much of this potential was actually exploited during the pandemic (as is still exploited) and with what performance. As Adams-Prassl et al. (2020) reports the share of tasks that can be done from home differs across occupations and there are also numerous "first time" remote working employees, who could potentially face a challenge adapting to the new situation.

Morikawa (2020) explores this issue in an article based on interviews within a Japanese economic research institute finding a lower productivity in the WFH setting. He highlights some contributing factors: new software and hardware that the employees need to learn to use, work that cannot be done from home because of security reasons or a poor working environment. Contrasting that in an earlier experiment conducted with Chinese call centre employees, unrelated to the current crisis, Bloom et al. (2015) found a positive effect of WFH on productivity. However, this was a special setting because as they write call centre work does not involve "teamwork" and their performance can be clearly tracked. Results from Rymaniak et al. (2021) on the perceived "quality" of one's work across three countries (Poland, Spain, Estonia) show that these impacts can even be mixed across countries. While in Estonia as a result of the mandatory telework, they find a perceived increase in the work quality, in Poland and Spain, the same indicator shows a decrease.

However, as Morikawa (2020) proposed, certain, often crisis-specific, factors might be responsible for this change. Some employees might not have the necessary equipment (like a computer or suitable desk and place within their home) to engage in WFH or to perform their tasks properly, which can further suggest that the assumed potential substitution is not possible. Carillo et al. (2021) studies the adjustment of employees to remote work in France during the pandemic. They propose and confirm that there are various factors on various conceptual levels (individual, job, organisational level and crisis and non-crisis specific) that influence whether the adjustment is seamless or not (i.e. there is no or only minor performance change). They point to WFH environment, previous WFH experience, ICT proficiency, the length of the adjustment period, but also to professional isolation as main drivers that can hinder the adjustment. From these elements, they define the environment, duration and professional isolation as specific to the crisis. Zoonen et al. (2021), analysing a Finnish sample of employees during early stages of the pandemic, have also found strong support for the notion that these contextual factors (e.g. change in the working environment, disruptions, new tasks) have adversely effected the ease of adjustment to the WFH situation.

Therefore, we think it is important not just to know how well WFH indices represent actual behaviour, but also to understand whether these factors (such as earlier experience of environmental factors) adversely impact productivity in this new situation. Our contribution to the literature is therefore twofold: first, based on survey data collected among Hungarian employees in March-April 2020 we conduct an empirical testing of a simple WFH index, derived from the data of CEDEFOP's Skills Panorama (CEDEFOP 2020) project. Second, we analyse two ideas: (1) there could be a divergence from reaching the potential WFH rate due to adverse factors (such as lack of technical equipment, employer decisions, etc), (2) even when controlling for these adverse factors the performance of WFH is not necessarily in line with the occupational possibility of WFH. We focus on whether the employees have previous experience with working from home as it is shown to be an important driver in other studies (Carillo et al. 2021; Zoonen et al. 2021).

The rest of the chapter proceeds in the following way: Section 3 introduces a simple WFH potential index that we use for measuring occupational WFH potential. Section 4 briefly presents the survey that has been conducted and serves as a basis for the empirical analysis. Section 5 describes our assessment of the WFH potential index against observed behaviour, while Section 6 investigates employee performance change in the WFH context. Finally, in Section 7 a brief conclusion summarizes the chapter.

2.3 A WFH potential index

As it was discussed there were multiple indices used by different papers estimating WFH potential. Here we implement a definition very similar to Saltiel (2020), we base our estimation on Skills Panorama (CEDEFOP 2020) data and use their broad occupational level (corresponding to occupations, covering 40 occupations) skills index to determine our own WFH index, in a way similar to Rio-Chanona et al. (2020) remote labour index (RLI) . We define a negative case for working from home using the following characteristics of the occupations: 'strength', 'use of machine' and 'service and attend', 'use of ICT', 'gather and evaluate information'. The Skills Panorama dataset provides a value between 0-1 for each of these characteristics, indicating how important they are for the given occupation. We calculate the WFH as an average of these characteristics, taking the 'inverse' (1-x) value of all, but the latter two – as presented in Equation 2.1.

$$\text{WFH}_{score} = \frac{[\text{Use of ICT}] + [\text{Gather and eval. inf.}] + [\text{Strength (rev.)}] + [\text{Use of machine (rev.)}] + [\text{Service and attend (rev.)}]}{5} \tag{2.1}$$

With this we gain an index which supposedly increases as the feasibility of working from home increase. For example, for *ICT professionals* we calculate the score as follows:

Occupation	WFH score	WFH feasible
ICT professionals	0.84	yes
Office professionals	0.77	yes
ICT technicians	0.77	yes
...		
Legal & social associate professionals	0.63	yes
Health professionals	0.62	yes
Hospitality & retail managers	0.59	no
Health associate professionals	0.59	no
...		
Technical labourers	0.48	no
Agricultural labourers	0.47	no
Cleaners and helpers	0.47	no

Table 2.1: ***Sample of calculated WFH scores.*** *Source: own work.*

$$\frac{0.85 + 0.74 + (1 - 0.04) + (1 - 0.13) + (1 - 0.23)}{5} = 0.84 \tag{2.2}$$

One clear advantage of this method, beyond its simplicity, is that the Skills Panorama dataset provides data for all European Union member states therefore it is quite straightforward to replicate this calculation for other member states.

The calculation gives us a list of negative WFH scores by occupation, therefore the higher the score the less likely it is for an occupation to be feasible in a WFH setting, the mean of the calculated score is 0.60. We are going to use these occupational level scores later. We can also apply a simple binary classification to decide whether an occupation is feasible to be done from home or not - after inspecting the generated scores (see Table 2.1) and ranking the occupations by the scores it seems acceptable to classify every occupation over the mean to be not feasible for WFH.

Then using Skills Panorama data we have applied these binary WFH classifications on the overall occupational structure of the Hungarian economy and calculated the sectoral shares of potential WFH (share of people holding an occupation in the given sector which can be done from home) and the total economy wide WFH potential. We estimate that about 38% of jobs can be potentially done in a WFH situation in Hungary. Putting this estimate into context: US estimates were between 34-44%, Germany 42%.

It needs to be noted here that while this calculation does give us a share of people holding occupations which are feasible to be done from home it does not account for those jobs which cannot be done from home, because of the sector that they are in. An example of this would be a retail manager, who by their occupation could potentially work from home, but given that other people who they manage cannot work from home their role comes into question. However, there is a high potential for changes in task structures, which we investigate further in this paper later.

Nevertheless, this rate is in line with reported rates of home working due to the coronavirus in Hungary. A representative public opinion survey by the Publicus Institute et al. (2020) has recently found that about 41% of Hungarians are working from home (however this survey was not representative in terms of sectors or occupations). Nevertheless, we are interested in not only the total rate, but also whether the WFH index is a fitting predictor at the occupational level. For this, we use responses from an online survey collected through March-April 2020, where we asked employees about their work related experiences during the pandemic situation.

2.4 Survey

We have conducted an online survey[5], from 2020 March 27 to Apr 27, collecting 1074 responses altogether.

For this analysis, we have limited our scope to respondents who are between 16 and 65 years old, are currently working in Hungary, are employed or were employed recently and have provided their position (employment position). Due to bias towards higher educated respondents, it was not feasible to create a sample that would be representative for all possible groups in the country. Therefore, we have decided to work with a smaller, more specific sample. We therefore have excluded all respondents without tertiary education, resulting in a more homogenous sample, that we have weighted in order to get a sample that is representative for this group in terms of sex, age and region (see Appendix A). This left us 469 observations to work with.

This also means that we are working with a sample whose potential for holding jobs where WFH is feasible is higher. The dataset is close to being representative without weights, but using a simple raking method we have created a weighted version of the dataset bringing our sample within ±5% of the target population in terms of gender, age group, region and broad occupational group.

In the survey data we have a high share of respondents who said that they were working (even before this situation) from home. A weighted share of 54% have said that they were working from home in the last one year, this is a much larger share than what has been reported by the Hungarian Central Statistical Office (2020) for 2018 Q1 - about 10% for residents with tertiary education. This can be explained by multiple factors: increase in the last two years could be a contributor, but more importantly the different wording of our question can drive the difference - we captured respondents who *have worked in any situation* from home, not only those who reported '*working from home*'.

We also got a high ratio of people saying that they are working from home in this new situation. Due to the crisis about 85% of our respondents are currently working from home - this is a slightly higher ratio than what was reported by Publicus (73%) (Publicus Institute et al. 2020). This again can be explained by differences in the questions asked.

2.5 WFH potential and observed behaviour

We will use our survey results to test the proposed WFH index. In the survey we have asked our respondents to indicate their employment position - we received nearly as many position names as respondents. To consolidate this, we have first used the fuzzywuzzy (A. Cohen 2011) package available in Python, which is able to combine results of multiple matching mechanisms (e.g. Levenshtein distance) for a first round of matching these free-text answers to ESCO occupations. Then we car-

[5] In the creation of the survey we have received valuable advice from the Institute of Informatics at Corvinus University of Budapest, IFUA Horvath & Partners and the Competitiveness Research Centre.

ried out a manual checking of all entries and matches to arrive at a complete set of matches between positions in the responses and ESCO occupations.

We use this matched dataset to calculate the WFH share of each occupation and to compare it to the calculated WFH scores. The correlation between the score and share is 0.58. This indicates that at the occupation level there is a connection between the WFH score and the actual observed values; therefore the WFH index is potentially a fine predictor.

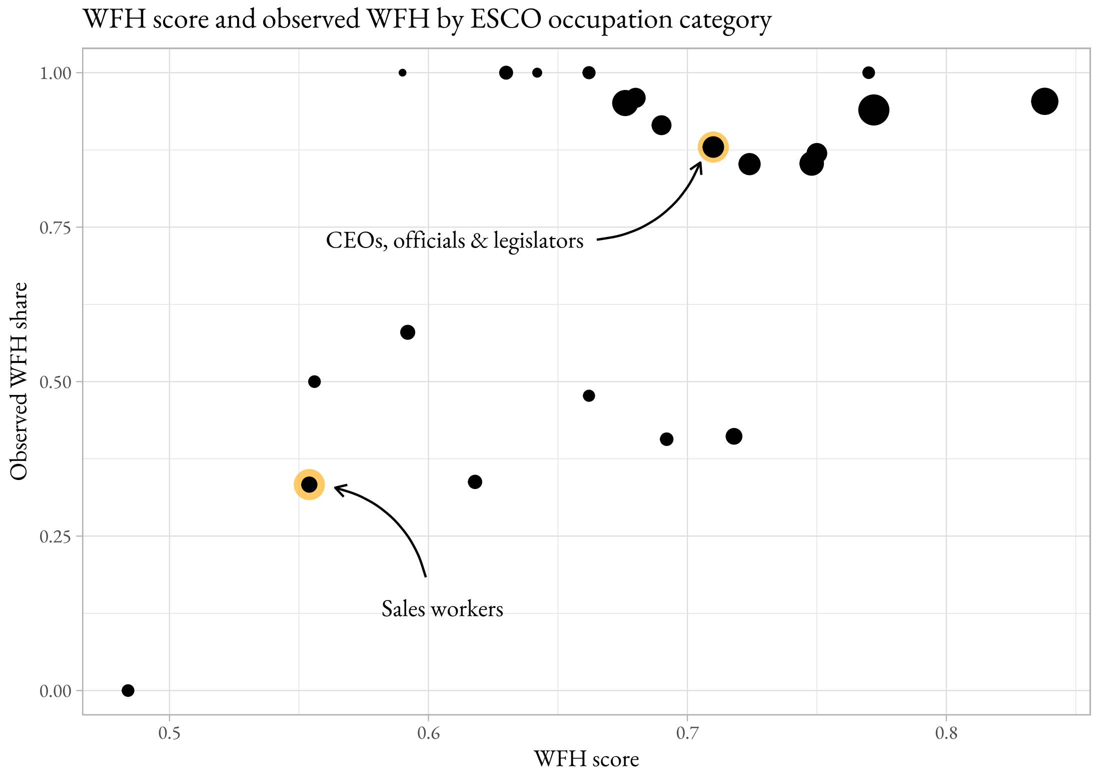


Figure 2.1: ***WFH score and observed WFH by ESCO occupation category.*** *40 ESCO occupation groups shown, the size of the circles represents the number of employees in each group. Source: own work.*

To investigate the strength of the relationship further and to account for potential confounders on observation level we specify a probit model with various controls. We specify the probability of working from home in the recent weeks as :

$$P(Y = 1|WFH) = \Phi(\alpha_0 + \beta_1 \times WFH_i) \tag{2.3}$$

where Y is if the person has been working from home in the recent weeks, WFH_i refers to the observed index score for the given occupation, while α acts as a constant. The survey weighted version of this model is estimated on the data. The estimation results (presented in Table 2.2) show that the WFH score significantly affects the probability of working from home recently, the effect is robust for including demographic dummy variables (age, gender, not shown in results table).

It is still significant (however only at the 10% significance level) if we include a dummy variable indicating that the person in question has not worked from home before, however if both the demographic variables (gender, age) and the previous WFH experience is included it loses its significance in the model. This indicates that whether the respondent was working previously from home is a better indicator of whether they are going to work from home, than their occupation. However, we believe this factor is correlated with the occupation (as a high WFH is also a good predictor of prior WFH experience[6]), therefore does not invalidate our general finding that in occupations with higher WFH scores it is more likely to switch to WFH in a situation like this.

The average marginal effects of the model (2) indicate that if the person has not worked from home their chances of doing that now are reduced by -23%, while 0.01 increase in the WFH score increases the chances of working from home now by 0.6%.

Figure 2.2 shows the fit of the predicted values (from model 2) against observed behaviour - working from home in the last few weeks. This indicates (at least considering this population) that the WFH score proposed here is a relevant measure of potential for working from home. Comparing marginal effects at different probabilities (Figure 2.3) it can be seen that the effect of the occupation, captured in the WFH score is much higher for those who were not working from home previously - this is in line with the notion that there are jobs where working from home is (and likely was) possible, but was not available for (or chosen by) the employees for reasons unknown to us.

	Dependent variable:			
	WFH recently (yes)			
	(1)	(2)	(3)	(4)
	Average marginal effect			
WFH score	1.30***	1.22***	0.61*	0.60
	(0.38)	(0.42)	(0.36)	(0.37)
No prior WFH experience			−0.23***	−0.23***
			(0.05)	(0.05)
Further controls (gender, age)		X		X
χ^2	35.63***	40.94***	79.79***	85.02***
Pseudo R^2 (Nagelkerke)	0.08	0.08	0.16	0.17

Note: All regressions use probit specification, weighted for design effects. N=466.
*Standard errors in parentheses. *p<0.1; **p<0.05; ***p<0.01*

Table 2.2: ***Probit model results for WFH recently as a function of WFH score and prior experience.*** *Source: own work.*

This indicates (at least considering this population) that the WFH score proposed here is a relevant measure of potential for working from home. Comparing marginal effects at different probabilities (Figure 2.3) it can be seen that the effect of the occupation, captured in the WFH score is much higher for those who were not working from home previously - this is in line with the notion

[6] We have also tested a model specification, where we investigated the effect of occupational WFH score on the probability of prior WFH experience – results indicate a clear connection – but that just confirms that employees in occupations with higher WFH scores are more likely to have WFH opportunities even without an epidemic.

that there are jobs where working from home is (and likely was) possible, but was not available for (or chosen by) the employees for reasons unknown to us.

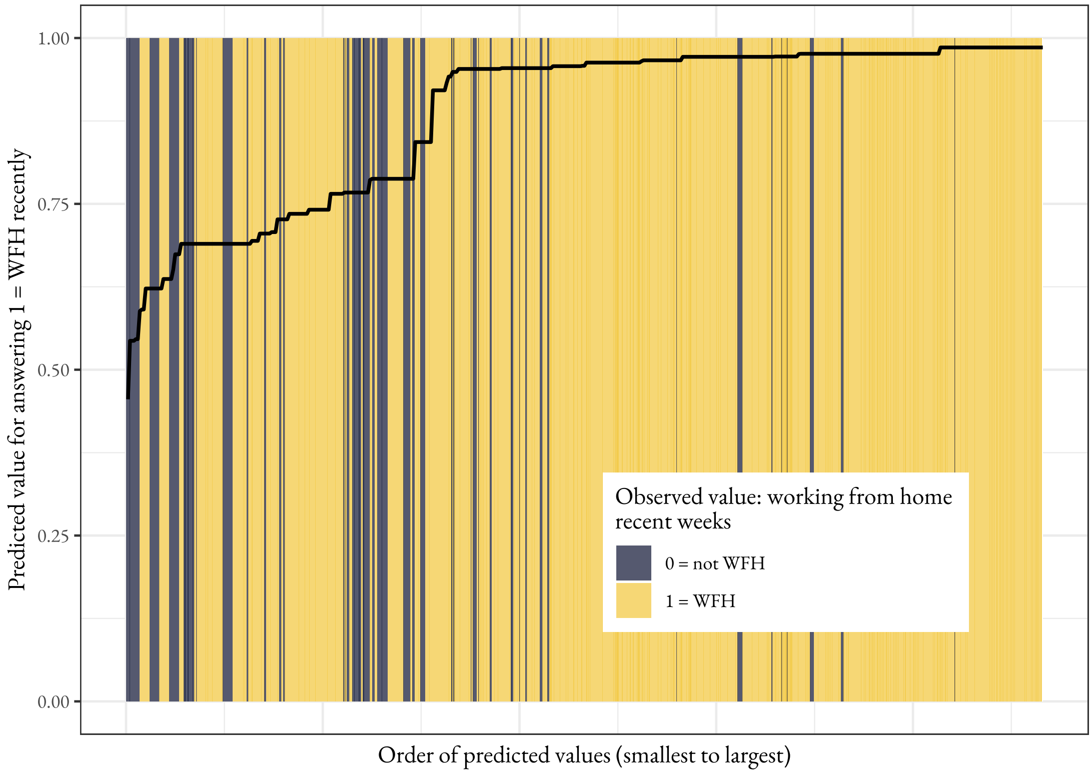


Figure 2.2: ***Comparison of predicted and observed WFH in weeks preceding the survey.*** *Source: own work.*

2.6 WFH and performance

Another important point that we have raised earlier is the performance of the employees in a WFH setting. In our survey we have asked the respondents to rate how well they are able to perform in the WFH setting compared to a "normal" work setting. The respondents were asked to use a four-choice scale with choices "Not at all", "Less well", "Nearly as well", "Totally". For this analysis, we constructed a binary variable from these choices - one category for weaker and one category for nearly as good performance. These scores are of course subjective perceptions of the employees, but can give an indication about the general level of performance.

We use the WFH scores once more to show how performance relates to the potential of the given occupations. This analysis is concluded on a limited sample, as for this we can only consider respondents who have worked from home in the recent weeks. Here we exploit that in the current situation it is likely that WFH is not a choice for most employees, but rather a necessity; therefore we do not expect the otherwise important self-selection mechanism (those who expect the same performance while working home will choose to work from home) to play a role. We model the effect of WFH score of occupations on the working from home performance indicator using, once more, a probit model specified as follows:

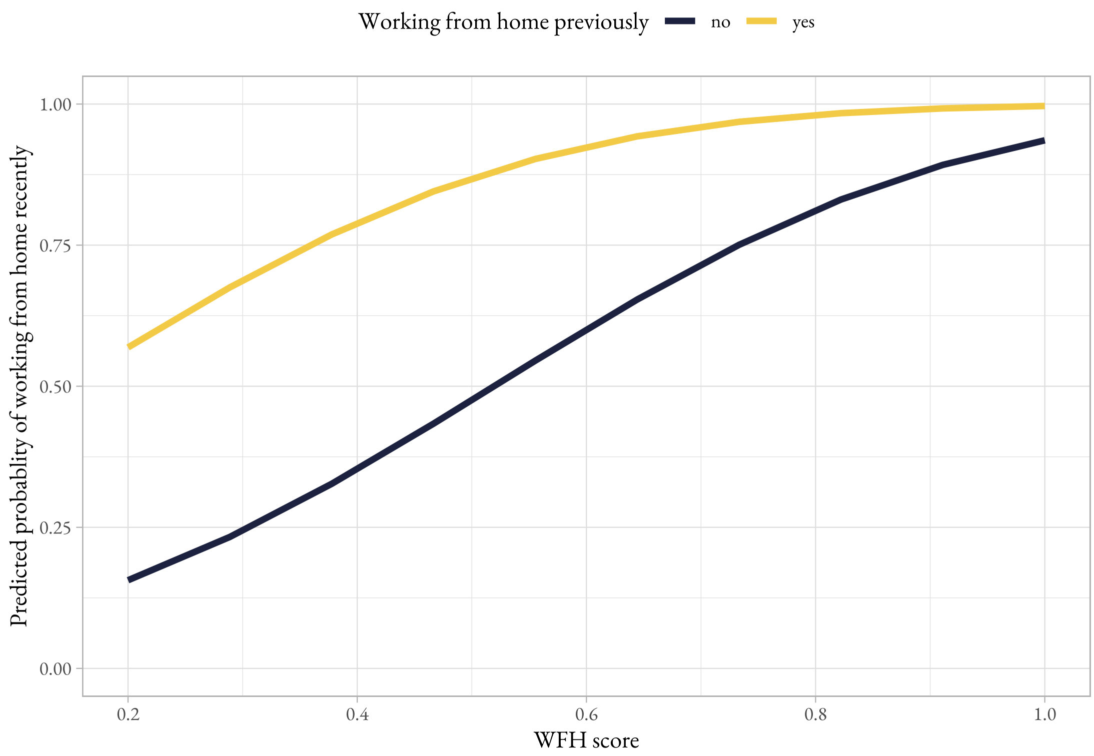


Figure 2.3: ***Predicted probability of working from home recently conditional on WFH score, by previous WFH experience.*** *Source: own work.*

$$P(Y = 1|WFH) = \Phi(\alpha_0 + \beta_1 \times WFH_i) \tag{2.4}$$

where $P(Y = 1|WFH)$ is the performance loss conditional on working from home, α is the constant as before and WFH refers to the observed index score for the given occupation. The model is estimated on a sample of 407 answers. We estimate four specifications: (1) a simple specification with on the WFH score as an independent variable, (2) a specification similar to our model from earlier: where a dummy variable indicating whether the person has worked from home previously is added, (3) a model with another added dummy indicating whether the tasks of the employee has changed as they switched to working from home and finally (4) a model where we add yet another dummy variable controlling for whether the employee has employer provided equipment.

Results of the models are presented in Table 2.3 and shown in Figure 2.4 Model 1 indicates that working from home in lower WFH score occupations could mean a lower performance, and this effect stays significant even with the introduction of the lack of prior WFH experience. However, as we can see in Model 3 the effect of WFH score will become insignificant once we also control for significant change in tasks done.

Therefore, from these results it seems that there is a WFH penalty, but not necessarily at the occupation level. Those who have not worked before in this setting could see a decline in performance as well as those whose tasks have changed. Furthermore, those who have employer provided equipment, which we can assume sufficient for the tasks, have a lower probability of performance drop. The good news is that all these factors can easily be changed - WFH experience can be gained (and should - even before situations where it becomes a must - as it turns out from this analysis) and hopefully employees can adapt to new tasks. It also seems like employers can help mitigate the productivity loss - we investigated one factor here - the providing of suitable equipment, but there could be more ways for this. But overall, in this sample, we do see a loss of productivity due to the novel WFH setting, with the lack of prior experience and a change in tasks being significant contributors to this.

	Dependent variable:			
	Weaker performance in WFH (yes)			
	(1)	(2)	(3)	(4)
	Average marginal effect			
WFH score	-2.21***	-1.51**	-0.91	-0.93
	(0.57)	(0.59)	(0.66)	(0.64)
No prior WFH experience		0.24***	0.19***	0.19***
		(0.07)	(0.06)	(0.06)
Significant change in tasks			0.26***	0.25***
			(0.07)	(0.07)
Equipment provided by employer				-0.10*
				(0.06)
Further controls (gender, age)			X	X
χ^2	44.36***	67.78***	96.58***	102.46***
Pseudo R^2 (Nagelkerke)	0.10	0.15	0.21	0.22

Note: All regressions use probit specification, weighted for design effects. ***N=407.***
Standard errors in parentheses. $^{*}p<0.1$; $^{**}p<0.05$; $^{***}p<0.01$

Table 2.3: ***Probit model results, employee performance as a function of WFH score and prior experience.*** *Source: own work.*

2.7 Resilience and the role of management

Results from the previous section already hint towards the fact that some factors are able to contribute to the *resilience* of employees - they can mitigate the labour productivity drop that switching to WFH could otherwise entail. We identify prior WFH experience as well as employer provided equipment as relevant factors. However, we also posit, based on literature such as (Carillo et al. 2021), that *professional isolation* and the lack of sufficient management support can contribute to a lower performance as well.

We can test this assumption based on our survey sample, exploiting questions that measure the use of various communication technologies. Given that we have established that certain environmental factors already have an effect on self-reported performance, we build on this, but we introduce

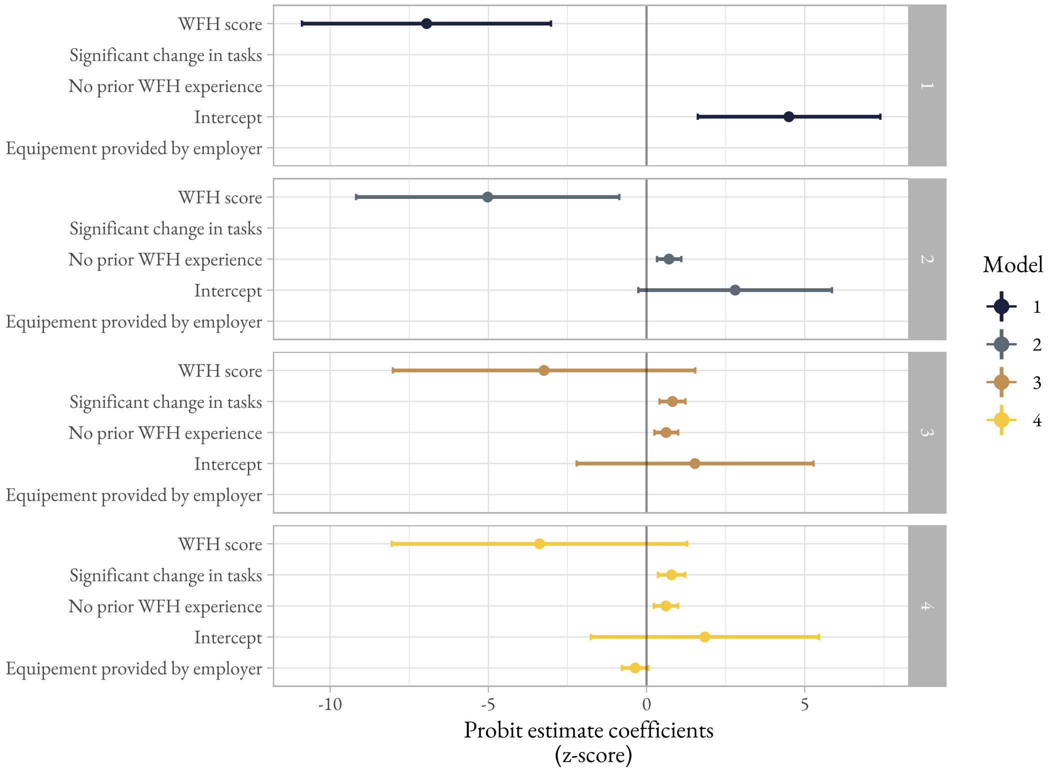


Figure 2.4: ***Probit estimation coefficients, employee performance as a function of WFH score and prior experience.*** *Source: own work.*

two additional variables based on the questions presented in the Appendix (Section A.2).

2.7.1 Communication

First, we start with a descriptive analysis of the responses regarding communication. Figure 2.5 shows the share of answers given about the use of different technologies, grouped by self-reported performance in WFH context. Looking at the figure hints at a higher pre- and post-COVID rate of some technologies in the higher performing group. This is especially prevalent in the case of using teleconferencing solutions: 59% of the higher performing group reported using teleconferencing more frequently than usual, while 57% of the lower performing group reported not using teleconferencing at all.

This might indicate that there is a relationship between the use of teleconferencing and avoiding a lower performance. To test this, we can set up another regression specification, building on the analysis that we have concluded so far:

$$P(Y = 1 | weaker\_performance) = \Phi(\alpha_0 + \beta_1 \times more\_frequent\_comm_i) \qquad (2.5)$$

where the $more\_frequent\_comm$ variable is a variable capturing whether the respondents have either (1) used teleconferencing more than usual, or that they have (2) started to use teleconferencing, while they have not used it before. Given that we have also established that a significant change in tasks contributes to weaker performance, we test this specification on two subsamples, one

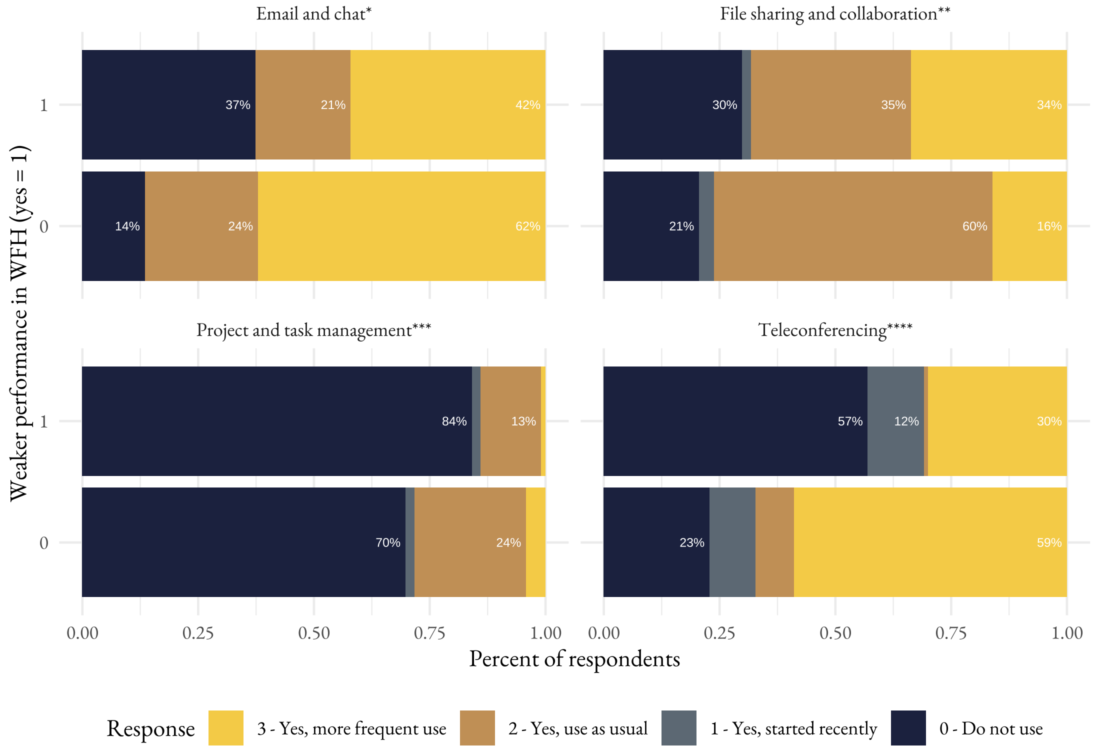


Figure 2.5: ***Survey responses regarding the use of different technologies.*** *Source: own work. Notes: * e.g., Outlook, Gmail, ** e.g., Messenger, Teams, Skype, Slack, *** e.g., Zoom, Teams, Webex, Skype, **** e.g., Asana, Trello, Jira*

containing respondents whose tasks have changed significantly, while the other contains the rest of the sample.

Results of the analysis are shown in Table 2.4. For the subsample with tasks unchanged, our models prove to be unhelpful. Neither the individual independent variables, nor the overall models, explain variation in the dependent variable. Basically, we see that within the group (of employees with unchanged tasks) neither the more frequent teleconferencing, nor the prior WFH experience makes a substantial difference.

In the subsample of people with significantly changed tasks, however, both the model including previously used explanatory variables and the individual variables seem to have significant estimated parameters. As before, the lack of prior WFH experience can contribute to a lower performance, and the higher the WFH score for the occupation, the less likely that a lower performance is experienced. Both estimated parameters are higher than what we have estimated previously on the full sample. The variable, that we have newly introduced (*more frequent teleconferencing*), also gets a significant negative coefficient. Our interpretation, that more frequent communication lessens the chance of lower performance, seems to be supported by the estimated parameter. However, given that the parameter was estimated on the subsample, this means that this effect is detected when it accompanies a significant change in work tasks.

Our conclusion, therefore, suggest that a more frequent communication became especially crucial in those cases where employees had to change what they are doing, i.e., they had to significantly change their tasks. This seems like a logical conclusion: if tasks that are expected from the employees

	Dependent variable:			
	Weaker performance in WFH (yes=1)			
	Sub-sample: tasks unchanged		Sub-sample: tasks changed	
	(1)	(2)	(3)	(4)
	Average marginal effect			
More frequent teleconferencing	−0.14	−0.09	−0.72	-2.32^{*}
	(0.44)	(0.46)	(0.97)	(1.21)
No prior WFH experience		0.01		3.65^{**}
		(0.54)		(1.70)
WFH score		−0.65		-19.99^{**}
		(3.94)		(7.88)
Further controls (gender, age, sector)		X		X
χ^2	0.18	5.97	0.7	14.85^{**}
Pseudo R^2 (Nagelkerke)	0.0	0.04	0.02	0.35
Observations	185	185	34	34

Note: All regressions use probit specification, weighted for design effects.
Standard errors in parentheses. $^{*}p<0.1$; $^{**}p<0.05$; $^{***}p<0.01$

Table 2.4: ***Probit model results, employee performance as a function of teleconferencing and prior experience.*** *Source: own work.*

were changing, managers need time and contact to explain those tasks and set expectations towards the employees, continued feedback, when establishing the new work task is likely also helpful. If these measures were missing from the side of the management, employees were likely to feel lost and may have had issues to carry out the assigned tasks sufficiently.

The fact, that we find no significant effect of the more frequent communication in the subsample where tasks have not changed signals something else. If *professional isolation* would have led to a lower performance, we would have expected this subsample to report a weaker performance as well, conditional on their levels of communication. However, we offer an explanation for why this might not have been the case: (1) the survey has been conducted in a relatively early period of the pandemic (March 2020), it could take time for professional isolation to build up and have an impact on performance. This would mean that in this sample, we do not yet see the effect of professional isolation, but we do see the effects of confusion from employees taking up new tasks without sufficient support.

2.8 Conclusion

Stay-at-home policies provide a means to fight the virus, but they also come at a cost. Working from home is not possible for many employees and in many occupations. In this paper, we presented a simple occupation level WFH index based on CEDEFOP's Skills Panorama data. Using survey data collected among Hungarian employees with tertiary education during March-April 2020 we showed that the WFH index is an acceptable predictor of WFH probability. However, previous experience with WFH can be an even better predictor.

We have also proposed that WFH, even if possible, can have an effect on employee performance. Using the aforementioned survey data we have shown in the paper that this is indeed the case. Not having prior WFH work experience or significant changes in the tasks being done can cause employees to perform weaker. However, we have also seen that support from the employer, such as sufficient equipment, can decrease the probability of this performance loss.

Furthermore, we have shown that actions of the management matter even more in the case where employees face as significant change in their tasks. Analysis of subsamples of the data suggest that in these case, more frequent communication can help avoid a weaker job performance.

Based on these results, we believe that although WFH is possible - and its feasibility is related to those factors that are represented in our WFH index - not all WFH experiences are the same. Those who had previous experience with WFH are taking this obstacle easier, as well as those who are supported, technically and through more frequent communication, by their employer. Which brings us to a point that should be important for employers even in "normal times": those employers who allowed their employees to try out working from home before the pandemic seen a lesser drop of productivity now. Meanwhile, the findings suggest that if a reorganising of work tasks is necessary, increased communication can help to align expectations and maintain job performance.

3

Firm Behaviour and Performance in the Pandemic

The chapter discusses how the COVID-19 pandemic has impacted firms' performance in the two years that we can consider the height of the pandemic: 2020 and 2021. We subsequently shift our perspective from people to groups of people working together - organisations. We also shift our perspective in a temporal manner: while in Chapter 2 our focus was on the early days of the pandemic now our investigation looks a bit farther ahead. The chapter builds on research that has started before the pandemic: the data collection on firm characteristics by the Competitiveness Research Centre (CRC) at Corvinus University, which was later extended by financial data of the surveyed firms, reaching into the years after the pandemic. This is the setup that has enabled us to study the effects of the pandemic on a sample of Hungarian and to investigate how different firm characteristics, including management directions have influenced resilience during and after the pandemic. Material presented in the chapter has been published in Hungarian in Közgazdasági Szemle (Economic Review - monthly of the Hungarian Academy of Sciences) as *Kiss-Dobronyi, B., Czakó, E., and Losonci, D. (2024), "Menedzsmentgyakorlatok és a hazai vállalatok árbevétel-változása a COVID-19 jelentette gazdasági sokk idején [Management practices and changes in turnover of domestic firms during the COVID-19 economic shock]", Közgazdasági Szemle (Economic Review - Monthly of the Hungarian Academy of Sciences), Vol. LXXI No. 3, pp. 229–254.* The dissertation author's contributions were (CRediT): Conceptualization, Methodology, Formal analysis, Writing - Original Draft, Visualization.

3.1 Background of the chapter

Research into the competitiveness of firms, management practices and the relation of various firm characteristics to outcomes has been ongoing for years as part of the research program of the CRC of Corvinus University of Budapest (Chikan et al. 2019; Chikán et al. 2019). In the latest wave of this research program survey data has been collected on various characteristics of Hungarian firms in 2018-2019. We have been already analysing this data for the purpose of better understanding firm competitiveness and the relationships between management practices and performance Chikán et al. 2022a when the COVID-19 pandemic hit in 2020.

Discussions at this point, however, resulted in the realisation that given the data have been collected before the pandemic, but we are able to link post-pandemic financial accounts to the firms surveyed, we have at our hands a dataset that can be used to investigate how resilience of the firms were connected to certain characteristics. Suffice to say this was not an easy task, especially, because we were not looking at the data to confirm or reject a single hypothesis and at the same time our data has included a very granular picture of these firms, with over 2000 variables capturing answers to a variety of survey question reflecting a wide-array of firm differences. What we wanted to capture - using our pre-COVID characteristics and our post-COVID financial results - were those factors that were crucial in explaining performance differences.

3.2 Introduction

A recurrent question in economic and business research (e.g., Bloom et al. 2013; Bloom et al. 2010; Bender et al. 2018) is whether and how management practices impact performance of firms. Does different management directions, styles and practices lead to differing measurable outcomes? We address a small slice of this question: what management and firm characteristics make a difference in outcomes during an unusual shock, a crisis. We do this, by employing data collected before the COVID pandemic on firm and management characteristics, as well as financial performance, and data collected on the financial performance of the same firms after and during the pandemic.

The rest of the chapter is organised as follows: first, the third section reviews the relevant literature, we focus on Hungary because that is where our data comes from; the fourth section describes our data, while the fifth section describes our method for deriving an *expected performance* from historical data and the sixth describes our method for linking differences between *expected* and *observed* performance to management practices. The seventh section presents the results, while the eight section discusses the results considering what we know about Hungarian firms, finally the ninth section concludes.

3.3 Review of the literature

Much have been written as soon as 2020 about the impacts of the COVID-pandemic (for some comprehensive works see Kolosi et al. 2020; UNCTAD 2020; Palócz et al. 2020, see also Chapter 2). Our focus lies on Hungarian literature, as our sample of firms is a Hungarian sample. Undoubtedly, the pandemic has caused an unmatched economic shock, challenging international organisations, governments, firms and employees alike. Furthermore, the economic shock has been extraordinary, not just in its magnitude but also in its nature. It was a combination of both supply- and demand-side economic shocks (Pollitt et al. 2021). On the demand side we have seen depressed consumption - partially driven by government action to curb the spread of the virus. While on the supply side we have felt the impacts of disrupted supply-chains and limited production capacities.

This unexpected economic shock has motivated research all around the world, including Hungary. Effects on employment (Drabancz et al. 2021; Köllő et al. 2021), performance of companies (Köllő et al. 2021; Szeiner et al. 2023; Éltető et al. 2023; Pogácsás et al. 2023), organisational and management reactions (P. Juhász et al. 2021; Olasz 2022; Sass et al. 2022; Pogácsás et al. 2023) or needed operational practices (Olasz 2022, Chapter 2) have all been studied. Based on these research, it can be stated that Hungarian firms had to deal with a substantial vis major impact during (and after) the pandemic. Firms have been affected by supply-chain disruptions, have lost revenue, while their costs have generally increased (P. Juhász et al. 2021; Szeiner et al. 2023; Pogácsás et al. 2023). Nevertheless, according to results from qualitative studies, laying off people (even in this situation) was seen as a last resort (Sass et al. 2022). Still, during the pandemic employment has substantially decreases (Köllő et al. 2021), which was only made worse by limited financing opportunities (Drabancz et al. 2021).

Further studies focusing on Hungarian firms have found heterogeneous effects. Industry or economic sector of the firms have been, understandably, the most important factor (Pogácsás et al. 2023; Sass et al. 2022), with ownership and export capabilities shown to be substantial factors as well (Köllő et al. 2021). While the study (Köllő et al. 2021) showing the effect of ownership and export capabilities have not considered sectoral differences, it did show a stronger revenue decreases for firms that are foreign owned and export oriented.

Organisational responses to the crisis have also been analysed. Sass et al. (2022) researched the reactions of foreign owned firms who operate in Hungary. In their interpretation while the pandemic has not changed general organisation practices, it did drive these corporations to introduce various measures in response to the crisis. Then some of these practices (e.g., working from home) became the *new normal* and have been accepted as normal operating procedures. Meanwhile, P. Juhász et al. (2021) highlighted how management perceived the need to react: the altered requirements of managing and leading created new challenges, with the need to support employees and to keep collegial relationships alive adding more pressures to the managers (the need for this highlighted in Chapter 2). Similar problems are emphasized by Éltető et al. (2023) and Olasz (2022): lack of in-person connections and related managerial challenges, the issue of integrating new hires were very much issues specific to the pandemic situation.

A frequently noted issue in the literature, the role of digitalisation. Multiple studies have argued that the ICT capability of firms was a primary factor of resilience against the pandemic. The underlying assumption was generally this: given a high ICT capability, firms are likely to be able to maintain at least some of their activities digitally, therefore overcoming several limitations coming from the pandemic (P. Juhász et al. 2021; Sass et al. 2022; Szeiner et al. 2023; Éltető et al. 2023; Pogácsás et al. 2023, see also Chapter 2). This has been especially the case in firms where *working digitally* or working from home has been standard operating procedure even before the pandemic (Olasz 2022). In these firms, it has been easier to adapt to work from home practices (see Chapter 2). Nevertheless, the role of digitalisation is uneven across the full spectrum of employees, as it is noted by Köllő et al. (2021).

Now, it has been a longstanding aim of firm competitiveness research to provide insights on the role of management towards better firm performance, and through that better economy-level and national competitiveness Chikán et al. 2018. As part of this research program multiple studies adapted the resource-based view of the firm (J. Barney 2021; J. Barney 1991; J. B. Barney 2001; Peteraf et al. 2003): Chikán et al. (2009) and Chikan et al. (2019) used this approach for constructing their firm survey. Analysis of data collection in these studies has shown a relationship not only between managerial practices and competitiveness, but also the capabilities of functional areas within the firm and overall competitiveness (Chikán et al. 2022a). Nevertheless, until 2019 the relevant surveys focusing on Hungary, compiled by the Competitiveness Research Centre have not included financial accounts of the surveyed firms. In the latest wave of the research program, however, this has changed (Chikán et al. 2019; Chikan et al. 2019). Furthermore, given that the NACE sectoral classification of the firms' economic activity [1] is available in the data we can compare financial data of the sample to financial data from other sources (including HCSO and Orbis).

This latest wave of the CRC data set therefore enables us to connect pre-pandemic firm characteristics to post-pandemic financial outcomes. In this chapter therefore we analyse how the variance of management practices and characteristics influence the firms' performance and their resilience to shocks. The temporal setup of the data collected also enables us to elaborate on the direction of the effects, given *time precedence* of the data collection on firm directions and management practices compared to outcomes. This also hints us to understand relationships measured here as weakly causal (Keith 2019), given that we can infer that the outcome is unlikely to change the observed characteristic (as it was observed years earlier).

Overall, however, as it was stated before, we aim to conduct an exploratory study, without having strong hypothesis about the relationship between certain management practices and financial outcomes. Our approach is data led: we use a large subset of the more than 2000 total variables in the CRC survey to highlight those factors that did influence financial performance of the studied firms.

3.4 Data sources

We connect a total of four different data sources for the analysis. Data on management practices and firm characteristics are obtained from the CRC data collection's latest wave, with survey collection finished in 2019. We have connected financial accounts to these firms from the Bisnode database for years 2014-2020. Furthermore, we have added sectoral averages based on data from HCSO and Orbis Europe data. For an overview of the data sources and their linkages see Figure 3.1.

3.4.1 CRC and Bisnode data

As discussed, to obtain data on management practices and directions of Hungarian firms, we have used data gathered by the CRC of Corvinus University of Budapest. The survey process, that has ended in 2019, covers more than 200 Hungarian, mostly medium-sized enterprises. Variables primarily capture perceptions and statements of the top management about the practices, aims, strategy and performance of the firms, while it also includes more objective statements as well (Chikan et al. 2019). Importantly, the data set includes 4-digit TEAOR (corresponding to NACE) codes for the firms, defining the economic sector that they are active in (Wimmer et al. 2021), this also allows us to link the data to sectoral statistics. Notably, the targeted sample of the original survey is representative to the Hungarian economy in terms of size and sectoral composition (Chikan et al. 2019). Given that the dataset collects responses not just from the CEO of these companies, but often from functional managers and tries to build a comprehensive view of the firm, this dataset has been used

[1] Actually, the dataset contains the TEAOR classification of the firms, which is the official Hungarian sectoral classification mostly corresponding to NACE.

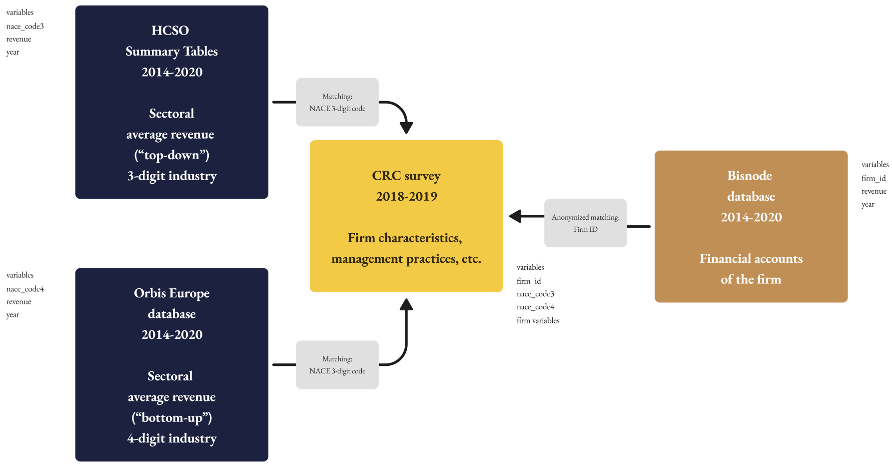


Figure 3.1: ***Data sources used and relationships between them.*** *Source: own work.*

in a variety of studies to investigate the behaviour of Hungarian firms. These include the role of functional capabilities on firm-level competitiveness (Chikán et al. 2022a) or the role of innovation (Kiss 2022), digitalisation (Hartvig et al. 2023). There are two reports focusing on the descriptive characteristics of the dataset: Chikan et al. (2019) and Wimmer et al. (2021).

It needs to be noted, that given the setup of the survey, most of the answers captured are perceptions of how the managers see their firms. This inevitably means that there might be an uncaptured bias introduced by intention or by mistakes. Most of the question are defined on a Likert-scale, while some questions require binary (yes/no) answers. There are some, albeit less frequent, free text and numerical questions as well. In our study, we focus on the former, ignoring questions that have less standardised answer options (former). As depicted on Figure 3.1 the database of survey responses from the CRC data collection have been enriched with financial accounts data obtained from the Bisnode database (as described in Wimmer et al. (2021) too). While the original enrichment only added financial accounts for the period 2014-2019, we have extended the time-series of the accounts to 2020 to be able to investigate the impacts of the pandemic.

Bisnode was a company offering decision support and firm information services. For the CRC data collection, the research team has been in contact with Bisnode Hungary, who agreed to enrich the survey data with data from their firm database that included financial accounts for the targeted firms. The parent company of Bisnode Hungary has been acquired by Dun & Bradstreet around 2021, which led to the Hungarian branch becoming a part of Dun & Bradstreet as well.

3.4.2 HCSO and Orbis datasets

As stated and depicted in Figure 3.1 we further complement the existing CRC and Bisnode dataset with sectoral statistics. These are compiled from the HCSO Summary Tables and Orbis Europe databases. We use both datasets to define an *average performance* at the sectoral level. The two datasets allows us to have to slightly different approaches: a *top-down* approach based on the HCSO Summary Tables and 3-digit industry classifications and a *bottom-up* approach based on the Orbis Europe firm-level data and 4-digit industry classifications. In the former we use the pre-calculated sectoral averages as an anchor, while in the latter we calculate sectoral averages from the available firm level data (within a 4-digit economic sector).

The *top-down* approach is based on the HCSO Summary Tables. We use the dataset called *Annual economic structure data by firm-size (legal entities)*[2]. This dataset contains summarized revenue statistics for the 3-digit economic sectors in the Hungarian economy for the years in question.

Meanwhile, for the *bottom-up* approach we utilise data for Hungarian firms from the Orbis Europe database. We create 4-digit sectoral summaries, including only Hungarian firms, who were active between 2014-2020 and had at least 50 employees in 2018. We ensure that the size of the firms are in line with the size of the firms in the CRC sample: we exclude micro-enterprises and firms with over 1000 employees. To avoid bias introduced by having too few observations for a 4-digit industry, we further exclude economic sectors where we have less than 4 firms in total.

> The **Orbis Europe** database is a global database of company information that includes data on both public and private companies. While according to existing studies it does not provide full coverage of the economy, it performs reasonably well in developed countries, with data quality and volume increasing over time. (Bajgar et al. 2020)

Note that this means that we obtain two separate sectoral average revenue time-series. The *top-down* approach captures the whole economy (i.e., no data gaps) it will not represent differences within the smaller sectoral segments (as it is defined for 3-digit sectors), meanwhile the *bottom-up* approach might have incomplete coverage (as Orbis does not necessarily cover the full economy, see Bajgar et al. 2020), but the firms that *are covered* are much more similar in terms of economic activity to our firms in the original CRC sample. Therefore, we will use the two indicators in parallel to provide robustness to our estimations.

3.5 Estimating the expected revenue on a sectoral level

Our aim is to investigate those management practices that differentiate firms in a way that they end up having different impacts on their performance outcomes. Our methodology is the following: we create variables of *expected revenue* based on the connection we observe between firm-level revenues and relevant sectoral revenues in the past. Then we identify firms which, during the pandemic, have produced revenue numbers that are substantially different from what is their *expected revenue*

[2] In Hungarian: *Éves gazdaságszerkezeti adatok létszám-kategóriánként (jogi egység szinten)*, at the time of writing (2024/9/11) can be found at https://statinfo.ksh.hu/Statinfo/QueryServlet?ha=YE302

number, based on how the overall sector has responded. Finally, we identify characteristics and practices in which these firms might diverge from others in the sample population.

In the followings we described our logic behind the selection of the variables and the overall methods as well as the practical steps of the analysis. Changes in firm performance are generally measured with a change in a financial outcome variable. However, our study uses revenues as the main dependent variable to measure performance on. This is similar to the approach taken by Köllő et al. (2021), where the authors note that revenue can be a reasonable indicator of firm performance in this case, because there is a strong correlation between revenues and intermediate input costs and this strong correlation is unlikely to have changed substantially in the year when the shock has happened, which means that changes in revenue are likely highly correlated with changes in value added at the firm level.

As for the practical steps of the estimation: we estimate expected revenue based on time-series of historical revenue for the firm in question and well as its relation to sectoral average revenue. Expected revenue for the year 2020 is modelled with an ARMAX or ARIMAX approach (Rob J. Hyndman et al. 2008; Rob J Hyndman et al. 2018). The applied ARMAX model is shown in Equation 3.1, while the applied ARIMAX model is shown in Equation 3.3.

$$y_i = \beta_1 x_1 + \phi_1 y_{t-1} + \cdots + \phi_p y_{t-p} - \theta_1 z_{t-1} - \cdots - \theta_q z_{t-q} + z_t \tag{3.1}$$

which can be rearranged as

$$\phi(L) y_t = \beta_1 x_t + \theta(L) z_t \tag{3.2}$$

leading to the ARIMAX model, such as

$$\Delta^d \phi(L) y_t = \beta_1 x_t + \theta(L) z_t \tag{3.3}$$

In the estimation y_t being the firm's t period performance indicator (revenue), the standard Autoregressive (AR) integrated (I) moving average (MA) (ARIMA) model is extended with the impact of an exogenous variable ($\beta_{i,1} x_t$), where the exogenous variable is the average revenue observed in the firm's sector (x_t). Other parts of the equations are in line with the standard model specification: p is the order of the autoregressive model, q is the order of the moving-average model, while (in the case of ARMAX) d is the degree of differencing. Furthermore, $\phi(L)$ is the autoregressive, while $\theta(L)$ is the moving average part of the equation, where L is the lagged variable. From the outcome of the equations we name for firm i the t period predicted value $\hat{y}_{i,t}$.

The ARIMAX model that we specify for each of the firms in the sample is done by using the implementation of Rob J. Hyndman et al. (2008) of the R *auto.arima* function. The algorithm minimizes the Bayesian Information Criterion (BIC) in order to select an efficient specification. Based on this we keep a specification (which can be ARMAX or ARIMAX) for each of the firms in the CRC sample. Individual specifications are shown in Table B.15 of Appendix B.

However, as we do not expect the models to give us a robust point estimate of expected revenues (nor this is our purpose) we use the error terms of the estimations to specify an interval of expected revenues:

$$\sigma(\epsilon_{i,1}, \epsilon_{i,2}, \ldots, \epsilon_{i,t-1}); \mu(\epsilon_{i,1}, \epsilon_{i,2}, \ldots, \epsilon_{i,t-1}) \rightarrow N(\mu, \sigma) \tag{3.4}$$

$$\hat{y}_{i,t}^{max} = \hat{y}_{i,t} + \hat{\epsilon}_{i,95} \tag{3.5}$$

$$\hat{y}_{i,t}^{min} = \hat{y}_{i,t} + \hat{\epsilon}_{i,05} \tag{3.6}$$

where $\hat{\epsilon}_{i,95}$ is the 95. percentile of $N(\mu, \sigma)$ distribution, while $\hat{\epsilon}_{i,05}$ is the 5. percentile of the same distribution. With this, we aim to estimate an interval of *expected revenues*. The process and its outcomes are illustrated in Figure 3.2.

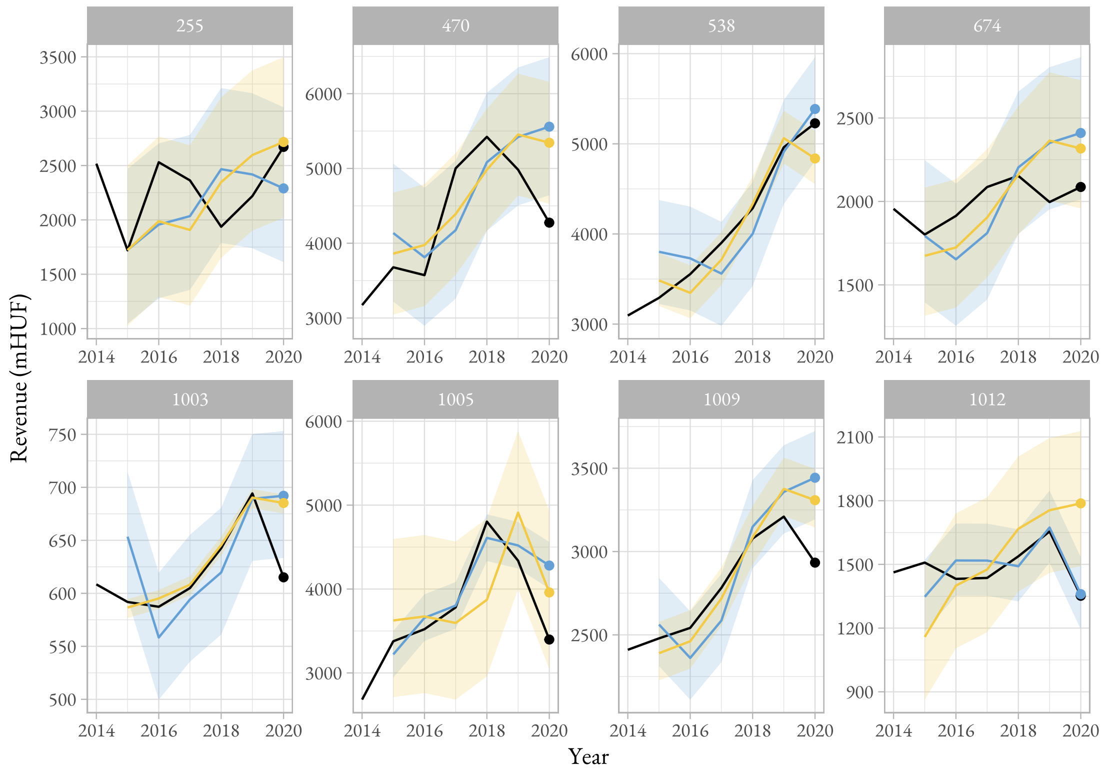


Figure 3.2: ***Predicted and observed revenue in a sample of firms.*** *The observed revenues are shown as a solid black line, while the predicted revenues are shown with coloured lines. The HCSO data based predictions are shown with blue, while the Orbis data based predictions are shown with yellow. A "confidence interval" of probable revenue outcomes has been defined for both estimations based on error terms derived from the historical data. This is shown with a semi-transparent are around the coloured lines. Numbers above the figures show a randomized ID for the individual firms. Source: own work.*

The intervals that we obtain from this estimation process make the assumption that the relationship between the performance of the sector and the performance of the firm are stable over time. Basically, we capture how much the firms' outcomes were sensitive to outcomes at the industry level, and then assume that this sensitivity has not changed during COVID. We create the *expected revenues* intervals with this in mind, using both sectoral average performance (i.e., how much the *sector* was impacted by COVID) and time-series of the firms' own performance. If the *observed performance* of the firm stays within the *expected interval* it means that the firm's performance was impacted by the pandemic *about as much* as the next firm in the sector. However, if the observed performance is outside of the expected interval, it means that the firm has performed substantially worse than what was expected from them based on their own trends and how much their sector has been impacted.

Due to data gaps, and the restrictive sectoral specifications covering three different data sources (we need to be able to produce predictions from Bisnode, Orbis and HCSO data as well) the process yielded 58 firms who we have complete data for. Out of which 45 firms produce revenue within their *expected intervals* in 2020, while 9 produced worse and 4 better revenue numbers. In the rest of the chapter we focus on the difference between firms who performed *within the expected interval* and firms who performed *worse than expected*. Unfortunately, we need to ignore the better performing group, given the very small observation number.

3.6 Analysing the role of management and leadership practices

As discussed, we analyse differences of managerial practices between firms classified based on their performance in the *worse than expected* and in the *within the expected interval* groups. Due to the low number of observations and the ordinal or categorical nature of the variables, we apply two appropriate methods: the Fisher's exact test and the Cochran-Armitage test (Agresti 2010). Fisher's exact test is used for analysing contingency tables, this means that the method will treat the included variables as nominal (categorical) variables. This method, therefore, discards information about the ordering of the responses, such as those captured in a Likert-scale, this inevitably leads to loss of information. However, this method does not rely on restrictive assumptions, and it is a precise and robust method, which is particularly valuable for our binary (yes/no) variables. Further, it is a non-parametric method, which calculates probability (p-values) without *estimating* parameters. As Agresti (2010) describes it: based on the row- and column totals of the table (*contingency table*) we derive a hypergeometric distribution, which is independent of probabilities in rows and columns. Following this, the probability that a given table follows the observed figures, can be calculated such as:

$$\frac{(\prod_i n_{i+}!) \times (\prod_j n_{+j}!)}{\prod_{i=1}^{r} \prod_{j=1}^{c} n_{i,j}!} \tag{3.7}$$

Meanwhile, the Cochran-Armitage test is developed for analysing ordinal variables. It is aimed at contingency tables, which contain two nominal and multiple ordinal values (Agresti 2010). Therefore, the test fits well to the Liker-scale questions from our dataset. The null-hypothesis of the Cochran-Armitage test is that there is no linear relationship between the ordered categorical variable and the binary variable. In our case, the Likert-scale answers (which are ordinal) will be the categorical and the group affiliation (*worse* or *expected* performance) will be the binary variable.

Using these two methods, we analyse answers to questions asked in the CRC survey focusing on questions asked from the CEO of the firms. Altogether we test 317 variables this way, we exclude a total of 31 questions, given that the number of observations for these questions is less than 5 in at least one of the groups. We select those from the remaining questions where difference between the two groups (*worse* or *expected* performance) is significant at the 5% level in *both of the tests*. This yields a total of 12 questions. We analyse these questions further, as we suggest answers to these questions highlight significant differences between the group of firms performing as expected and the group of firms performing *worse than expected*. We report test results for all other variables in Appendix B in Section B.5.

3.7 Results - management practices of firms performing *worse than expected*

Questions include from the CRC database in the analysis cover seven separate areas:

1. Characteristics of the firm, internal capabilities
2. External environment of the firm
3. Strategy
4. Organisational and leadership structure
5. Leadership style
6. Human resources management
7. Decision support and controlling

Our method of analysis, discussed in the preceding section, has compared questions for the two groups for a total of 286 variables covering these areas. While we have found a robust difference between the groups in 12 variables, we also *have not found* a significant difference for the remaining 274 variables. Those 12 variables were we have detected a substantial difference are from six separate areas, we did not find a difference in the *7. Decision support and controlling* area. Test results for the remaining variables are reported in Appendix B, Section B.5.

The variables where we have identified substantial differences can be grouped into four categories:

- Firm characteristics
- Environmental protection
- Employees
- Management practices

Table 3.1: *Questions, scales and descriptive statistics for questions with significant differences between groups performing weaker and as expected. Source: own work, based on the survey design of CRC.*

Question code	*Question*	*Scale*	*CRC survey area*	*Category*	*p-value*		*Mean*	
					Fisher	*Cochran-Armitage*	*Expected performance*	*Worse performance*
V4b	The owner and/or their family member(s) are actively involved in the company's management.	1 - Yes, 2 - No	*(I)*	**Firm characteristics**	0.02	0.01	1.6	1.12
V13f	What business risks do you perceive in relation to your company? **financing sources, credit, loan opportunities**	1 - Not Important 3 - Moderately Important 5 - Very Important	*(II)*		0.05	0.04	3.02	2.11
V42d	How important is the influence of the following groups or organizations on your company's environmental practices?	1 - Not Important 3 - Moderately Important 5 - Very Important	*(IV)*	**Environmental protection**	0.03	0.04	4.2	3.56
V43c	Does your company implement the following management practices? **Environmentally focused management system (e.g., ISO 14001, EMAS)**	1 - Yes, 2 - No	*(IV)*		0.06	0.04	1.51	1.89
V49h	If your company has a dedicated human resource management function or if there is an executive who handles this as part of their role, please assess the organizational contributions based on the following aspects: **The HR department operates systems that organizational members need.**	1 – Strongly Disagree 3 – Undecided 5 – Strongly Agree	*(VI)*	**Employees**	0.07	0.1	3.91	3.29
V50a	To what extent does the following capability contribute to the development of a competitive organizational culture in your company: **We hire people who, based on their past achievements, fit our organizational culture.**	1 - Strongly Disagree 5 - Strongly Agree	*(VI)*		0.08	0.09	4.64	4
V58a	How do you try to address labor shortages? **employee re-training**	1 - Never 3 - Sometimes 5 - Always	*(VI)*		0.02	0.08	3.3	2.38
V14b	Please evaluate the extent to which the following statements are true for your company: **Our company's goal is to maximize our profits.**	1 – Strongly Disagree 3 – Undecided 5 – Strongly Agree	*(III)*	**Management practices**	0.01	0	4.09	4.89
V32a	How applicable are the following statements to your company? **The company's management understands the digital challenges and opportunities facing the company.**	1 – Strongly Disagree 3 – Undecided 5 – Strongly Agree	*(IV)*		0.01	0.03	4.09	3.22
V47d	How important are the following behavioral and thinking patterns for an ideal leader? **(d) Performance indicators (KPIs) are just part of the leadership toolkit; it is necessary for leaders and employees to also own the goals.**	1 – Strongly Disagree 2 – Disagree 3 – Undecided 4 – Agree 5 – Strongly Agree	*(V)*		0.06	0.03	4.12	3.44
V47e	**(e) The leader's role includes professional guidance, precise direction, and supervision.**		*(V)*		0.05	0.03	4.36	3.67
V47g	**(g) The leader's responsibilities include emotional and professional support and development of their team members.**		*(V)*		0	0.01	4.1	3.33

Table 3.1 presents the questions and their classification in detail, furthermore it displays test results (Fisher, Cochran-Armitage) and mean values for both groups. It needs to be noted that we have also examined the differences between the two groups using additional descriptive indicators, but we did not find significant differences. Section B.1 in Appendix B describes these tests and their outcomes in detail.

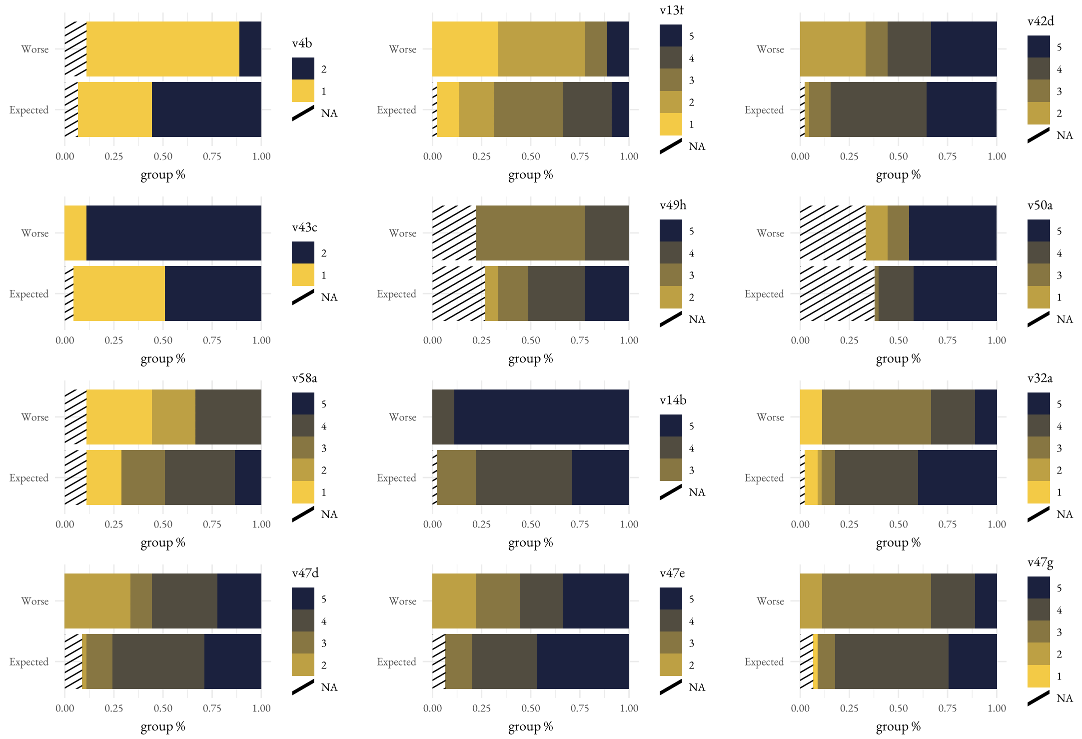


Figure 3.3: ***Distribution of answers for questions with significant differences between groups performing weaker and as expected.*** *Source: own work.*

Figure 3.3 shows the distribution of responses to the selected questions (where there are substantial differences) between the two groups.

In the category of Firm characteristics, we identify two variables that has different distributions in the two groups: in the *worse* performing group we have a higher number of family firms, with family members taking an active role in operations (v4b), at the same time there is a lower risk perception in the *worse* performing group towards financing sources and loan opportunities (v13f).

The higher proportion of family businesses among the *worse* performing companies are easy to align with existing knowledge about family businesses in Hungary. Kállay et al. (2023) shows that Hungarian family typically have lower equity and profitability. Considering that the crisis has led to new and unexpected financing challenges (Drabancz et al. 2021) and an increase in costs (Pogácsás et al. 2023) it is conceivable that family business might had a hard time reacting to the effects of the pandemic.

The connection between the environmental protection variables and the outcome variable is less straightforward to explain. In the *worse* performing group we can observe a lower presence of environmental management systems (v43c), while the focus on consumer's environmental expectations (v42d) is also lower in this group. We posit that these answers are related, but we cannot assert that they are directly related to financial performance. Nevertheless, based on the existing literature (Diófási-Kovács et al. 2023) we note that digital readiness of firms can be correlated with environmental performance, which might point to the role of unobserved variables here.

The Employees category results are biased by a high non-response rate. However, based on the observed differences in the *worse* performing group re-training is less likely to be a response to employment issues (v58a) - while there is no difference in other methods (e.g., using temporary employees, migrant workers or aiming for efficiency gains). In this group the HR systems are less trusted by the CEO (v49h) and he/she in general thinks that hiring is *not* a primary factor in the firm's competitiveness (v50a). These results / answers are clearly linked to the leadership style of the CEO, which we will discuss next.

Finally, the Management practices category is not only where we have the most items, but also the most important, as it pinpoints many issues that can be clearly linked to the firms' resilience. First, in the group achieving *expected* performance there has been varying answers to the question whether the primary goal of the firm is profit maximization, reflecting more recent trends of stakeholder engagement and corporate value theories, meanwhile in the group achieving *worse* performance the answer was a unanimous 'yes' (v14b). Similarly, the *worse* performing companies reported to be generally less ready for digitalisation (v32a).

This is also the category, where we have observed multiple questions within the same question group producing significant differences between the two groups. The v47 question group, which asks about leadership behaviours and style, shows substantial differences in three separate items. This question group holds a total of 10 items, out of which we find some differences (at least one test indicates a significant difference) in a further two items, while we find no differences in the remaining five items. Figure 3.4 shows the distribution of answers across the two groups for all questions in the question group.

First, performance measurement is captured by the understanding and use of Key Performance Indicator(s) (KPI) (v47d) . Here, CEO's of the *worse* performing group - opposing the average opinion - think less that KPIs are just a communication tool, which need to be supported by *ownership* of the firm's goals by employees. The next question with a substantial difference (v47e) reveals that leaders in the *worse* performing group are less likely to believe that the leader's role involves professional guidance and supervision. Then, from the third highlighted question (v47g), it seems that they view providing professional and emotional support to employees as less of a leadership responsibility (this is where the most significant difference compared to the *expected performing* group is observed). It is also worth mentioning that in the case of questions v47a and v47i, Fisher's exact test shows a difference; however, this difference does not appear in the Cochran–Armitage test due to ordinal similarity. Nevertheless, observing the results of these question give some more flavour to the emerging picture of the leaders in the two groups. Question v47a is the question where the average score in the *weaker* performing group is higher, the statement here is that the role of the leader is to *"Clearly define goals, carefully monitor their implementation, and intervene when deemed necessary."*, most of the respondents in that group *strongly agreed* with this statement. Meanwhile, the

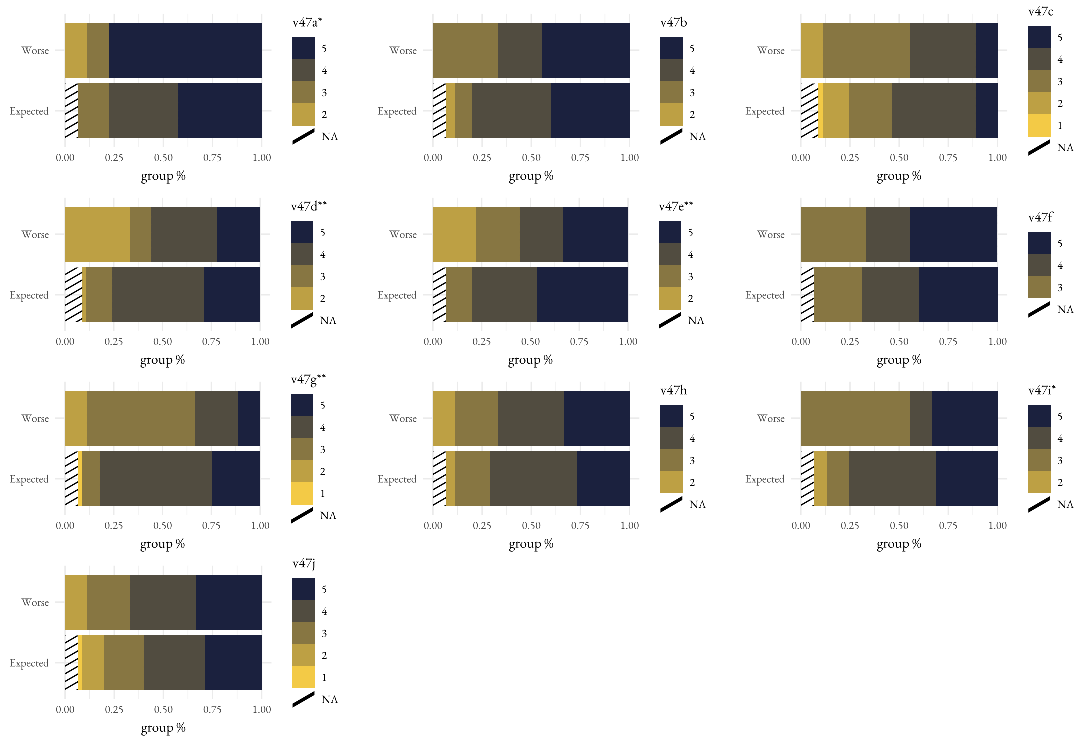


Figure 3.4: ***Distribution of answers for the v47 question group.*** *Source: own work.*

v47i questions ask about the necessity of building trust between the leaders and employees - here the *worse* performing group's leaders has generally given a lower than average score, indicating that they do not think that this is a core priority for leaders.

Table 3.2 compares two main leadership styles as formalized by Dióssy et al. (2023) in line with questions of the CRC survey. Viewing the results through the lens of this two-category classification of leadership styles our results point into the direction that leaders in the *worse* performing group generally prefer the *relationship-oriented* leadership style less compared to the *task-oriented* style - which is supported by differences in 4 items.

3.8 Discussion of the results in light of literature about Hungarian firms

The presented results — namely, that we observe differences in these variables after following methodological steps, without any prior theoretical expectations or selection — are particularly interesting because, for example, Dióssy et al. (2023), starting from the same dataset, highlight some of the same variables to investigate the relationship between leadership styles and digitalisation. In their research, based on Móricz (2022), they operationalize leadership attitudes that determine digitalisation and digital readiness, emphasizing question v32a as the most determining variable related to attitudes toward digitalisation strategy (0.927 factor loading). Furthermore, Dióssy et al. (2023) use the v47 question group to operationalize leadership styles. Their research (see Dióssy et al. (2023)) identify two distinct leadership styles: the relationship-oriented style, characterized by support and development of employees, openness toward them, and the prominent role of trust; and, the task-oriented

Table 3.2: ***Results for variables of leadership styles.*** *Based on the formulation of Dióssy et al. (2023, p. 10). Source: own work.*

Question code	In the *worse* performing group	Style item
Task-oriented leadership style		
v47a	higher (only Fisher)	Clearly defines goals, carefully monitors their implementation, and intervenes when deemed necessary.
v47h	no significant difference	The leader's tasks are largely focused on ensuring that employees perform their tasks as well as possible.
v47e	lower (both tests)	The leader's role is professional guidance, precise direction, and supervision.
v47c	no significant difference	KPIs are the primary tool for communicating the goals of the company towards employees and managers.
v47j	no significant difference	In the organization trust is based on monitoring and supervision.
Relationship-oriented leadership style		
v47f	no significant difference	The leader's role is to personalize the goals, lead by example, and motivate toward implementation.
v47g	lower (both tests)	The leader's responsibilities include emotional and professional support and development of their team members.
v47i	lower (Fisher)	Building trust is an important leadership task because it enables the creation of innovative solutions.
v47d	lower (both tests)	KPIs are just part of the leadership toolkit; it is necessary for both leaders and employees to have ownership of the firms' goals.
v47b	no significant difference	[*The leader*] Clearly and convincingly communicates the goals, discusses the tasks together, and entrusts the implementation to employees, who can turn to the leader if needed.

leadership style, which focuses more on tasks and goals in relation to employees (a top-down leadership style), working with strict deadlines and precise task allocation. Dióssy et al. (2023) also show that leadership styles can be measured in the questionnaire using the v47 question group.

However, it is important to note that these styles typically appear in some combination in leaders' attitudes. The results presented in Table 3.2 can be easily aligned with conclusions found in the literature. Regarding leadership style, Sass et al. (2022), while examining foreign-owned automotive and electronics companies, concluded that continuous communication with employees and increased employee solidarity were necessary crisis management solutions. Moreover, the issue of trust and loyalty became critical, especially in relation to remote work. Similarly, P. Juhász et al. (2021) identifies lower managerial self-confidence, the deterioration of collegial relationships, and the increased importance of paying attention to employees as management problems to be solved. As they put it:

> "*During the crisis managers need to manage not only tasks, but also emotions.*" (P. Juhász et al. 2021, p. 139)

The importance of leadership style during the crisis is further emphasized by one of their respondents, who they quote:

> "*adult-to-adult communication were necessary, however, this is not the standard way of*

communicating in many organisations“ (P. Juhász et al. 2021, p. 139)

Their research also highlights the increased importance of *authenticity* in leadership. Reviewing these conclusions provides insight into the connection between the weaker presence of relationship-oriented leadership styles and weaker performance during the crisis. Both P. Juhász et al. (2021) and Sass et al. (2022) show that competencies associated with relationship-oriented leadership (trust-building, communication, emotional leadership/support, authentic leadership) were essential components for crisis management. The absence of these qualities, as the results also suggest, led to poorer crisis management and, consequently, to worse outcomes.

It is also worth examining the relationship *between* those variables which found to be significantly differ between the groups. Figure 3.5 visually presents these associations, focusing on the strength of associations with coefficients above 0.3.

The relationships between the variables reveal a strong connection among the variables in question v47, as well as between variables v42d and v49h. Therefore, the responses to the key variables in question v47, along with the variables related to environmental practices (v42d) and HR (v49h), are correlated. A similar relationship is observed between variables v4b, v13f, v32a, v43c, v50a, and v58. This represents a connection around family businesses (v4b): the risk of credit opportunities (v13f), digitalisation preparedness (v32a), use of corporate governance systems (v43c), employee fit (v50a), and workforce retraining (v58a) are the interconnected variables.

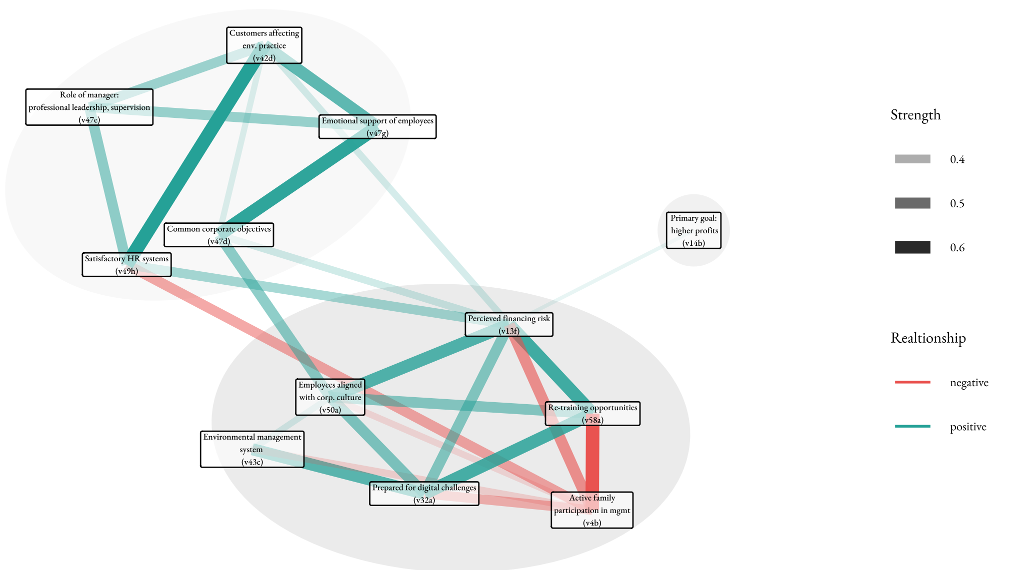


Figure 3.5: ***Strength of association between selected variables.*** *The strength of association between variables that show a significantly different distribution between the worse and expected performing groups. Only correlations above absolute 0.3 are shown. Source: own work.*

Interestingly, question v14b, which addresses the extent to which profit is a company goal, does not correlate with the responses to the other questions. We present correlations between all selected questions in Appendix B, Table B.2.

From these relationships, we observe the emergence of three distinct thematic areas. These partially overlap with previously established variable categories. In the management practices category, the v47 variables are not only theoretically interconnected but also in terms of the responses received, fundamentally capturing a leadership style. On the other hand, the variables categorized as firm characteristics and employees also correlate, describing certain types of companies. Finally, the issue of profit orientation (v14b variables) is empirically separate from the others. Overall, the results suggest that these three factors (which are largely independent of one another) need to be present simultaneously for *weaker* performance to manifest.

It is also important to revisit the areas where we found no significant differences. As previously noted, no significant differences are observed in the variables related to decision support and controlling (7. category). This result is intriguing as it seemingly contradicts findings by Szanto (2022). Szanto (2022) concluded from the CRC questionnaire that, according to managers' perceptions, intuitive/experience-based decision-making led to better adaptability during the 2016–2019 period. However, there are various reasons to suggest that this contradiction is only apparent. First, Szanto (2022) also describes that successful experience-based decision-making requires strong human capital within the company, a condition that is not clearly met by the weaker-performing companies we examined (see, for example, variable v50a). Furthermore, as Szanto (2022) points out, very few companies in the sample had managers who perceived their organization as poorly or inadequately adaptable during the 2016–2019 period, a time with far fewer shocks. Therefore, the differences observed here may be less predictive of a company's responsiveness in the face of a significant shock, such as the pandemic.

Based on the above, it's worth summarizing what we can learn from these results and the common characteristics we see among companies that achieved lower-than-expected revenues:

- There is a significantly lower presence of characteristic of a relationship-oriented leadership style (e.g., employee support, emotional support, adult-to-adult communication) in firms performing *worse* than expected.
- The leaders of these companies were much more likely to respond that their company's primary goal is maximizing profits.
- CEO's of these firms were much less likely to view recruitment as a strategically important issue.
- In the lower-than-expected revenues group the share of firms where owners and/or family members involved in management is higher.
- Before the crisis, these companies were less concerned about reduced credit opportunities and financing sources.

3.9 Conclusion

In our analysis, we examined the management practices and revenue outcomes of Hungarian firms covered in the Competitiveness Research Centre's 2019 survey database. Comparing their financial outcomes before and after the economic shock caused by the COVID-19 pandemic, taking sectoral performance and firm characteristics into account. Using time-series data at the firm and sectoral levels, we estimated the expected revenue for each company, assuming that the shock had the same impact on them as it did on other firms in the same sector/industry. Subsequently, utilizing the capabilities of the CRC 2019 database, we investigated whether there were common characteristics among the companies that achieved revenues *worse* than expected. We did not find statistically significant differences among 274 variables in the CRC database between the lower revenue, *worse* performing companies and the companies with expected revenues. We presented and interpreted the 12 variables (categorized into firm characteristics, environmental protection, employee and management practices categories) where significant differences were found.

A more detailed examination of these variables and categories revealed that companies performing *worse* than expected and generating lower revenues share certain characteristics and differ from the companies in the other group in important aspects. Among the underperforming companies, there is a significantly higher number of firms where the family owner and/or owner is involved in management. Leaders of these firms have also perceived their credit and financing risks as lower, while their management is strongly focused on maximising profits. Probably most importantly, we have highlighted significant differences in management styles: CEO's of the *worse* performing companies typically exhibit fewer relationship-oriented management practices. The leader considers goal setting as part of their responsibilities, while support, trust-building, and communication with employees are given less prominent roles. Employee selection is also not considered a strategic issue. Interestingly, environmental protection also emerged as a point of difference: leaders of these companies view customer demands for environmental protection as less important, and they also apply environmental management systems less in their companies. Finally, the leaders of these companies perceive lower digital readiness and attribute less significance to digitalisation.

This analysis is exploratory in nature, it does not aim to establish how these presented correlations emerge through specific mechanisms. Therefore, we do not attempt to decipher whether the greater-than-expected decrease in revenues results from supply-side, supplier-related, or demand-side, customer-related factors. However, the identified factors describe and illustrate a management style and firm characteristics that, we posit, are related to and may have contributed to the *worse*-than-expected performance. The assumption of a causal relationship is supported by the temporal precedence utilized in the research: the data on management practices and firm characteristics were collected well before the onset of the pandemic; thus we can assert that a reverse causality is unlikely: the reactions and weaker performance could not have caused the management responses.

From the previously described management practices, a picture emerges of a company and management that views employees more as production factors rather than as empowered and retained human resources (colleagues). Those firms that were unable to maintain their performance, as the rest of their industries, characterized by owner interference, yet they do not engage deeply in professional work and place the achievement of higher profits above other corporate goals. In this group, relationship-oriented management style traits are marginalized.

Addressing the shock caused by a health crisis specifically required the tools and solutions of relationship-oriented management styles: employee-employer relationships, and the role of trust between employees and employers, became increasingly important. At least as important were the capabilities and solutions related to digitalisation, given that during much of 2020, it was the companies capable of a rapid digital transition that managed to maintain their results. Nevertheless, uncovering the mechanisms behind these correlations need to be the subject of future research.

4

National Competitiveness Patterns and the Pandemic

In this chapter, after exploring how the pandemic has impacted people (Chapter 2) and firms (Chapter 3) in Hungary, we take another step back and look at the macro view. We investigate how the pandemic has impacted the competitiveness of nations and how different institutional systems in those nations have resulted in significantly different competitiveness outcomes. This chapter builds on ideas that have been developed over the years in the Competitiveness Research Centre (CRC) at Corvinus University, with the main framework of how people, firm and national competitiveness are linked in a single system conceptualised by Attila Chikan, Erzsebet Czako and their colleagues (Chikán et al. 2018; Chikán et al. 2009; Chikán et al. 2019).

This framework posits that national institutions, which often are represented in government policies and directions, are major drivers of competitiveness: mostly through shaping the environment that businesses operate in, but also through direct means. This is an idea that we aim to test and explore in the context of the COVID pandemic. In the chapter we first create clusters of countries, based on the types of policies (and the evaluation of those polices) that they have historically implemented. Then we look for groups who have had historically similar national competitiveness scores, but have adopted differing sets of policies and finally, we test how the competitiveness score of these groups have changed compared to each other. The question we ask, basically, is that given the same competitiveness level can be achieved with differing sets of policies in normal times, will a crisis change this? Our answer is that it does.

Material presented in the chapter has been published in Competitiveness Review as *Chikán, A., Kiss-Dobronyi, B., Homoki-Szabó, E., and Molnár, B. (2024), "Government influence on national competitiveness (evidence from the COVID era)", Competitiveness Review, 35 (6).* The dissertation author's contributions were (CRediT): Conceptualization, Methodology, Formal analysis, Writing - Original Draft, Visualization.

4.1 Introduction

Institutions matter, but they do not change overnight. As the COVID pandemic hit the world at the beginning of 2020 governments and businesses alike have certainly realised this. National institutions, norms and culture – which constrain government actions within boundaries – have driven potential responses in different directions, which resulted in different answers to the question: how well the national competitiveness and national economies can grapple with the shock that COVID meant?

In this article, we discuss the role of national institutions on competitiveness. We posit that national institutions, that are formed through long-term government policy, and that result in forward-looking government policy, influence how an economy works and can react to changes. We further suggest that there are different 'configurations' of government policy – and institutional setting – that can achieve the same level of competitiveness. However, these different 'configurations' can also influence other characteristics of the economies, i.e., how resilient they are to external shocks.

All governments aim to boost their country's competitiveness, or at least maintain it during emergencies. They have different strategies to do so, which are dependent on their institutions: some strategies focus directly on improving the population's living standards, while others take an indirect approach, aiming to enhance the economy's operational efficiency, which in turn, is expected to improve living conditions (shown later in Figure 1). The success of these strategies in increasing competitiveness largely depends on how well they align with the country's current situation and their institutional setting. Take for example Portugal and Poland, two countries which are both members of the EU, had similar competitiveness rankings in the last decade (in most years they are only 1-4 places apart in the IMD ranking). Yet, they have rather different policy-mixes and institutional systems. Poland ranks highly on economic performance, while Portugal less so, but compensates with a higher infrastructure score. This shows up in government policy 'configurations' as well: if we look at the IMD sub-pillar scores for government efficiency, compared to Poland, Portugal scores high on the societal framework indicator, but lower for the tax policy indicator. Despite these long-term differences, the two countries have generally maintained close competitiveness scores. They basically reached the same goal through different means. But when it comes to reacting to the shock of COVID, they have produced rather different outcomes: the gap between the two countries in the IMD rankings have increased to 8-9 positions (with Portugal taking the lead).

We aim to uncover and better understand this type of difference and its consequences. Our methodology involves analysing the IMD competitiveness rankings of 62 countries from 2010-2019 to form clusters based on long-term government policies. The study then looks at how these clusters fared during the years 2020-2022 during and following the COVID pandemic.

The rest of the article is organised as follows: following the literature review and the analytical framework; we discuss the empirical methodology and the IMD data used; then interpret the results and describe how resilience to shock were conditional on the institutional setting or on government 'configuration'; ending with conclusions.

4.2 Literature review

4.2.1 National competitiveness

Since the 1970s, 'competitiveness' has been a popular term in economics and economic policy, and the notion is still intensively studied today (Bruneckienė et al. 2023; Dabbous et al. 2023; Linsi 2020). Nevertheless, an agreed upon definition of competitiveness is still lacking, as the term is used with dif-

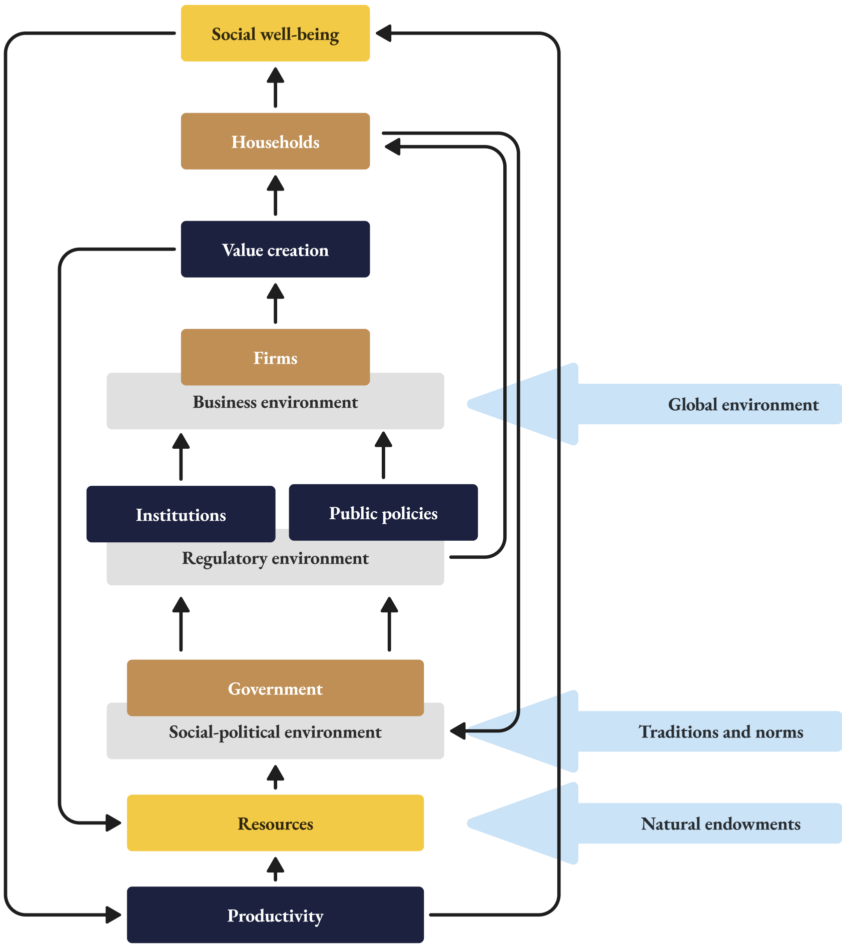


Figure 4.1: ***Framework for analysing national competitiveness.*** *Source: edited by the authors, based on Chikán (2008) and Chikán et al. (2018).*

ferent meanings, even in similar contexts (Aiginger et al. 2013; Benítez-Márquez et al. 2022; Buitrago R et al. 2023; Falciola et al. 2020; Kiseľáková et al. 2018). Initially, the debate centred on macroeconomic perspectives (Boltho 1996; Davies et al. 2000; Krugman 1994), but it has expanded to include national, state, regional, and firm levels (Buitrago R et al. 2023; Linsi 2020; Hodges et al. 2022). Our research (with a focus on the role of the government) is by nature at a national level, but pays attention to the structural components of the macro phenomena. Most scholars agree (Amaral et al. 2019) that the overall measure of macro level competitiveness needs to be some indicator of national development (Buitrago R et al. 2023), as it is insufficient to judge competitiveness from a solely economic point of view (Hodges et al. 2022). It is also probably the reason why competitiveness indices have enjoyed substantial popularity: they consider multiple aspects beyond the economic (Kaplan 2003; Oral et al. 1996). To analyse the competitiveness consequences of government policy, we elaborated on research that combines institutional and microeconomic approaches. Out of these two approaches, the related microeconomic approach (J. Barney 1991; Kor et al. 2004; Michael E Porter 2004; Michael E. Porter 1990) is far more established, but research on the role of institutions is also emerging (Aiginger et al. 2013; Buitrago R. et al. 2021; Campbell et al. 2007; Esser et al. 1996; Meyer-Stamer 2005; Park 2012; Pedersen 2010; Chisadza et al. 2021). For our analysis, we find Chikán (Chikán (2008)) the most appropriate framework. This model (detailed in Figure 4.1 and further elaborated in Figure A1 in the Appendix) is based on microeconomic and institutional theories. It defines national competitiveness as a nation's ability to produce, use, and sell goods and services in the global market, enhancing citizen well-being and resource yields sustainably, supported by favourable government conditions and incentives.

We further posit that there is a necessary precondition linking competitiveness to the performance of other factors of the national economy: a precondition of competitiveness is that the government provides favourable conditions and appropriate incentives for the effective use and renewal of resources. These conditions and incentives build a bridge between the macro- and microsphere, as well as between public- and economic policies. In the model, the two interconnected drivers of competitiveness are the well-being of the population and resource productivity, which are in continuous feedback. A definitive goal of the system is to increase the well-being of the population (which can be proxied as the collection of households), while households with high levels of well-being are expected to provide more productive labour for the economy. The three main sets of actors (households, firms, and government) are interconnected via the mechanisms of the markets and operate according to the logic of IO (Industrial Organisation) studies. The fundamental logic connecting the macro and micro sphere is based on the double value creation principle (Chikán 2008), according to which the purpose of firms in the economy is the simultaneous, interlocking shareholder value creation and consumer value creation. This principle connects the business sphere both with the social objective of well-being (via customer satisfaction) and with productivity (the effective use of resources). National competitiveness is also affected by external factors. Social norms and traditions and global economic changes, just like natural and geographical conditions, greatly influence the operation of national economies (see Lee et al. 2018). Within the usual framework of competitiveness analyses, these factors are less driven by individual national economies; therefore we treat these as exogenous factors. The main actor of institutionalized influence on society (and on competitiveness) is the national government, making analysing government behaviour/actions a convenient proxy for studying institutions' impact on factors of competitiveness. Main channels of impact are the economic and social policy measures of the government and their characteristics, and direct interventions of the state (Mazzucato 2021).

4.2.2 Measuring national competitiveness

To capture these factors and their contribution to overall competitiveness several indicators, mostly composite indicators, have been proposed. These indicators often combine "objective" and "subjective" data to present a comprehensive view of national competitiveness, employing both national statistics and survey-based methods. The most cited indices are those compiled by the WEF and IMD (Benítez-Márquez et al. 2022; Bowen et al. 2011; Buitrago R et al. 2023; Buitrago R. et al. 2021; IMD 2020; IMD 2021; Kaplan 2003; Kiseľáková et al. 2018; Kramulová et al. 2016; Oral et al.

1996; Schwab et al. 2020).

4.2.3 COVID as an external shock

Since institutions and their impacts usually do not change overnight, it is particularly useful if we can study a situation where an external shock interacts with the existing institutional system of the countries in question. The COVID-19 pandemic has been such a shock and, with its prolonged consequences, remains a key concern of policymakers as well as businesses (Barrett et al. 2023; Kiss-Dobronyi et al. 2023). Valuable research on the effects of COVID-19 related government interventions on competitiveness have already been published focusing on the importance of institutions (Chiplunkar et al. 2021), the effectiveness of national policies in given countries (Okhrimenko et al. 2021; Sharma et al. 2022), affecting specific industries (Salinas Fernández et al. 2022) and on upgrading the definition of competitiveness (Clinch et al. 2020). Compared to these works, this paper holds a more holistic approach, focusing on the effects on wider national competitiveness performance in interaction with institutions.

4.3 Methodology

4.3.1 Data used

This paper uses the IMD database, as it contains comparable data both before and after the pandemic. Since the focus is on the impacts of governments on national competitiveness during the pandemic, special focus is given to the government efficiency pillar of the database (for the contents of the government efficiency indicator see 'Government and Regulatory environment' row in Table 4.1).

4.3.2 Analytical approach

Our analytical approach employs the following steps: (1) we cluster countries based on the policy choices and performance of their governments in several dimensions in the decade before COVID-19 (between 2010-2019), to group similar government policy "configurations" together, (2) we analyse whether country groups with statistically similar competitiveness scores before COVID-19 but with different government policy configurations, have reacted differently to the pandemic, i.e., whether change in their competitiveness was dependent on the structure of how countries in the cluster are governed. We defined a configuration of government based on the countries' governments' performance on indicators representing fields of government performance. These indicators supply us with a basis for clustering (discussed in detail in the next section). Two essentially different configurations might be (i) a case where performance in social policy is strong, and tax policy is weak, while another might be (ii) a case where tax policy is strong and social policy is not so substantial. Figure C.1 in Appendix C shows how these steps relate to the overall model presented before. Relevant terms in the context of competitiveness metrics are used based on the IMD's definition (IMD (2021)). Importantly, our study is a post-study by design, with data collected in 2023. Historically, the pre-treatment period ('before COVID-19') covers the years 2009-2019 (inclusive). The "treatment" happens in 2020, and post-treatment entails data for 2021 and 2022. Whilst we admit it is

Table 4.1: ***Matching of the pillars of the IMD to the key elements of our model framework.*** *Source: own work.*

Corresponding pillars of the IMD competitiveness ranking	Key factors of our framework for analysing national competitiveness
Basic Infrastructure Domestic Economy Scientific Infrastructure Technological Infrastructure	**Resources**
Attitudes and Values Education Health and Environment	**Social-political environment**
Business Legislation *Institutional Framework* *Public Finance* *Tax Policy* *Societal Framework*	***Government and Regulatory environment***
Employment Finance International Trade International Investment Labor Market Prices	**Competitive business environment**
Management Practices Productivity and Efficiency	**Firms and Value creation**

hard to say we have fully got back to a post-COVID world by 2021, the key differences in government performance we are interested in materialized in the year of the treatment, allowing for considering 2020, 2021 and 2022 as post-treatment observation points. As it has been stated, in this paper we work with the national competitiveness indices compiled by IMD (2021). We make slight adjustments to the IMD scores (z-score transformation), to be able to treat them as a panel dataset (see further details in Section C.3 in Appendix C). As a first step of the analysis, we further transform the IMD overall national competitiveness score, to exclude the government efficiency sub-pillar as we want to use this sub-pillar as an independent variable (further details in Section C.4).

4.3.3 Clustering based on the structure of government efficiency

We posit that different structures ('configurations') of government policy can result in similar levels of competitiveness. While it has been shown that government efficiency in general is linked to overall national competitiveness (see Appendix 1.5 for details), there are multiple ways, i.e. multiple configurations of government structure, which can lead to similar overall outcomes (i.e., competitiveness score), but differing various important specificities. We use a K-means clustering algorithm (Hartigan et al. 1979) to generate country-clusters based on the average government sub-pillar scores of the countries through 2010-2019. We use the scores of all five sub-pillars of the 'Government efficiency' main pillar of the IMD scoring. To filter out annual fluctuations, we use average scores across the years in the sample. The five sub-pillars are: (1) Public finance, (2) Tax policy, (3) Institutional framework, (4) Business legislation, and (5) Societal framework (for our conceptual framework, see Figure A1 in the Appendix, for the structure of the IMD pillars see Figure A2). We choose five for the number of clusters based on minimum BIC-value across the possible cluster numbers (Schubert 2023). The five clusters are generated using the K-means method, with 100 iterations for the centre points, hence limiting the stochastic element in the final clustering (Broder et al. 2014).

4.4 Results

Results of the clustering can be seen below in Figure 4.2 and in Appendix 1.6. The figure shows the mean and standard deviation values of the clusters for 2010 and for 2019. Membership of the countries is listed in Appendix Table A5. Between the sum of squares to the total sum of squares, the ratio is 67.8%, indicating a sufficient fit.

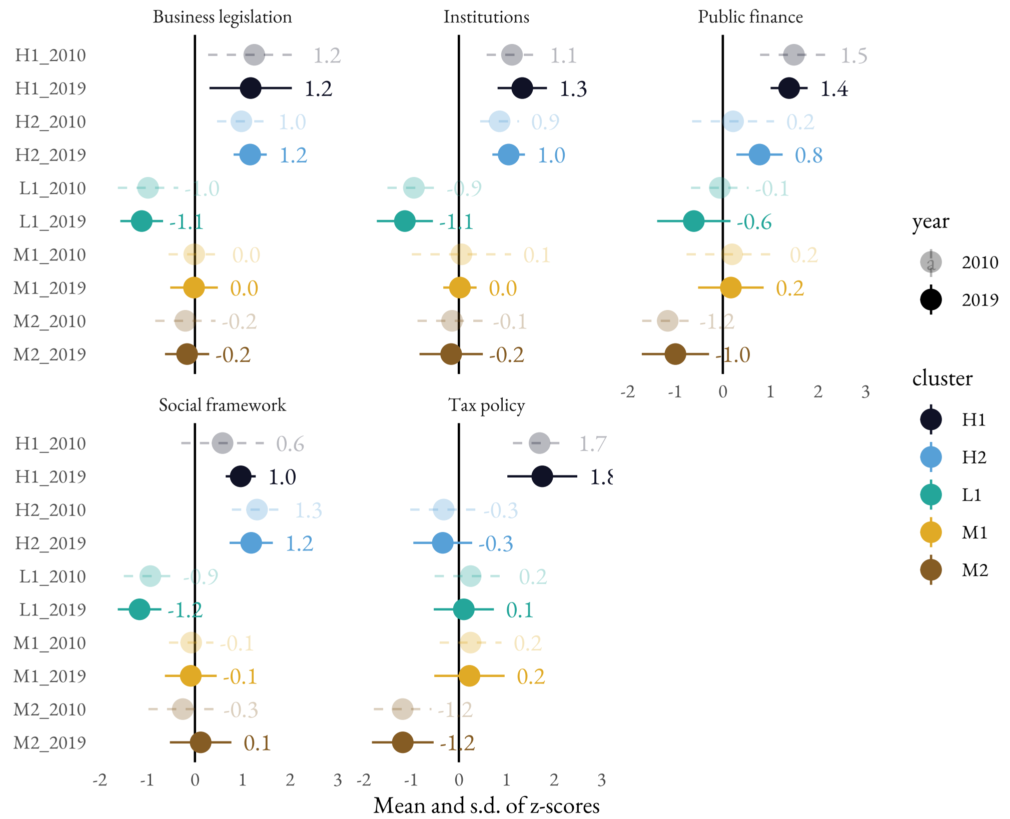
We name the clusters H1 and H2 (H standing for high), M1 and M2 (M standing for medium) and L (L standing for low), signalling the clusters' competitiveness qualification. We observe that:

- H1 consists of six highly competitive economies. They are all small, technologically advanced economies. The name of the group is: Small advanced economies.
- H2 is a cluster of the economically most developed countries with related cultures. We name this cluster Scandinavian, Northwestern European and Commonwealth economies.
- M1 includes Developed non-EU economies and East Central European economies. This is a very diverse group: one third is from northeastern European ex-soviet economies, one third from Southeast Asia and one third from the rest of the world, including the USA.
- M2 collects two culturally related groups and is named the Southern and East Central European economies cluster, with Japan being the exception.
- L1 is the most mixed group, consisting of the least competitive countries of the IMD sample. This is the cluster of Developing economies.
- It is important to note that the applied clustering approach created clusters consisting of culturally close subgroups of countries - see the Inglehart-Welzel Cultural Map's 2023 version (World Values Survey Association 2023).

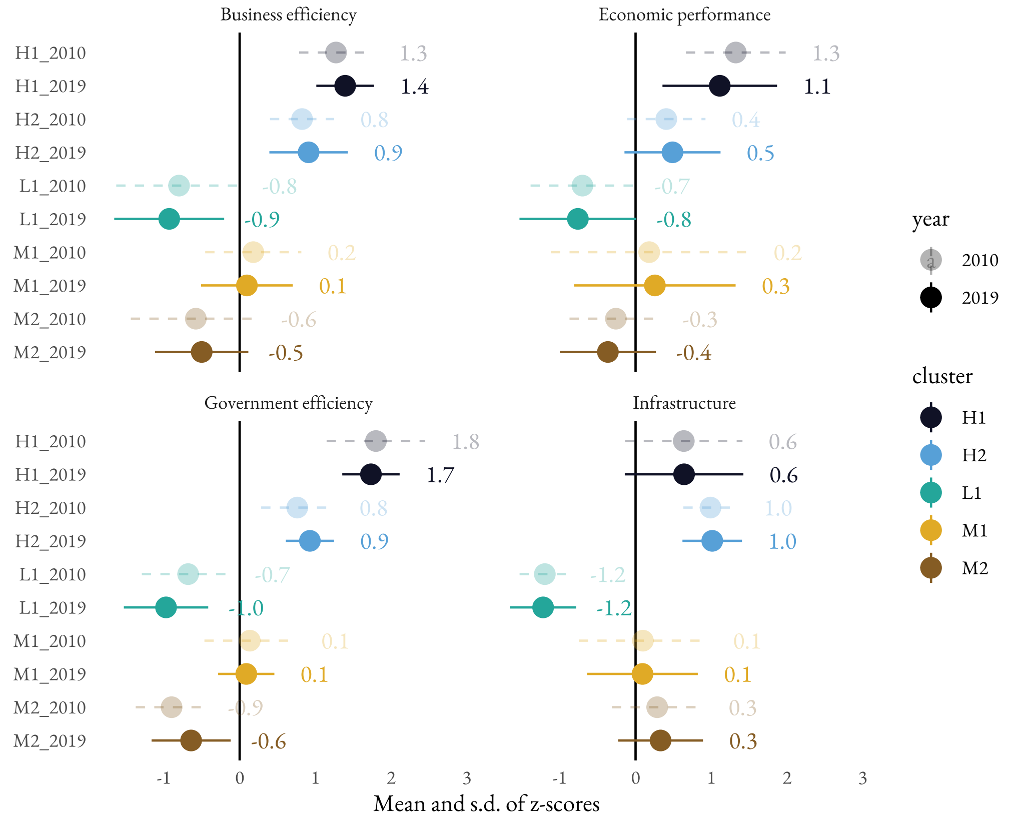
We then test whether IMD scores were similar in the past for the clusters. We do this for the IMD overall competitiveness without the government component indicator (IMD_constructed, for detailed discussion see Appendix 1.4). See Figure 4.3.

The left-hand-side axis indicates that with regard to the IMD_constructed variable, the difference between H1 and H2 and the difference between clusters M1 and M2, respectively, are not significant through all years (see Table A4 in the Appendix). This observation indicates that the clusters capture country groups where, as we have posited before, different government configurations result in similar competitiveness performance.

The two cases we identify are between clusters H1-H2, which are Scandinavian, Northwestern European and Commonwealth economies mostly in the EU (H2) and Small advanced economies (H1); and between clusters M1-M2, which are the Southern and East Central European economies (M2) and a mixed category, the cluster of the Developed non-EU and East Central European economies (M1). We note that cluster L1 is significantly lagging in terms of competitiveness. It is excluded from



(a) *Government component scores.*



(b) *IMD competitiveness component scores.*

Figure 4.2: ***Average and standard deviation of z-scores of IMD pillars in the clusters.*** *Source: own work.*

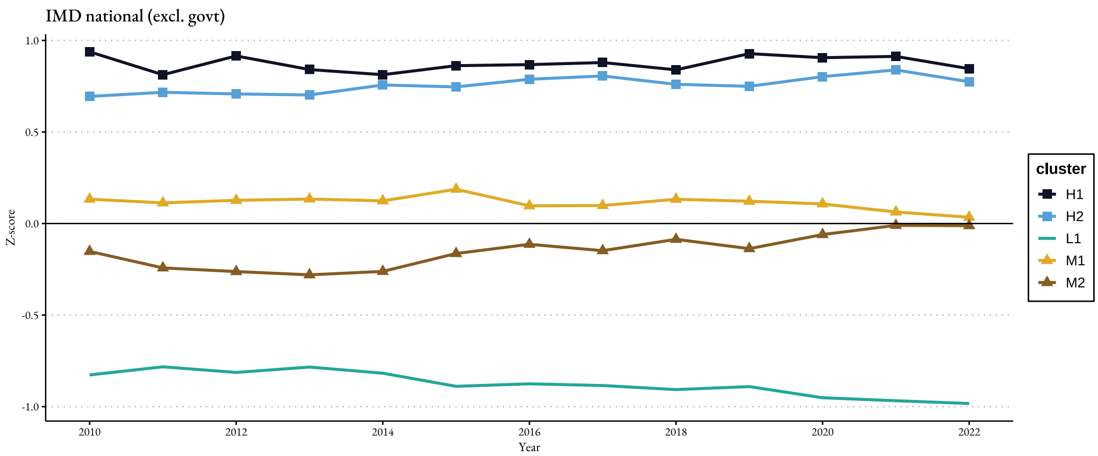


Figure 4.3: ***Average IMD scores through the period.*** *Source: own work.*

further analysis – as it lacks a group with similar competitiveness score, but different government configuration. Clustering of the countries reveals two insights: the same level of overall competitiveness can be achieved with different configurations of governmental policy (i.e., different focus areas). We have seen that these structures (as measured in the IMD) can differ quite a bit between the clusters; however, a common pattern was a generally higher infrastructure component score in the case of European countries, with generally lower scores on public finance and tax policy and higher scores on social framework. This result is in line with the general understanding of the cultural characteristics of the respective groups of countries: infrastructure (including human infrastructure) is well-developed in Europe and generally seen as being an advantage, but European countries also have stronger redistribution and role of government, translating to higher tax rates (tax policy) and higher public debt (public finance) (see Girdenas et al. 2013). In contrast with fast developing, small, advanced economies: these states have much less regulation, higher business efficiency and often a generous tax policy. Nevertheless, this also means less redistribution, less of a "welfare" state, which can be noticed in the lower societal framework score. While this is necessarily a simplification, we can understand the results as pointing towards two competing structures: (1) the welfare state with a strong infrastructure stock (including human infrastructure and knowledge), higher levels of redistribution, and a strong societal framework, (2) the market liberal state with beneficial tax rates, low public debt, in general, a smaller government that has economic superiority, but ranks lower in scores of its societal framework[1]. With the 2-2 pairs of clusters, we can further differentiate between highly competitive (H1 and H2) and moderately competitive (M1 and M2) country groups. See Table 2 - note that these classifications are not connected at this point to the COVID-19 crisis.

[1] While in this case, our sole purpose is to name the generated groups, it would be more precise to follow a concept such as the varieties of capitalism (Hall et al. 2001). Using that characterisation, one can see that the group that we name *"welfare" state* is related to *coordinated market economies*, while the group that we name *market liberal* is closely resembles Hall's *liberal market economies*.

Table 4.2: ***Classification of clusters based on national competitiveness level and configuration of government performance.*** *Source: own work.*

		National competitiveness	
		Mid-range	High
Configuration of government performance	Market liberal	**M1**	**H1**
	"Welfare" state	**M2**	**H2**

4.5 The impact of COVID-19 conditional on government configuration

We established that similar levels of competitiveness can be achieved with different government policy configurations. Now we focus our attention on whether these different configurations produced differing outcomes during the emergence of an exogenous shock: COVID-19. We employ a modified version of the Difference-in-differences (DiD) method (Wooldridge, 2013) between clusters which had similar national competitiveness scores before COVID. Basically, we test whether differences between groups (which differences were insignificant) have changed due to COVID. Comparisons are made therefore between H1-H2 and M1-M2 clusters, respectively. DiD is a method that mimics experimental research design by studying the effect of a "treatment" on the differences between two groups that before the treatment had identical trends (as in slope of growth) (Huntington-Klein 2023; Wooldridge 2013). Now, generally the DiD method is applied with a control and a treated group (i.e., one group is affected by the treatment while the other is not); in our case the setup is slightly different because both of our groups are treated. What this means is that we will not be able to interpret the estimated DiD coefficient as we would do it in a standard DiD application ; however, we will be able to tell if the difference between the two groups has changed. What we will not be able to tell is the composition of that change, i.e., whether one of the groups did better or the other did worse, or both at the same time. Figure 4.4 graphically represents the main idea of the method.

For this to be a valid estimation we need some assumptions to hold. Most importantly we need the groups to have parallel trends without the intervention, i.e., we need to be sure that the change in difference is not due to some naturally occurring trend. While we cannot directly test the presence of parallel trends we can employ a method like that of described by Lima et al. (2018) testing anticipatory effects or the placebo effect. We test whether differences are significant with random treatment periods before the actual treatment: we modify the data in a way that we assume that the "treatment" has happened in random periods in the past, and we analyse whether we get false-positive results. (Huntington-Klein 2023)

We test this for the overall competitiveness indicator as well as for the four main pillars of IMD competitiveness (Infrastructure, Business efficiency, Economic performance, and Government efficiency) (see section 1.7.2 in the Appendix). Figure 5 shows the test results for the pre- and post-treatment periods. To capture an impact due to the treatment (COVID) we expect the parallel trends assumption to hold pre-treatment (i.e., that there is no significant difference with the "fake" treatment periods) and to have a significant parameter estimate in the DiD estimation post-treatment – this is what we mean and report by "test results" in the table.

	IMD overall national competitiveness*	IMD infrastructure	IMD business efficiency	IMD economic performance	IMD government performance
H1 vs H2	X Pre-treatment X Post-treatment	X Pre-treatment ✓ Post-treatment	X Pre-treatment X Post-treatment	X Pre-treatment ✓ Post-treatment	✓ Pre-treatment X Post-treatment
M1 vs M2	X Pre-treatment ✓ Post-treatment	X Pre-treatment X Post-treatment	X Pre-treatment X Post-treatment	X Pre-treatment ✓ Post-treatment	✓ Pre-treatment X Post-treatment

Table 4.3: ***Pre-treatment and post-treatment test results.*** *Note: for pre-treatment lack of significant difference is indicated with an x (X) while significant difference in the pre-treatment period is indicated with a tick (✓); for the post-treatment period a significant difference is indicated with a tick (✓), * excludes government performance. Source: own work.*

In the case of cluster H1-H2 we see that the parallel trends assumption holds for the overall competitiveness, but we detect no effect of the treatment in the post-treatment period. This can be either due to the lack of impact or two opposing impacts offsetting each other. When we analyse the components, we see that parallel assumption holds for infrastructure, business efficiency, and economic performance. It does not hold for government efficiency, which is expected as we did the clustering based on this. In the case of infrastructure and economic performance we also see post-treatment impacts, i.e., that the difference in differences is not the same after the treatment as it was before. In the case of clusters M1-M2, we see that the parallel trends assumption holds for both the overall competitiveness measure and for its components too. However, the treatment only has impacts on the overall indicator and with regard to economic performance. Hence, the overall competitiveness difference is driven by the difference in economic performance. Cluster M2, the group of "mid-range" European welfare states performs better during COVID than cluster M1 in terms of economic performance, which then drives the better overall competitiveness result based on our analysis.

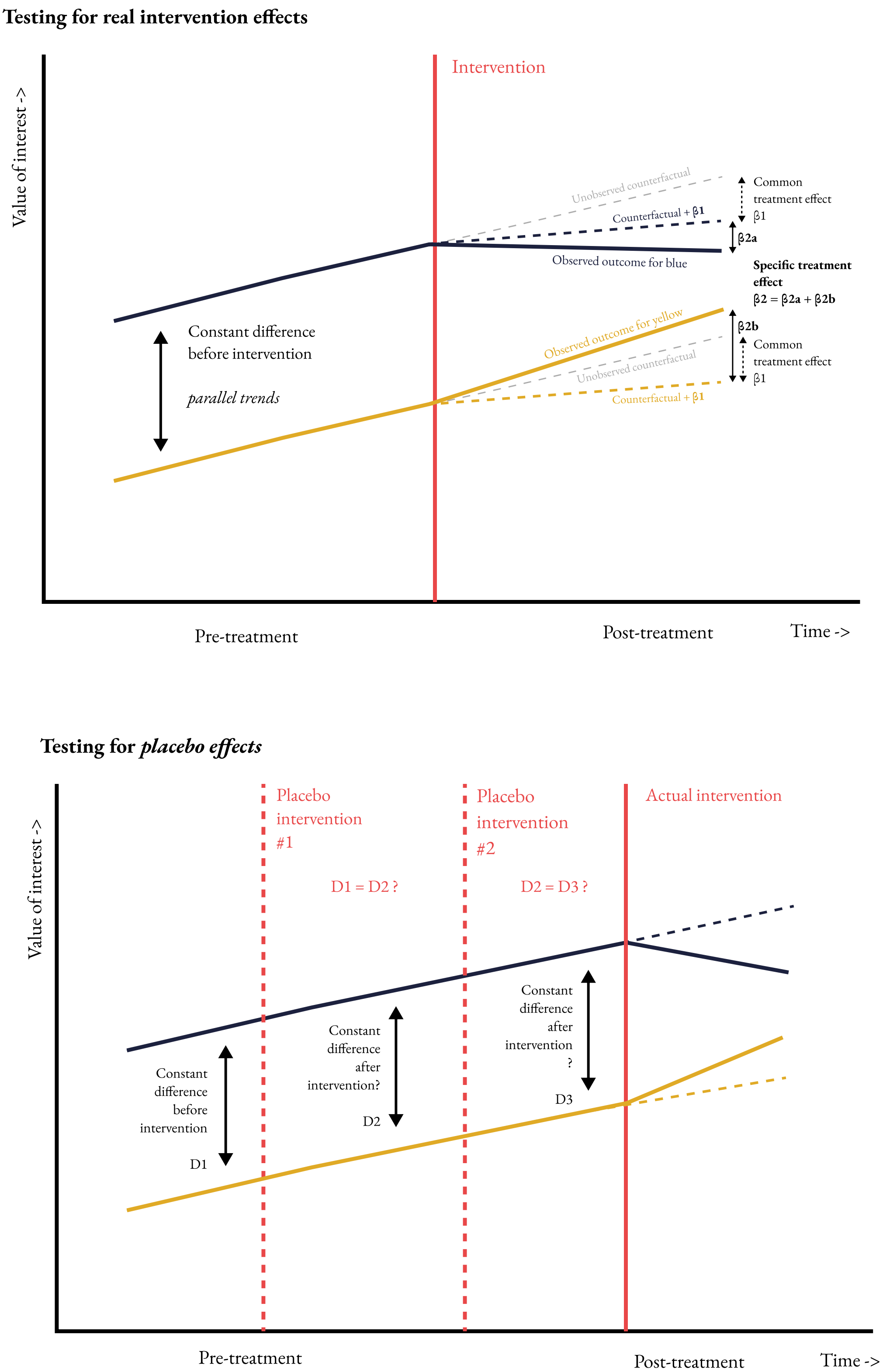


Figure 4.4: ***Graphical representation of the modified difference-in-differences (DiD) method.*** *Source: own work.*

4.6 Disentangling component differences

4.6.1 The high competitiveness groups (H1 and H2)

For clusters H1-H2, the groups with the highest competitiveness performance, the parallel trends assumption holds for overall competitiveness and infrastructure, as well as business efficiency and economic performance. In the post-treatment (COVID) period, however, they show new significant differences in terms of infrastructure and economic performance. We have discussed that these component-level impacts might be offsetting each other; hence we see no significant effect in overall competitiveness. Given the DiD cluster H1-H2 numerical results (Table A7 in the Appendix) we see this playing out in the numbers: the estimated interaction effect (covid x clusterH2) for the H1 cluster in terms of infrastructure is +0.19, while for economic performance it is negative: -0.45. Applying the relevant weights, we get what is presented in Figure 6. While overall competitiveness of cluster H2 is still lower in the post-treatment period than cluster H1's, there is a (non-significant) shrinkage of the difference driven by competing forces. The COVID impact, in interaction with the clusters' relevant policy and institutional structure, increases relative economic performance for H2, while it increases relative performance in infrastructure for cluster H1.

4.6.2 The medium competitiveness groups (M1 and M2)

For clusters M1-M2, a different picture emerges (see Appendix Table A8 for numerical results). There are no significant impacts for most subcomponents, but there is a significant increase in terms of economic performance for cluster M2. This feeds into the overall competitiveness score. Eventually, this leads to a narrowing gap between overall competitiveness of M2 and cluster M1, with cluster M2 improving after treatment (but still behind). Section 1.7.3 in the Appendix details the drivers of these effects further; in short, the performance of cluster M2 is considerably better in both employment and international investment terms relative to cluster M1 during the COVID period.

4.7 Discussion and implications

This paper analysed how different long-term government policies, institutions or government 'configurations' can reach similar competitiveness outcomes and how those different 'configurations', at the same time, can lead to dissimilar outcomes when it comes to reacting to an external shock. The originality of the article lies in its combination of institutionalist and microeconomic views of competitiveness, considering the importance of government policy and the influence of institutions not just on long-term competitiveness, but on short-term reactions to shocks. The findings indicate a correlation between government efficiency and competitiveness, and provide evidence that governments with a welfare orientation were more resilient, maintaining national competitiveness during the crisis. Institutions and government policies are linked with national competitiveness - our research supports this connection. We show that countries can reach similar levels of competitiveness with different "configurations" (approaches) of government policy. By analysing IMD's competitiveness rankings, we identified two main types of government policy-mixes in both highly competitive and medium competitive countries, which correspond to the countries' long-term institutional setting:

- a welfare state-like involving more government intervention to provide social services; and
- a market liberal with more limited government involvement, focusing more on free-market mechanisms.

Further analysis suggests that some countries (H1) achieve higher competitiveness by emphasizing stronger market elements, while others (H2) attain slightly lower but still strong competitiveness performance via welfare state policies. The exogenous economic shock caused by COVID-19 allowed us to study how these different groups react to shocks. Our findings indicate that the COVID shock did not have a significant effect on the difference between the two high competitiveness (welfare, and market liberal) groups. Most likely, that is because these states had stronger social support systems in place, which helped cushion the economic impact of the pandemic. However, it did influence difference between countries in the medium competitiveness group. In terms of competitiveness our results indicate that the welfare-oriented states were more resilient. In this group (medium competitiveness) states that focused on supporting society and had strong social systems in place have been more resilient at handling the economic / competitiveness problems caused by COVID. But generally, having a strong social framework and investing in public services is costly and might mean substantial redistribution. Therefore, we cannot suggest that in "normal times" these policies would also lead to higher competitiveness than their market liberal counterparts, but we do show that in times of crisis they might induce higher resilience. A common notion related to the shock is the trade-off between efficiency and resilience. For an illustration, an example from inventory management may be useful: some businesses follow a lean system by keeping only the minimum necessary inventories. Meanwhile others, keeping extensive local inventories, focus more on resilience. This idea can also apply to nations: one fares better due to the lower costs and higher efficiency in normal times, but an efficient system is also more vulnerable in times of shock. We see this effect being replicated here on a macro-scale. Societal investments in social policy or healthcare pay-off in times of crisis, even though they bear costs in "normal times". Notably, these effects were only visible for medium but not for the high competitiveness countries, further indicating that these differences might disappear at a higher level of development and competitiveness.

5

Green and Sustainability Issues: Recovery from the pandemic

This chapter is somewhat removed from the topics that the other three chapters have touched upon so far. We are still considering economic developments around COVID-19 and still have a strong regional focus around Hungary, however, this chapter looks beyond of *what has happened* and asks the question *what could happen*? The chapter builds on work that spans multiple studies and was part of an initiative to investigate recovery from COVID-19 shocks through sustainable development. The author of this thesis have been part of many of these studies, including but not limited to Pollitt et al. (2021), Hummelen et al. (2021), Kiss-Dobronyi et al. (2023), Kiss-Dobronyi et al. (2021), and Dafnomilis et al. (2022).

Ideas explored in this chapter and in these more broad works posit that government policy-led recovery efforts responding to the pandemic can simultaneously advance economic recovery and sustainable growth, responding to climate risks. These works also link the broader concept of resilience to inherent characteristics of nations, while Chapter 4 has explored the connection of government configurations and national competitiveness, focusing on proactive resilience, this chapter focuses on re-building and how the structure of the economies supports re-building efforts. Hence, what we called reactive resilience in Chapter 1.

Crucially, the chapter does not try to analyse impacts of EU initiatives *actually implemented*, such as the 'Green New Deal' or the 'Recovery and Resilience Facility' (RRF). However, given that the RRF has required substantial green spending European Commission 2025 the hypothetical recovery that we model does have some resemblance to this large-scale initiative. In fact, many 'green' projects in Visegrad countries have been financed since 2021 from this instrument. Opposed to this, the 'Green New Deal' is a more general climate and infrastructure initiative, that was not approved in relation to COVID-19 and economic recovery.

Material presented in the chapter has been published in Society & Economy as *Kiss-Dobronyi, B., Fazekas, D., and Pollitt, H. (2021), "Macroeconomic assessment of possible Green Recovery scenarios in Visegrad countries", Society and Economy, 43 (2021) 3, pp 227–252.* The dissertation author's contributions were (CRediT): Conceptualization, Methodology, Software, Writing - Original Draft, Visualization.

5.1 Introduction

The COVID-19 pandemic is a health crisis that has happened on a scale not seen in recent decades. Its impact on people's lives and our society is significant and already the target of multiple research endeavours from various fields. Nevertheless, it is also an economic crisis, stemming from changes in consumer behaviour as well as government measures to curb the extent of the pandemic.

Against this backdrop, it is unquestionable that governments have an obligation to step up and provide relief for those who are in need, and to help stabilize the economy (Stiglitz 2020). They are already doing it with different policy responses, often focusing on providing credit guarantees, wage subsidies and loans (IMF 2020; O'Callaghan et al. 2020) to compensate reduced private sector demand. However, as the crisis passes, governments will also need to introduce longer-term recovery packages to help their economies recover and to provide new opportunities for those who lost their livelihoods.

How this will be done is an important question. For the short term, governments have already announced a multitude of "relief" programs. These programs include unprecedented spending plans (Bruegel 2020; O'Callaghan et al. 2020; IMF 2020), with a focus on keeping firms solvent and consumers spending. But for the long term, questions remain about the best policy response.

The looming crisis, with lockdowns and travel restricted, has also created the largest fall in CO_2 (carbon-dioxide) emissions ever seen (Evans 2020; Liu et al. 2020). However, it is recognised that, without policy interventions, rates of CO_2 emissions and environmental degradation could increase again as the economy recovers (Evans et al. 2020; Hummelen et al. 2021; IEA 2020c; Pollitt et al. 2021; Shan et al. 2021). While United Nations (UN) Secretary General Antonio Guterres has already said that "Coal has no place in COVID-19 recovery plans" (Lewis 2020), there are countries where spending on fossil fuel-based energy is a primary component of recovery plans (such as Australia) (Murphy 2020).

But even without direct spending on fossil-based energy, recovery plans without elements to induce a large-scale green-transition will likely have adverse effects on the environment. While policies that are "colourless", such as general consumption boosting policies (e.g. value-added tax reductions) or non-targeted investment policies, will probably not have a direct adverse effect on greenhouse gas emissions, they keep the status quo of environmental harm (Dafnomilis et al. 2022; Hepburn et al. 2020), meaning that their environmental effects are dependent on the current economic structures of production. Due to the lack of large-scale global economic decoupling[1], these policies are still likely to have negative impacts on the environment (e.g. increasing carbon emissions in line with economic growth).

That is why there are now calls for a 'green recovery' and ideas 'to build back better' (Harvey 2020; Hepburn et al. 2020; IEA 2020b). Therefore, it has been proposed that economic recovery should have at least two goals now: to restore employment and economic activity, but also to support work towards reaching climate goals by limiting CO_2 emissions.

This paper proposes a Green Recovery Program (GRP), which aims to contribute to both of these aims: To restore employment (and economic activity) through working towards climate neu-

[1] For a discussion on whether decoupling of CO_2 emissions and economic growth is underway either in absolute or relative terms see for example G. Cohen et al. (2017) or Mikayilov et al. (2018).

trality with government support. The geographical coverage of the paper is the Visegrad group[2]; we cover Poland, the Czech Republic, Hungary and the Slovak Republic individually in the analysis. At the point of writing, none of these countries have yet announced large-scale individual recovery programs, but all of them face substantial challenges from the crisis because of their open economies.

Furthermore, in the coming years, regardless of the impacts of COVID-19, these four countries have to make serious progress towards agreed environmental goals such as energy efficiency, cutting dependency on fossil fuels and the electrification of road transport. All countries have emission reduction targets at least in line with the EU's Effort Sharing Regulation (ESR), in the range of 7%–20% reduction of greenhouse gas emissions by 2030 compared to 2005 emission figures (European Commission 2020a). How far countries are from the target differs quite much, but progress is mostly needed. Based on latest available data Poland stands at +21% (over its 2020 goal of +14%), while Czechia stands at +4% (reaching its 2020 goal, below its long-term goal of −14%) and Slovakia stands at −5% (above its 2020 goal, below its ambitious long-term goal of −20%), while Hungary has already hit its long-term goal of −7% (European Commission 2020a). Nevertheless, all countries are well below their long-term renewable sources in power generation targets and mostly below their 2020 targets, which indicates that progress is still needed in this area.

The main contribution of this paper is not only to outline one such 'green' recovery pathway for these countries, but also to simulate, compare and explain this recovery's labour market, economic and emissions consequences. The exercise also necessarily includes an estimation of economic and labour market impacts of COVID-19, which is then used as a point of comparison for the GRP results presented. The approach used is an ex ante model-based one, specifically, using the E3ME macroeconomic model.

This article is structured as follows: Section 2 details the opportunity and rational for a 'green' recovery in the Visegrad countries. Section 3 introduces the methodology used in our assessment and the scenarios that we assessed. Section 4 presents the estimated COVID-19 economic impacts in the Visegrad countries, in terms of employment impacts, emissions reductions and economic activity, followed up by the impacts of the GRP scenario and estimates of the required government financing. Section 5 summarizes the findings and concludes.

5.2 Green Recovery in Visegrad countries

Various groups have already discussed how a 'green' recovery program could work in the EU. For example, the World Wildlife Fund (WWF) has outlined a macro-level package (WWF European Policy Office 2020) and the cities of the C40 coalition have published an agenda focusing on "Green and Just" recovery (C40 Cities Climate Leadership Group 2020). Early on, based on a survey of leading economists (Hepburn et al. 2020) categorised possible recovery measures and outlined their potential environmental impacts. This work has been continued by O'Callaghan et al. (2020) who established the Global Recovery Observatory, collecting and categorizing announced recovery measures, taking their environmental impacts into account. The magnitude of these measures varies

[2] The Visegrad region consists of four countries who share historical and cultural similarities: Hungary, Poland, Czechia and Slovakia. This group was selected because while they share certain similarities, their economic structures are different enough to highlight the differing impacts of recovery policies.

over a wide range, from energy efficiency measures, green energy investments or budget consolidation through carbon taxes, with large-scale projects also in the mix.

Grandiose projects such as WIIW's proposed '100% Renewable Energy Sources (RES) e-highway' (Creel et al. 2020) are certainly appealing, and could result in a large-scale boost to economic activity if completed. Nevertheless, as the IEA notes (Varro et al. 2020) – based on experiences after 2008–09 – what historically works well is rather the expansion, scaling up and financing of existing schemes and frameworks. In these cases, often there is existing administrative capacity, working processes and understanding from both funding agencies and recipients. This helps to build trust and does not put unnecessary burdens on granters and grantees.

These factors are especially important in times of uncertainty. In the Visegrad Countries, there is accumulated experience with such programs. After the 2008–09 crisis, multiple EU member states included 'green' elements in their recovery programs. A study for the European Commission (Cambridge Econometrics 2011) evaluated some of those programs, including those of the Czech Republic and Slovakia. At the time, both programs were deemed successful. The recovery program in Czechia included a 'Green Investment Scheme', which targeted energy efficiency improvements mostly in residential buildings. In Slovakia, there was a similar but smaller program, which was complemented with a renewable installation subsidy targeted towards households (Cambridge Econometrics 2011). Both programs also included a car scrappage scheme – similar to what we see in Germany now (Miller 2020).

The Visegrad countries therefore have experience with these programs and an opportunity to build on already-existing schemes, but there are other reasons for a 'green' recovery as well, these will be discussed in the following paragraphs.

Looking back to the 2008–09 crisis, the boosting of aggregate demand through government interventions happened mostly through tax cuts in developed countries and through public infrastructure investments in developing countries (International Institute for Labour Studies 2011). However, the standard alternative of general tax cuts may not be effective because V4 countries have lower savings and wealth than other countries[3] and therefore may not increase spending in response. When such measures were introduced after the financial crisis, it was questioned whether the effects can be significant even in countries like the UK (Phillips 2009).

Second, Visegrad countries are embedded in global value chains (Cieślik 2019; Grodzicki 2014). With these disrupted, it is important to increase investment in jobs that are producing for domestic demand. Creating a domestic market for renewable energy which is anyway expected to grow considerably in coming years (IEA 2020a) might serve this purpose. Although many of the components are sourced from imports (Pasimeni 2017), installation would need to be local.

Further, while the energy industry in general is more capital than labour-intensive, renewable energy technologies have higher labour needs than conventional technologies do, both in installation and operation & maintenance; they could therefore provide stable jobs (ECOTEC 2002; ILO 2011). It has also been shown that energy efficiency investments in Europe could create employment gains (Cambridge Econometrics 2015). Furthermore, installation of renewables and energy efficiency improvements are fields where low-skill workers could find employment (ILO 2011). This

[3] Based on Eurostat data.

factor is important because jobs lost due to the pandemic are largely in low-skilled sectors (according to Eurostat data available on 2020 Q2 and past employment, see Figure 5.1). In Hungary, losses in low-skilled service, sales and elementary occupations amount to 117% of net losses; in Slovakia 76% of the net loss is in these occupations (Eurostat 2020). These figures are in line with earlier reports on the risk of employment loss in vulnerable groups (such as people with lower education) (Pouliakas et al. 2020).

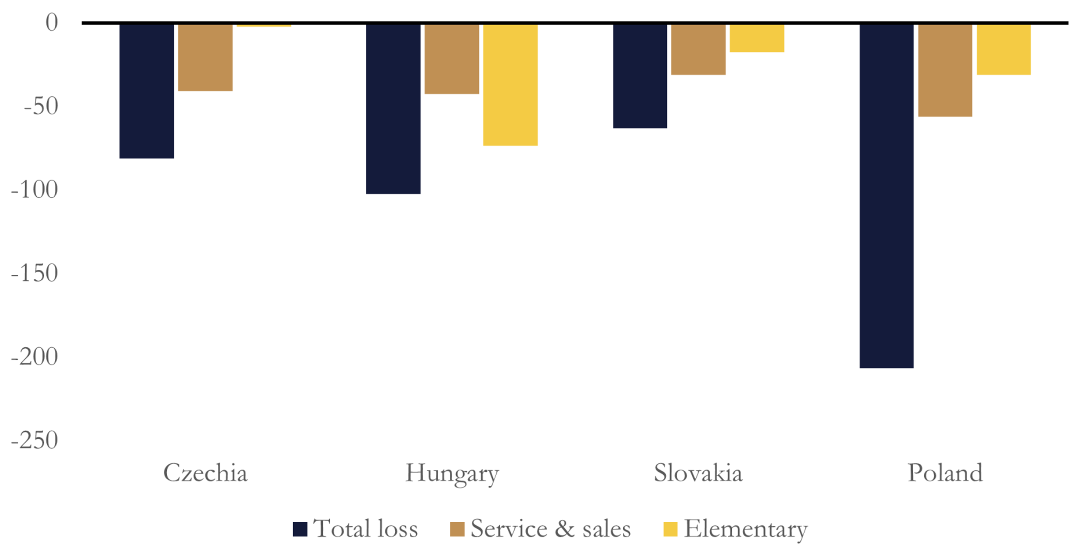


Figure 5.1: ***Employment loss in highlighted groups, comparing 2019Q2 to 2020Q2 in Visegrad countries.*** *'000 people. Source: own work, based on data from Eurostat (2020).*

Finally, the region's energy profile largely calls for a 'green' recovery for two reasons: (1) energy security and (2) dependency on fossil energy sources (particularly coal and lignite) (BloombergNEF 2020). Energy security is a long-standing issue in the region; a high dependency on imported oil and gas from Russia long ago shifted the region towards a vision of greater energy independence (Cambridge Econometrics 2020). Building renewable capacities is an evident solution.

Second, Czechia and Poland are still some of the most coal-intensive electricity producers (see Figure 5.2). Poland produces 79%, and Czechia 43%, of its electricity from coal (BloombergNEF 2020). Hungary and Slovakia have less reliance on coal, but all four Visegrad countries have existing coal and lignite plants that do not meet the environmental standards coming into force in 2021 (BloombergNEF 2020). Thus, there is a choice either to invest in retrofitting those plants, potentially creating "stranded assets" as both regulations and the market moves away from financing coal, or to start building new capacities, for which the current recovery provides a potential opportunity.

5.3 Methodology for assessment

The modelling exercises in this paper are built around the E3ME macro-econometric model. First, following the methodology set out in Cambridge Econometrics et al. (2020) and Pollitt et al. (2021), the impacts of the COVID-19 pandemic on the selected countries' economy and emissions are modelled. Second, three long-term scenarios focusing on versions of a 'green' recovery scenario are mod-

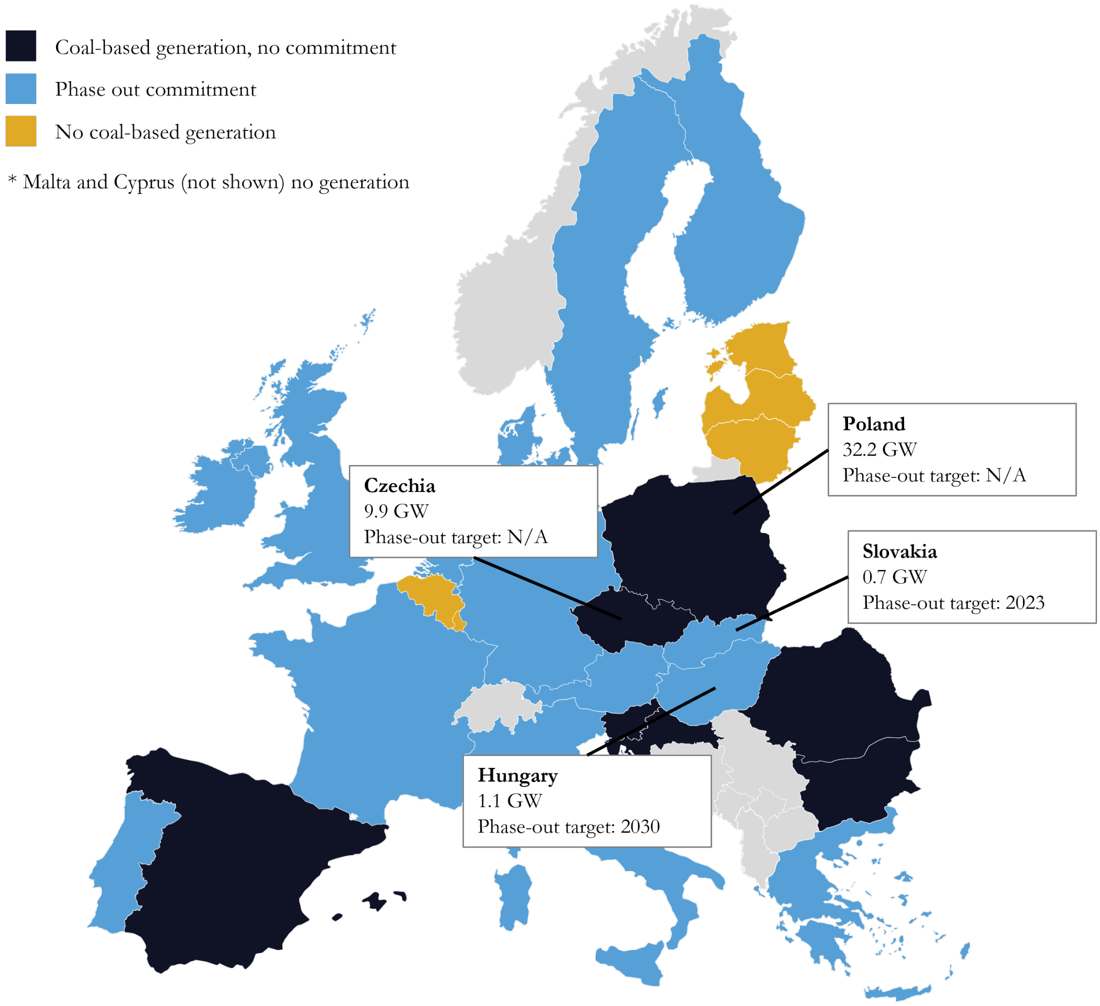


Figure 5.2: ***Commitments of European countries to phase-out coal****. Source: own work, based on data from Dempsey (2019))*

elled. In this section first the E3ME model is described briefly, followed by a description of the scenarios.

It worth mentioning that there have been similar modelling exercises, which intended to bring some of these measures together and present economic, labour and environmental outcomes of these policies. The IEA's Sustainable Recovery (IEA 2020b) report was one of these comprehensive exercises, where the authors have quantified possible global outcomes of a wide range of recovery measures. Another similar exercise was carried out by Pollitt et al. (2021) focusing on a range of "green" measures and comparing these to outcomes from a "consumption boosting" recovery. Not focusing on policies, but on assumptions about the "nature" of the recovery (Shan et al. 2021), published modelling of a series of global recovery scenarios with differing magnitude and carbon intensity. Similarly to other works, they show that while a recovery with the current status quo of carbon intensity of investments could boost CO_2 emissions, a less carbon intensive recovery could have important contributions to climate change mitigation (Shan et al. (2021)).

5.3.1 E3ME model

E3ME is a macroeconomic model built on Post-Keynesian economic theory and on econometric estimations of macroeconomic relationships. The model was originally developed by an international team, operating under the European Commission research programs (Cambridge Econometrics 2019). Since then, the model has been maintained by Cambridge Econometrics and has regularly been used in high-profile scenario-based policy analyses, including assessing the EU's 2030 environmental targets (European Commission 2020b), the EU's skills projections (CEDEFOP et al. 2018) and the 2018 New Climate Economy report[4] (New Climate Economy et al. 2018).

Recently, the model has also been used in assessing various 'green' recovery scenarios globally (Hummelen et al. 2021; Pollitt et al. 2021), in Latin America and the Caribbean (CEPAL 2020) and in a number of selected countries (Cambridge Econometrics et al. 2020; Kiss-Dobronyi et al. 2021).

E3ME simulates 61 world regions in total, 27 of them representing individual EU member states. In each EU country, the model works with 69 industrial sectors (corresponding to NACE Rev. 2 sectoral classification). Household consumption, which is divided to 43 categories, corresponding to COICOP classification, is linked to sectoral production in the model. Sectoral supply and demand are linked together through the use of input-output tables, while regions are linked through bilateral trade tables (Cambridge Econometrics 2019). The model is demand-driven, assuming an adjustment on the supply side to fit demand, subject to constraints.

The input-output linkages provide channels between producing sectors and final demand. This means that as the model is demand-driven, firms in the economy assumed to adjust their production (supply) to fulfil product demand. This process is subject to constraints, such as capacity constraints in labour and product markets, that feed back to prices and investment decisions (Pollitt et al. 2017), it is assumed that there is usually spare capacity in the economy. Policies that draw upon this spare capacity may lead to increases in output and employment (Cambridge Econometrics 2019; Mercure et al. 2019). Nevertheless, the pandemic has effected this output gap, which is reflected by our assumptions on the reduction of supply capacities.

The model's behaviour is different from that of Computable general equilibrium (CGE) models (e.g. GTAP, GEM-E3) which are often used for macroeconomic modelling. To highlight some important differences: E3ME adopts a 'bounded rationality' approach, represented through behavioural parameters estimated on historical data and the money supply is assumed to be fully endogenous (Pollitt et al. 2018). The model builds on economic relationships estimated on historical data. A full list of equations used to define these relationships can be found in Mercure et al. (2018), equations especially important in the current exercise are presented in Appendix D. Historical data was collected from various sources such as Eurostat, OECD, and the UN. Model parameters were estimated on this data using the concepts of cointegration and error-correction, based on Engle et al. (1987) and Hendry et al. (1984). To avoid issues with shorter time-periods and possible volatilities related to the economic transition of the 1990s, the model uses a shrinkage technique for estimating parameters of long-term equations in all EU member states who joined the Union in and after 2004 (Spicer et al. 2005). Ščasný et al. (2009, p. 468) describes this as "essentially adopting a western-European average", with the estimation basically assuming that on the long-run member states will

[4] For details and further project references, please see Cambridge Econometrics' website http://camecon.com.

converge to long-run behaviour of Western economies. This, importantly, includes all countries in the focus of this exercise.

E3ME is primarily used for policy analysis, rather than forming absolute projections. Therefore, a baseline scenario is usually simulated first, which represents a "business-as-usual" state of the world going forward. In this paper, the energy projections of the baseline are calibrated to the PRIMES 2016 Reference Scenario (Capros et al. 2016), while short-term economic-labour projections are calibrated to projections of the World Economic Outlook (IMF 2019). Long-term projections are calibrated to the Ageing Europe report (European Commission 2018). This is what we consider a "no-virus" baseline later in the paper. This approach is used to show how fast a 'recovery' can be achieved to pre-COVID levels of activity and employment.

The exercise also takes advantage of Future Technology Transformations (FTT), a suite of bottom-up technology models integrated with E3ME. The FTT:Power and FTT:Transport submodels are used in the modelling exercise. These technology models assume technology diffusion and learning effects within individual technologies and employ discrete choice modelling to forecast path-dependent choices made by agents in the system (Mercure et al. 2014). FTT:Power is a bottom-up technology model following these principles (Mercure et al. 2014), while FTT:Transport uses a similar approach with heterogenous agents to simulate private passenger transport (Mercure et al. 2018). These sub-models are used to simulate impacts of the 'green' recovery scenarios: e.g. subsidies for car scrappage or capital subsidies for renewables.

The E3ME model manual, which is a detailed description of data used, underlying mechanisms and equations, which form the model, is available at www.e3me.com.

5.3.2 The COVID-19 impact scenario

The COVID-19 scenario uses data, estimations and assumptions collected at the end of July and beginning of August 2020. It is close to what OECD named a "double-hit" scenario (OECD 2020b). The scenario makes assumptions about the impacts mostly for the year 2020. In the case of the Visegrad countries, it includes a "second-wave" of economic restrictions that is less severe than the first-wave; the size of impacts thus increases from the damage done in spring but does not double in magnitude. Assumptions on demand, supply and investment shocks are presented in Table D.1, Table D.2 and Table D.3 in Appendix D .

The scenario makes several assumptions, based on available data and estimates about the severity and effects of the crisis. These are mostly in line with what is described in Cambridge Econometrics et al. (2020) and Pollitt et al. (2021), but there are minor differences, so a summary of the inputs is provided here. Four main areas of inputs are considered (1) supply shocks, (2) demand shocks, (3) short-term government interventions and (4) effects on investments.

Supply shocks are driven by stay-at-home policies as well as health effects (people on sick leave or self-isolation). Impacts are calculated based on Rio-Chanona et al. (2020). Effects in this paper are estimated based on sector and job level, taking the feasibility of remote work and essential jobs into account. The resulting sectoral level shocks were adjusted using Google Mobility (Google 2020) data: an annualized decrease in activity at workplaces was used as an adjustment factor for the sectoral assumptions. The strongest effects are in forestry, basic metals, personal services, metal products, machinery, but also tourism and sports activities sectors.

Demand shocks were calculated using Google Mobility data reports (Google 2020) on activity at transit stations (transport services), retail and recreation (retail and entertainment) and TomTom Traffic Index (TomTom 2020) data (private transport). An average activity reduction was estimated based on observed behaviour in the first half of the year. This number then was annualized, and to account for the second-wave a multiplier of 1.5 was applied to it. The resulting activity reduction numbers were then used as negative shocks (i.e. reduction) on selected household consumption categories. For two special sectors, tourism and air transport, industry association estimates were used from (ICAO 2020; WTTC 2020) because it would be hard to capture impacts on international travel with local indicators. Tourism reduction is adjusted with the international/domestic rate of tourism, therefore where international tourism is stronger, the demand reduction will be higher. The resulting supply shocks and demand reductions are shown in Table D.1 and Table D.2 in Appendix D.

Short-term government interventions are taken from two sources: (1) Bruegel's collection of government interventions (Bruegel 2020) and (2) IMF's Policy Tracker (IMF 2020). Government interventions are treated as partly excess government expenditure and partly lump-sum transfers to citizens (wage compensation).

Finally, investment reductions are calculated using a three-stage method. First, after applying supply and demand shocks, as well as short-term government fiscal interventions, an output effect for 2020 using E3ME was estimated. Second, this output effect has been adjusted using answers from Bank of England Decision Maker Panel (DMP) (Bank of England 2020). The second step ensures that investment effects are applied to sectors which are likely to be affected through pessimistic expectations rather than direct impacts. Third, the time dimension of Bank of England Decision Maker Panel (DMP) was used to estimate the magnitude of investment effects for 2021. Sectoral investment effects predicted for 2021 in the Bank of England Decision Maker Panel (DMP) were compared to effects expected for 2020. From this, a forward-looking discount factor was calculated, which was then applied on top of effects simulated with E3ME. The direct investment shocks obtained by this calculation are shown in Table D.3 in Appendix D .

5.3.3 Green Recovery scenario

The Green Recovery scenario presented here builds on Pollitt et al. (2021), but considers the possible measure of the Green Recovery in the context of the Visegrad countries, plus introduces two sensitivities: a lighter and a stronger version of the recovery program. Contrary to 'green' recovery programs considered in Pollitt et al. (2021), in this exercise there is no assumption on VAT or sales tax reductions as part of the recovery programs. The different pathways will be referred to as follows:

- pre-Covid baseline;
- baseline with estimated COVID-19 impacts;
- Green Recovery Program (GRP) scenario;
- "light" GRP sensitivity;
- "strong" GRP sensitivity.

The GRP scenario considers four main measures:

- capital subsidy to renewable technologies;
- grid investment to accommodate the rapid uptake of renewable technologies;
- car scrappage scheme, applied only to cars replaced by electric vehicles (EVs);
- energy efficiency improvements in buildings, focusing on retrofitting.

First, three levels of capital subsidy are simulated. The main GRP scenario assumes a 50% capital subsidy to wind and solar PV technologies in 2021–2023, followed by 30% in 2024 and 2025. The "strong" sensitivity assumes a scaling-up of these numbers, 67% subsidy in the first period and 40% subsidy in the second period, while the "light" sensitivity uses 30% subsidy up to 2023 and 5% up to 2025. Renewable technologies are becoming cost competitive in the world, even without subsidies, especially in Europe (IEA 2018). However, it is not just a question of becoming cheaper; renewables must first become established in the market (e.g. with ancillary services available) before they can grow quickly (Mercure et al. 2014). Reducing the costs of renewables accelerates this process. A connected second point is the need for national electricity grid investments to accommodate the increased uptake of renewable technologies. A 400 EUR/kW investment need is assumed, based on the average cost of grid-scale battery projects (IEA 2019). Renewable energy generation is also important considering the European Union's strategic renewable energy target of 32% by 2030 (European Commission 2020c).

Third, a car scrappage scheme was a popular 'green' policy tool after the 2008–2009 crisis, and it is gaining momentum once again (Evans et al. 2020; Cambridge Econometrics 2011). However, in our scenario it is only applicable to new electric vehicle (EV) purchases, therefore pushing up the share of electric vehicles in the transport mix. In the "light" sensitivity of the scenario it is assumed that a total of 2% of the fleet in usage can be replaced in 3 years, this number is 3.5% in the main GRP scenario and 5% in the "strong" sensitivity one. A subsidy amount of 15% is assumed to reach these goals; this rate has been chosen based on the observed efficiency of such programs in other countries (International Transport Forum 2011).

Finally, through retrofitting, financed by government subsidies, an energy efficiency improvement primarily in buildings is assumed. The Intergovernmental Panel on Climate Change (IPCC) states that retrofitting the existing building stock is key to reducing emissions of the building sector (IPCC 2014). Retrofitting also provides co-benefits for residents, through savings in energy consumption and thus spending on energy. The overall effectiveness and extent of energy efficiency measures in buildings are dependent on several factors, including the building stock and the consumption reduction that can be achieved by retrofitting. The IEA's 2019 Sustainable Development Scenario assumes that, due to energy efficiency improvements, energy consumption of the buildings sector could be reduced by over 30% by 2030 (IEA 2018). It is of course a result of combined impacts of new buildings and retrofitting. Nevertheless, taking this and studies on the energy savings potential of public buildings in Hungary and Slovakia into account (Korytarova 2011; Korytárová et al. 2017) an 8% total reduction was introduced in the main GRP scenario (over 5 years). In the "strong" sensitivity scenario a 12% reduction is assumed, while in the "light" sensitivity one a 6% reduction is assumed in Visegrad countries. The costs of the measures are estimated based on Ürge-Vorsatz et al. (2010), assuming that 1.16 mEUR investment is required to reduce energy consumption in buildings by 1 GWh. This estimate is based on Hungarian data and there have been advancements in the

Table 5.1: ***Green Recovery scenario assumptions in base version and sensitivities.*** *Source: own work.*

	Cost assumptions	Green Recovery Program		"Light" sensitivity		"Strong" sensitivity	
Capital subsidy for renewables	Subsidy amount + related grid, battery investments 400 EUR/kW	50% (2021-23)	30% (2024-25)	30% (2021-23)	5% (2024-25)	67% (2021-23)	40% (2024-25)
Car scrappage scheme, fleet replacement in 3 years	15% subsidy on retail prices	3.5%		2%		5%	
Energy efficiency improvements, demand reduction in 5 years	1.16 mEUR investment / 1 GWh demand reduction	8%		6%		12%	

area since, so it is probable that costs in this aspect are overestimated.

The scenarios are summarized in Table 5.1.

5.4 Results

In this section, we present the country-level results from the modelling. The results focus on three dimensions and key indicators:

1. social dimension – employment;
2. environmental dimensions – level of CO_2 emissions; and
3. economic activity – gross domestic product (GDP).

These measures have been selected as together they give a summarised picture of the economy, as well as a slice of the environmental harm done by the economic activity. The order of the indicators is also important: the authors believe that in the current situation, keeping employment up and making sure that people can maintain their livelihoods could be the most important goal of a recovery program.

To provide insights about the financing needs for these programs, total government spending in GDP terms and the cost of the individual program components are also presented and discussed. It should be noted that the modelling does not make explicit assumptions on the cost of the program, costs are calculated based on endogenous responses to the introduced measures (i.e. there is no fixed budget for RES subsidies, but the cost of the measure depends on the endogenous response to the magnitude of the subsidy).

The text in this section focuses on the main GRP scenario, but results are presented for the "light" and "strong" scenarios as well in the figures. These results provide a range of potential impacts from the green recovery program.

5.4.1 Employment

The initial employment impacts (presented in Figure 5.3) of the GRP are positive for all four countries, although their magnitude differs substantially. In Hungary (HU), Czech Republic (CZ) and Poland (PL), there are also employment benefits after the support is withdrawn and beyond 2030. The main reason for the long-term benefits is the renewable subsidies; by putting these three countries on technology trajectories that rely more on domestic installation and less on imported fuel, there is a permanent boost to employment.

Figure 5.3: ***Employment*** *impacts in the modelled scenarios, % difference from no-virus baseline, Visegrad countries. The light-green area shows the results of the sensitivities, with the "light" sensitivity being the lower bound, while the "strong" sensitivity being the upper. Source: own work, based on E3ME model simulations.*

Total employment boost compared to the baseline with estimated COVID-19 impacts is about 213, 93, 34, 30 thousand additional Full-time equivalent (FTE) employment by 2023 respectively in PL, CZ, SK and HU. Long-term employment increase (by 2030) is about 81, 41, 0, 76 thousand FTE employment in PL, CZ, SK and HU respectively.

The employment impacts result from a mix of drivers: an uptake of construction work is necessary because of energy efficiency and RES investment measures, this is complemented by an increase in auxiliary sectors such as architecture, engineering, landscaping. The manufacturing of motor vehicles (due to car scrappage) is also an important driver. The boost of employment in these (and connected) sectors also causes higher disposable income, which in turn boosts employment in sectors of consumption (e.g. retail, wholesale, tourism). Finally, due to the measures being government programs, administrative jobs (e.g. public administration, legal, accounting) increase as well.

In the Slovak Republic (SK) the employment impact of the GRP does not persist because there is limited renewables take-up despite the subsidies. Figure D.1 in Appendix D shows the magnitude of renewable take-up in the countries' respective energy systems, highlighting this deficiency. Importantly, this effect is also a result of the current and expected energy pathways of the country, having a large share of its electricity generation from nuclear power. The short-term employment benefits (mainly the result of investment in energy efficiency and car scrappage) do not persist beyond the end of the support. In Hungary however, retail sectors react favourably to the recovery of consumption, inducing an employment increase in the long term, complementing the above described effects.

5.4.2 Environmental indicators

An interesting side effect of the COVID-19 pandemic is that due to the significant reduction of economic activity, it has caused a drop in CO_2 emissions (IEA 2020a; Evans 2020). However, it is likely that this reduction of emissions will not persist once economic recovery takes place. This is where a 'green' recovery could make a substantial difference. As shown in the results, a GRP would not only keep the reduction of CO_2 emissions, that the world achieved unintentionally, but could also introduce further reductions.

The effects (presented in Figure 5.4) are particularly evident and strong for Hungary, but also noticeable in the three other countries. In Hungary the reduction is driven by adoption of EVs (more than 70% of the reduction by 2025), while in Czechia both electricity (30%) and transport (50%) contribute substantially to the emission reductions (rest is energy efficiency and other spill-over effects).

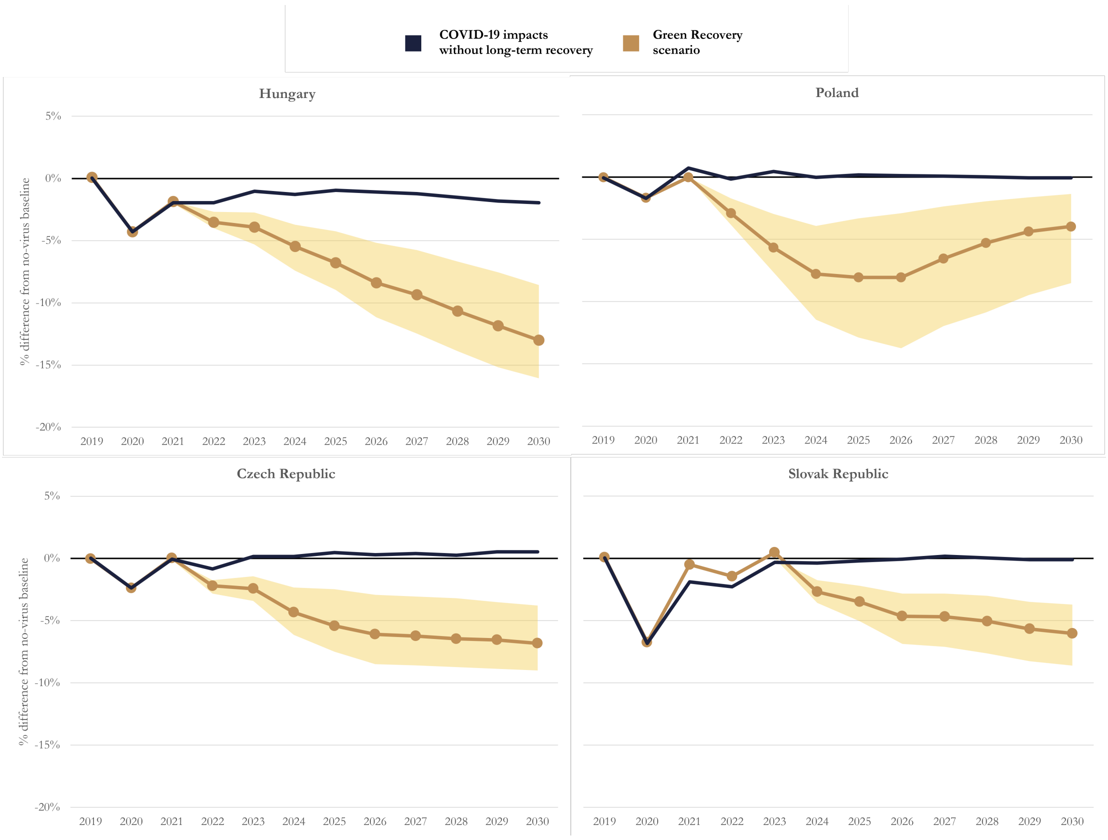


Figure 5.4: *CO_2 **emission** impacts in the modelled scenarios, the light-green area shows the results of the sensitivities, with the "light" sensitivity being the upper bound, while the "strong" sensitivity being the lower. Source: own work, based on E3ME model simulations.*

In the case of Poland, the scenario leads to a substantial decarbonisation of the power sector, replacing some of the current dependency on coal and on gas with new energy sources. Under the GRP scenario, by 2025 the share of wind energy in power generation grows to 40% (up from around 13% in 2018). During the early stages of the pandemic, it was already seen in Poland that the level of coal-fired generation dropped off, giving way to other energy sources. With a potential increase in carbon prices, competition from renewables and EU climate ambitions (BloombergNEF 2020), these recovery actions – as it was shown in the employment results – could help to change the track of the economic and energy systems. Even in our GRP results, however, Poland shows new investments, after the capital subsidies for RES end, for coal-based power generation (hence the upward curve in emissions). This is a stark reminder that without a restriction on new coal investments, coal will, at least to some extent, remain a dominant force in Poland.

It is noticeable that the sensitivities show quite a wide range in the emissions results. In CZ, SK and HU the difference between the 'light' and the 'strong' sensitivities is about 5 percentage points in reduction compared to the pre-Covid baseline by 2030. In the case of Poland, the difference is even stronger: the 'strong' version results in reductions of about 10%, while in the 'light' version it is only about 4%. To put the numbers into context: reductions in PL could total to 150 $MtCO_2$ over the 2021–2030 period, which is equal to about half a year's total emissions in the country. In absolute terms this is the highest reduction, as PL has the highest emissions across the four countries, however the reduction is comparable in Hungary (reduction amounting to about 8 months), in Czechia (about 5 months) and even in the Slovak Republic (4 months).

5.4.3 Economic activity

Results are presented in Figure 5.5 In general the modelling indicates that there could be a bounce-back in GDP in 2021 following the easing of restrictions introduced because of the pandemic. The E3ME model parameter estimates determine the dynamics of the bounce-back. There is an immediate recovery in Poland, while the 'natural' pace of recovery is much slower in other countries.

Looking at the results of the GRP scenario in economic activity, just as in employment, two set of impacts are combined. First, the immediate effect of these government policies channelled through additional investments, and second the long-term effects of the induced transition. Economic recovery could be even faster in the GRP scenario than employment recovery, due to the slower reaction of labour markets.[5]

Long-term effects are positive in all cases when compared to the scenario with COVID-19 impacts and no recovery, and mostly positive even when compared to the pre-Covid baseline, showing effects of the energy transition as well as the recovery. This result is most prominent in Hungary, with an additional 4.0% of GDP (by 2030) compared to the scenario with COVID-19 impacts. Impacts in CZ, PL and SK, compared to the scenario with COVID-19 impacts, are 1.5, 1.3 and 0.3%, respectively by 2030. When compared to a pre-Covid baseline, the results are still positive, but the magnitude is much less prominent by 2030 in this case: Hungarian impacts show a 2.6% increase, with 0.8%, 0.6% and −0.5% in PL, CZ and SK, respectively.

As noted previously, due to the lack of large-scale energy system transition driven by subsidies, the results in the Slovak Republic do not show a stable increase, either in employment or in economic activity.

[5] This is a consistent result from econometric modelling. When demand increases, companies initially increase production without hiring more people (i.e. by improving efficiency or asking existing staff to work longer hours). Only once the increase in demand is seen to be permanent will companies increase employment levels. Recruitment also takes time, lengthening the lagged effect.

Figure 5.5: ***Economic activity** impacts in the modelled scenarios, the light-green area shows the results of the sensitivities, with the "light" sensitivity being the lower bound, while the "strong" sensitivity being the upper bound. Source: own work, based on E3ME model simulations.*

5.4.4 Public Financing

It is important to stress that the current simulation does not maintain government budget neutrality for its measures in the GRP scenario. Since the time of Keynes, fiscal stimulus has been a widely accepted response to recession (Keynes 1936). In the current economic climate, with the scope for monetary stimulus highly constrained, fiscal policy is expected to play a large role in economic recovery (Gopinath 2020). There is an ongoing debate on the magnitude and effect of this increased government spending, with some saying that much larger government deficits could be manageable (Greeley 2020), especially in countries with monetary sovereignty (Kelton 2020).

As noted previously, this paper takes an approach in which the costs of the policies are endogenous to the modelling. For example, a 50% percent capital subsidy on renewables was used as an input, without restricting the effect of such policy or restricting the amount of total subsidy. The total cost thus depends on the rate of renewables take-up. Furthermore, the COVID-19 impact scenario, which is treated as a point where the recovery starts, already includes announced short-term government fiscal interventions. This also provides an opportunity to compare the cost of the Green Recovery scenarios going forward.

The cost of the measures contained in the GRP scenario is estimated to be around 1% of GDP in Hungary and Slovakia, and to be about 1.5–2.5% in the Czech Republic and Poland annually. Figure 5.6 presents the composition and magnitude of the estimated costs. Although this is a substantial increase in current government spending, it is less than what has been already announced in other countries as an immediate response to the pandemic. For example, the immediate fiscal impulse in Germany is expected to be at least 8.3% of GDP. There are figures of 8.0 and 5.5% of GDP for the UK and Denmark respectively (Bruegel 2020). It should be noted that, in the case of the GRP the spending is a longer-term commitment, that could add up to larger amounts (e.g. in the case of Poland, the total is about 9% of 2020 GDP over the 5-year period), but even these amounts are within the ballpark range of already announced packages.

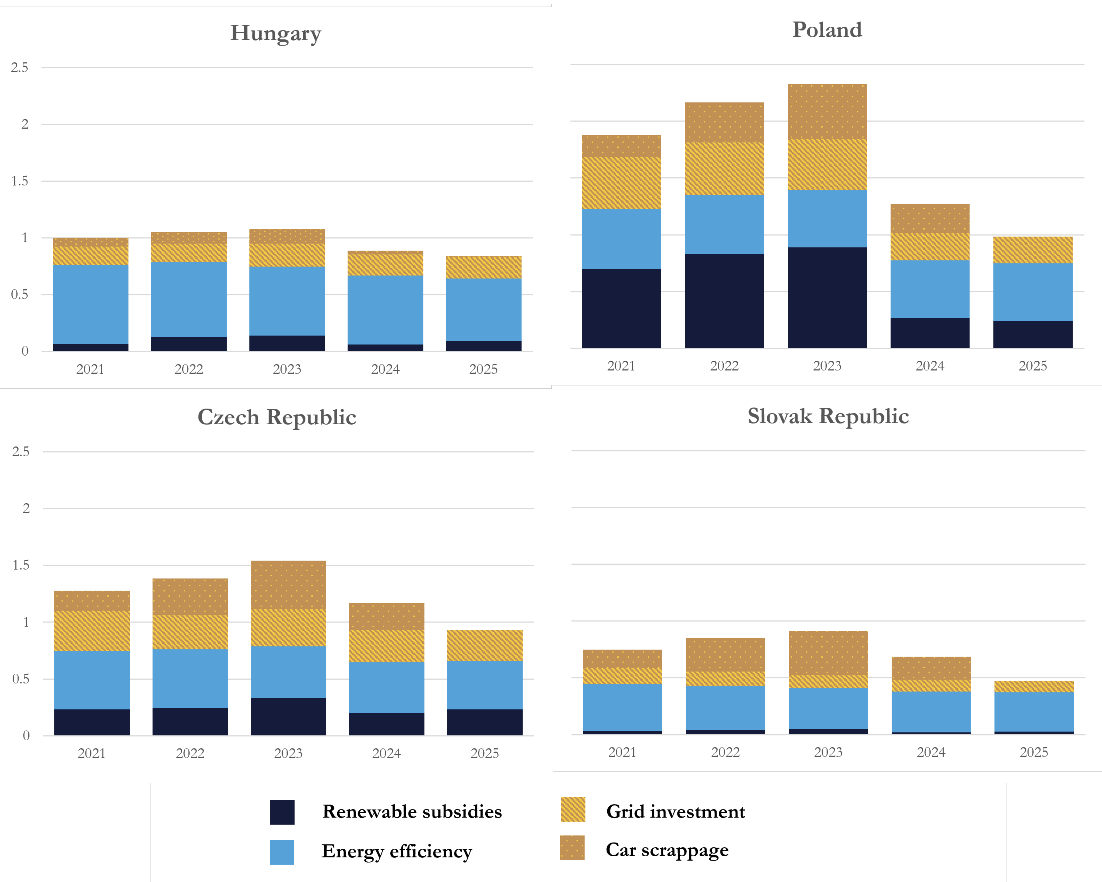


Figure 5.6: ***Cost of components in the modelled scenarios.*** *As % of the countries' GDP in the given year, Visegrad countries. Source: own work, based on E3ME model simulations.*

The composition of the costs for the Green Recovery scenario are quite different between countries. Energy efficiency costs are prominent in all countries, with car scrappage and RES subsidies, and thus grid investment, showing differing results. The differences are driven by the fact that, as noted previously, in these countries the subsidies bring down the costs of renewables by enough to trigger large-scale deployments, which can replace a major share of the current fossil-based energy generation (BloombergNEF 2020). Energy efficiency is relatively more important in Hungary and the Slovak Republic, which is largely due to differences in current levels of energy efficiency and what has been done in this area historically (Enerdata 2020).

5.5 Conclusion

The analysis presented in this paper focuses on the macroeconomic potential of Visegrad countries to undertake a 'green' recovery. The paper sets the case for a 'green' recovery, arguing that it is not only important to move into the direction of climate goals, but also could provide an important push towards pre-Covid levels of employment and economic activity.

The E3ME macroeconometric model was used to assess first the macroeconomic effects of COVID-19 on the economies of the four countries, second to simulate the outcomes of different magnitudes of a 'green' recovery program. Results obtained from the modelling exercise indicate differing impacts for the program across countries. In all countries, significant positive impacts can be observed on the short term: both in the Slovak Republic and the Czech Republic, as well as in Poland, the GRP induces a return in employment and economic activity to pre-Covid baseline within 3 years. In Hungary, the effect is similar, somewhat more muted in the short-term, but more persistent in the long term. This is an impact driven by initial investment stemming from the program policies, e.g. energy efficiency investment causes construction employment and thus higher incomes with spill-over effects, while increased EV sales mean higher sectoral consumption.

It can also be observed that this initial period induces large-scale RES deployment (see Figure D.1), which in turn drives further take up of RES even after the subsidies have been phased out. This, compared with the overall effect of higher employment and activity in the early (2021–2023) period, leads to long-term effects in all countries except the Slovak Republic. This long-term effect, by 2030, means that countries gain employment and GDP compared to the economic pathway caused by the pandemic, and even greater or equal to the pre-Covid baseline.

The different pace of recovery and the lack of long-term effects in Slovakia requires some attention. Induced RES investment, resulting from the GRP, is smaller in the Slovak Republic, which consequently leads to smaller long-term impacts, as the magnitude of the investments will not trigger a large-enough market transition towards renewables, which drives long-term outcomes in other countries.

As 'green' recovery programs, it is important that the measures decrease carbon-dioxide emissions. This condition is reached in all countries; however, not only the magnitude of reduction differs, but also the trend. An important result is that in Poland: emissions actually increase by the end of the period (i.e. 2030 compared to 2025). Once the RES subsidies end, coal returns to near cost-parity and path dependency means that investment in coal resumes, unless other measures are put in place. However, even considering this, with the GRP, next to a relatively impactful economic recovery, these countries can achieve CO_2 emission reductions amounting to 4–8 months of their current total emissions.

There are of course significant limitations in the analysis. Annual COVID-19 impacts are estimates based on observed impacts and assumptions. The spread of COVID-19 is an ongoing health crisis, and it may cause significant changes in our future economic behaviour. The assumptions of the design of the GRP are also largely based on previous studies (in some cases conducted outside the region), which may not be relevant here.

However, it is firmly believed by the authors, that it is important to think about such packages and to understand how they can impact the economy, taking into national characteristics into account. It is an important task to understand whether pursuing climate change mitigation and economic recovery at the same time is feasible, and to be able to determine how best to do this as well. This paper aims to do just that, focusing on a region that faces an important challenge and opportunity to tackle in the near-future.

6

Conclusion

6.1 Research outcomes

This thesis integrates four studies which start at the micro, employee level and stretch from there all to the macroeconomic, national level. In the Introduction (Chapter 1) I described a framework based on Chikán (2008) and Chikán et al. (2018) which establishes a linkage between the different layers of the economic system that I present in the chapters. Here in the conclusion I use this framework again, to recap and analyse how these impacts interact.

The outcomes discussed here can be largely classified into two categories: (1) a discussion of the various impact channels presented through the chapters that align with the framework based on Chikán (2008) and Chikán et al. (2018), (2) a discussion of general implications on the understanding of economic resilience and resilience building.

6.1.1 Selected impact channels of resilience

In this section, I discuss the various *impact channels* of resilience that are demonstrated in the chapters of the thesis and describe how they can be positioned in the overarching framework that I use. These examples show varying levels and processes of the economic system, where resilience and reaction to shocks of the various entities can have effects on other actors as well through interlinkages. The framework helps uncover some of these interlinkages, meanwhile I discuss commonalities these reactions and phenomena, irrespective of entities and layers of the economy, in the next section.

Chikán et al. (2018) and Chikán (2008) highlights the role of institutions in enabling competitiveness of firms and eventually leading to national competitiveness. Reflecting on this, I demonstrate in Chapter 4 how the overall competitiveness of nations with more focus on welfare-orientation proved to be more resilient. At the level of the firm, the model adapts ideas of the resource-based view, including how the heterogeneity of accessible resource, including human resources, can lead to differences competitiveness. In relation to this, in Chapter 2 and Chapter 3 I demonstrated that these type of 'resource' differences and differences in managerial capabilities does lead to different resilience and - facing the shock - performance outcomes. Finally, in Chapter 5 we see how existing systems and structures determine impacts of both shocks and certain recovery actions. This links to the long-term, institutional view of Chikán et al. (2018).

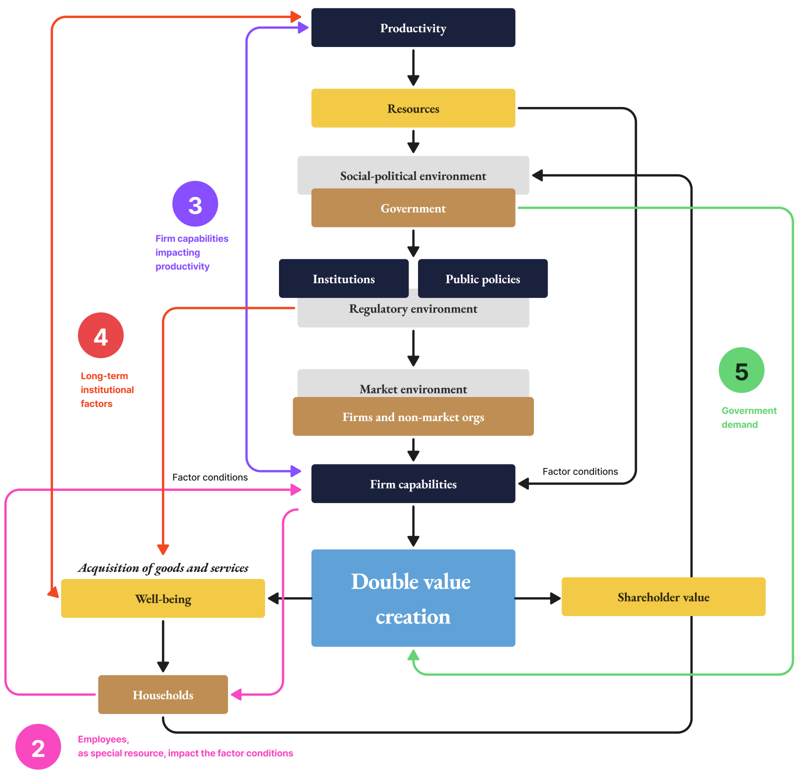


Figure 6.1: ***Framework of economic value creation and the proposed impact channels.*** *Source: own work, based on Chikán (2008) and Chikán et al. (2018).*

Figure 6.1 captures these impact channels visually in the framework built on Chikán (2008) and Chikán et al. (2018). The employee resilience that I discussed in Chapter 2 is mapped into the model as a connection between households (see bubble 2 and the pink lines), who supply the labour, and firm capabilities (based on Chikán (2008)) which includes factor conditions, e.g., access to necessary labour. However, rather than this being a one-directional connection my work suggests that this might need to be represented as a bidirectional connection, given that we have seen an example of firm capabilities (management practices) influencing the availability and quality of labour.

Then, considering the firm-level and the resource-based view, Chapter 3: access to resources and the ability to adapt determine overall productivity, especially when a shock happens. This is shown with the 3. bubble and the purple arrow. Crucially, this notion extends Chikan's model because it suggests that - at least in the case of shocks - there is a direct relation between productivity and firm capabilities. I hypothesise that this is mainly because during a shock, firm capabilities that are related to access to now scarce resources and the capability to re-configure have heightened importance. This would suggest that during these period dynamic capabilities (Teece 2012) too might have an increased role.

Finally, at the level of national economies and as for the role of government both Chapter 4 and Chapter 5 extend the initial model slightly. While Chapter 4 mostly emphasizes the relationship between productivity and well-being (which is stressed by Chikan and co-authors too, see Chikán

(2008) and Chikán et al. (2018)), it also highlights that there is a direct link between institutions / public policy and the well-being of households. Although, excluding this linkage might be explained by Chikan's focus on economic policy, while this might be seen as falling more into social policy. Nevertheless, Chapter 5 also extends the model because it highlights the role of government generated demand and direct government intervention in the market. With the re-emergence of industrial policy interventions (R. Juhász et al. 2024), especially with regard to crises, the model might need an extension here too, acknowledging that the government needs to take a role beyond guaranteeing fair market conditions and correcting market failures.

6.1.2 Commonalities in outcomes - resilience in general

These examples therefore, show ways how Chikan's framework can be extended, but they stay to be examples rather than a comprehensive re-analysis of the model, which would consider which extensions are fully necessary and what is the full theoretical basis for them. However, I believe it is important to show, that while the observed examples can be mapped into the model, and it can be shown how they impact parts of the economic system; these extension are necessary to get a picture that fits the observations better. I briefly return to this question in the Section 6.2 section.

All-in-all the framework provides us a good overview, because of how COVID-19 has impacted many layers of the economy simultaneously through a variance of factors. While there are various "level-specific" implications of the studies we can also identify common characteristics and patterns linking together responses in these /various layers of the economic system. This also links back to the general research questions that I have stated in the beginning (see page 5). Especially, *R1 "What are characteristics and behaviours that support resilience at the level of employees, firms and national economies?"* and *R2 "Are there more general commonalities in these behaviours?"*. In the next several paragraphs I discuss these implications, with a specific focus on general resilience-related implications.

First, **pre-existing conditions**, which are linked to *proactive resilience*, are in all contexts prove to be important. In the case of employees already existing experience with remote work, in the case of firms an existing direction towards digital solutions and in the case of nations a welfare focused government policy all contribute to stronger resilience.

Second, adaptation and flexibility is the basis of *reactive resilience*. However, adaptation can be difficult, and it needs to be supported to work. We see examples for this at the employee level - adaptation *can* happen (i.e., switching to new tasks if necessary), but without strong managerial support it might also lead to subpar employee performance. Similarly, at the national level we see how countries with established welfare policies fare better, e.g., in employment terms during the pandemic - welfare policies that enable adaptability and flexibility of the workforce. Finally, we too see this idea influence our recovery projections: it is a Keynesian tenet that during an economic downturn government spending can and should support demand in the economy (Jahan et al. 2014), my results show here that if this is done through adapting to a new economic-energy structure then several co-benefits can also be reaped.

And third, while I mostly discussed resilience in a positive light so far, the topic of trade-off between resilience and efficiency in the short term is inevitable. **The classical idea is to say that**

we only need redundancies and resilience building if the expected disruption from shocks multiplied by the probability of those shocks is higher than the cost of building resilience.

Nevertheless, this approach relies on a large variety of things to be *right*. In its core, it is a Cost-benefit analysis (CBA), which builds on a broad understanding of adverse events, including their magnitude and probability. To derive these variables, it often uses historical data assuming that what has happened in the past is a good indicator of what will happen in the future; and in numerous instances it looks at average impacts (from multiplying probabilities with magnitudes) (Stainforth 2024; Mercure et al. 2021). However, often this is not a suitable approach because (a) both the probabilities and the magnitudes of various natural events are changing - largely due to climate change - and (b) low probability events have very high magnitudes if they actually happen (so-called *fat-tail risks*) (Stainforth 2024; Avishai 2020; Taleb 2010; Mercure et al. 2021.

Therefore, even though the CBA minded assessment intends to take risks into account, in many cases it fails to actually account for *the real risks*. This, traditional, approach therefore underestimates the importance of resilience building in favour of efficiency. (Martin 2019) This, in turn can lead to massive failures in case of a real shock, just as it did in the case following COVID-19 for highly integrated and lean supply-chains (Bai et al. 2024).

The case that I therefore need to make, based on the experiences of COVID-19 related shocks, is twofold: **one, to account for unexpected risks, "black swans" and so-called fat-tail or heavy-tail uncertainties we need new methods beyond classical CBA-type assessments, we need to embrace the deep uncertainties that we face** (Taleb 2010; Mercure et al. 2021; Armstrong et al. 2025). This includes approaches such as the *'risk-opportunity'* approach of Mercure et al. (2021) or wider and more frequent applications of fail-safes in assessments, such as the precautionary principle

	Resilience building	Avoided damages	Costs	Co-benefits
Ch 1 - Employees	Enabling employees to gain WFH experience; managerial communication and support during adaptation	Task switching performance losses	Managerial time spent on building trust and communication	Loyalty, mental health of employees (P. Juhász et al. 2021; Sass et al. 2022)
Ch 2 - Firms	Relationship-oriented leadership, trust building; exploring digital solutions	Performance loss during shock	Managerial time spent on building trust and communication; time spent on exploring digital solutions	As above; potential yields from digital transformation (Dióssy et al. 2023)
Ch 3 - Nations	Welfare-oriented government policies	Competitiveness loss during shock	(in medium competitiveness) trade-off between general competitiveness and welfare	Competitiveness is on similar levels with both approaches
Ch 4 - Recovery	Reactive adaptation, using shock for systematic change	Long-term implications of COVID economic shock	Increasing debt, due to government spending	Forward looking: avoiding climate and energy security risks (Hartvig et al. 2024)

Table 6.1: *Examples of avoided damages, costs and co-benefits based on the chapters, references are provided, when the chapter does not directly make the co-benefit cases. Source: own work.*

(Kriebel et al. 2001). Consequently, new assessment are likely to increase the importance of resilience building over efficiency.

Second, the traditional approach largely considers resilience building opposed to efficiency. As I discussed earlier, in an efficient system resilience building is thought to be costly and only maintained in order to avoid damages, that are higher magnitude than the cost of resilience building (e.g., Nordhaus (2014), Tol (2011), Martin (2019), Landau (1969), Berbés-Blázquez et al. (2022), and Staveren (2023)). However, as this thesis illustrates through the chapters, **resilience building is not *necessarily* costly, in contrast, it can have economic value, not just through avoiding damages, but through other means (we can call them co-benefits) as well**. Resilience building that responds to well articulated risks can create new economic opportunities (Mercure et al. 2021), as well as they can lead to various co-benefits, that go beyond increasing resilience and therefore reducing damages from shocks. Table 6.1 presents examples of these from the previous chapters for various levels of the economic system. My findings here relate to the *R3 and R4* research question defined in the beginning (see page 5): *"How to these behaviours [i.e., building resilience] relate to performance in a non-shock environment?"*.

This pandemic has shown us that building resilience is valuable and as we live in an increasingly uncertain world it will be even more valuable tomorrow. Building resilience, however, starts with building trust and *treating employees well*, because, as it is shown, adaptability and flexibility, the components of *reactive resilience* are dependent on communication and trust among co-workers at the firm level and welfare policy and a social safety net at the national level. Building resilience, as I show through these examples, also does not have to be *"costly"*. In organisations adaptation can be supported just by talking clearly in frequently in stressful situations. While at the national level focusing on welfare and social policy, does not mean compromising competitiveness. Finally, when it comes to reactive resilience, as I have investigated, re-building and recovery can mean that we are *"building back better"*, enhancing our resilience towards other risks such as energy security or climate change, while repairing impacts of a shock.

Therefore, we can observe that things that have permanently changed during the pandemic in a positive direction were mostly continuations of existing tendencies: WFH and remote work opportunities have been increasing in most countries even before the pandemic, just as online retail. Meanwhile, we can also see that not all organisations and nations have reacted the same way and feared through the impacts of the pandemic with the same magnitude of damage. Scarring did happen in multiple economies and firms, who were not resilient enough in this situation, had to close down. This is why we have to analyse what we have observed during the pandemic and prepare ourselves for similar shocks using any insights that we can gain.

6.2 Limitations and further research

While the individual chapters (studies) often discuss their own methodological and other limitations, I find it important to discuss some general limitations of the thesis in this section as well. Given that the dissertation is focused on a complex topic (resilience) and aims to show examples from various layers of the economic system, it will necessarily be more of a snapshot of common behaviours than a comprehensive assessment. It is also tightly linked to the event itself: COVID-19, which was extraordinary in many aspects. Therefore, while I believe that there are general truths that these results underscore, as I discussed in the previous section, how much these findings can be generalized to other types of shocks is a difficult question.

When it comes to generalization, it further needs to be considered that all chapters (except Chapter 4) have a regional and/or country focus. Therefore, most of what I can confidently state is that these results are characteristic to Hungary and Central Eastern Europe. Although, as the reviewed literature shows, there is some evidence for other regions as well, I do not comprehensively review this.

Another important point is that most of this research has been carried out in the last five years, and many of the articles have focused on even shorter term impacts since the beginning of the pandemic. Chapter 2 analyses impacts a few weeks after the initial measures, Chapter 3 does this up to 2 years after the initial impacts, even Chapter 4 only looks into a couple of years of performance after the COVID-19 years. Long-term effects are, therefore, not studied in this dissertation and would need to be the subject of further research.

Furthermore, as discussed the dissertation presents research outcomes that mostly fit with the framework based on Chikán (2008) and Chikán et al. (2018), but it also suggests that extension would be preferable in order for the model to provide a more comprehensive and fitting picture of multi-level economic systems in times of shocks. However, further research would be necessary to provide sufficient grounding to these extensions, which can then also be supported by further empirical examples.

The extensions have three general directions: one is extending the model considering the economic and competitiveness effects of non-economic government policy, such as in Chapter 4, I suggest, based on the results, that social or health policy might be a factor as important as economic policy in terms of competitiveness when a shock happens.

Another potential extension is considering another aspect of government interventions: direct market interventions. It could be hard to reconcile this view with the ideology of the model, but with increasing industrial policy efforts (R. Juhász et al. 2024; Mazzucato 2021) and in general with the varieties of capitalism concept (Hall et al. 2001) it is important to see that governments often willing to take a more active role in shaping their economies. This has substantial impacts on competitiveness.

Additional to this, it would be interesting to further explore the impact channels of shock and resilience that I have demonstrated through the chapters. Specifically, studying interlinkages of resilience of the interlinked entities and layers of the economy could show valuable and important spill-over effects, that were not investigated in this dissertation.

Finally, Chikán (2008) have started with a model that considered firm capabilities in an RBV manner from the beginning. However, I call attention to the research outcome that firm capabilities can have impacts that go well beyond the standard role of the firm. E.g., good management can not only determine the firms position with regard to others on factor markets, but also can shape factor markets, by enhancing resilience of employees (Chapter 2, Chapter 3) or in general, their supply-chains. This way firm capabilities can have impacts beyond their competitive markets, having an impact on the broader society too.

All-in-all I believe that this dissertation shows some important evidence based on the COVID-19 shock about the nature and behaviour of various levels of the economic system in terms of their resilience and reactions to shocks. Ideally, these findings and ideas can be used to further thinking and research about building resilience, its relation to performance and competitiveness and preparing for shocks in varied levels of the economy against future shocks.

6.3 Five years after COVID

The COVID-19 pandemic and the related economic developments have changed various things in our life and in our economic systems. At the time of writing, it about five years have passed since the beginning of the pandemic. By now, most economies have recovered their economic activity to pre-COVID *levels* (see Figure 6.2 and Figure 6.3), and some, for example the US, even to pre-COVID trends (Robin Brooks et al. 2024; Fulford 2024). At the same time, however, as a result of government measures to restart the economy and supply-chain disruptions that are generally thought to be related to the pandemic, the world has experienced waves of broad-reaching inflation (Sevgili et al. 2025; Robin Brooks et al. 2024; IMF 2024). To make things worse, later periods of the recovery have coincided with major global geopolitical developments, such as the war in Ukraine, that has caused further economic disruptions in many parts of the world (Hartvig et al. 2024; IMF 2024).

Despite all of this, labour participation has mostly bounced back, restaurant consumption and retail sales have mostly recovered and inflation has largely stabilized (Sevgili et al. 2025) although prices have never settled back to earlier levels (Lerman et al. 2024). As Figure 6.4 shows price levels in the EU have stayed about 20% higher than they were in 2019, this means price levels that are about 12% higher than they would have been with a 2% inflation rate over this period. And although the magnitude of COVID-related inflation is shrinking in many countries, we can see that countries, who are also impacted by the geopolitical situation and the war in Ukraine, such as the Visegard

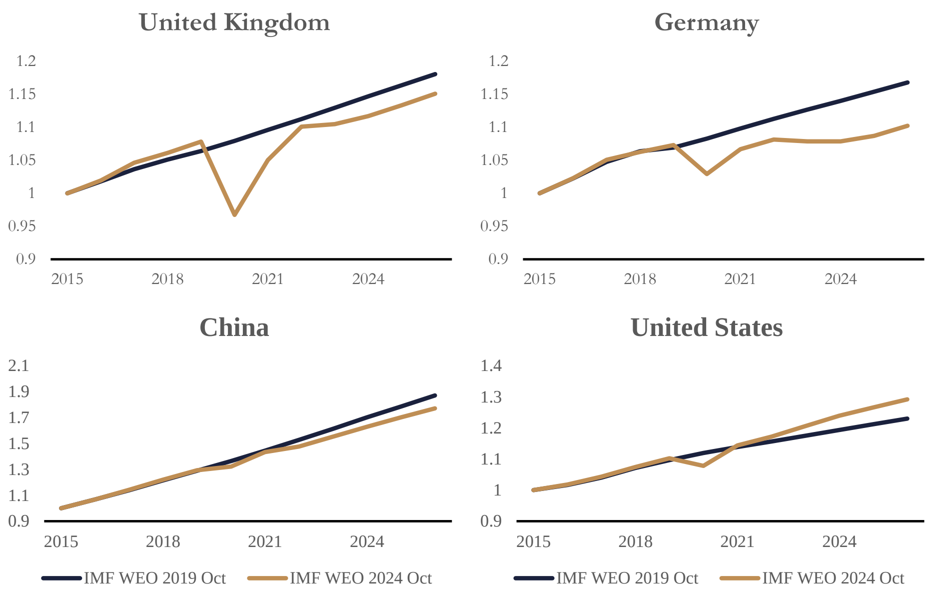


Figure 6.2: ***GDP growth projections in the selected economies: UK, US, Germany, China.*** *Constant price GDP index; 2015=1.0. The dark blue line shows WEO 2019 Oct based projections, while the yellow-brown line shows WEO 2024 Oct data. Source: own work, based on IMF (2019) and IMF (2024).*

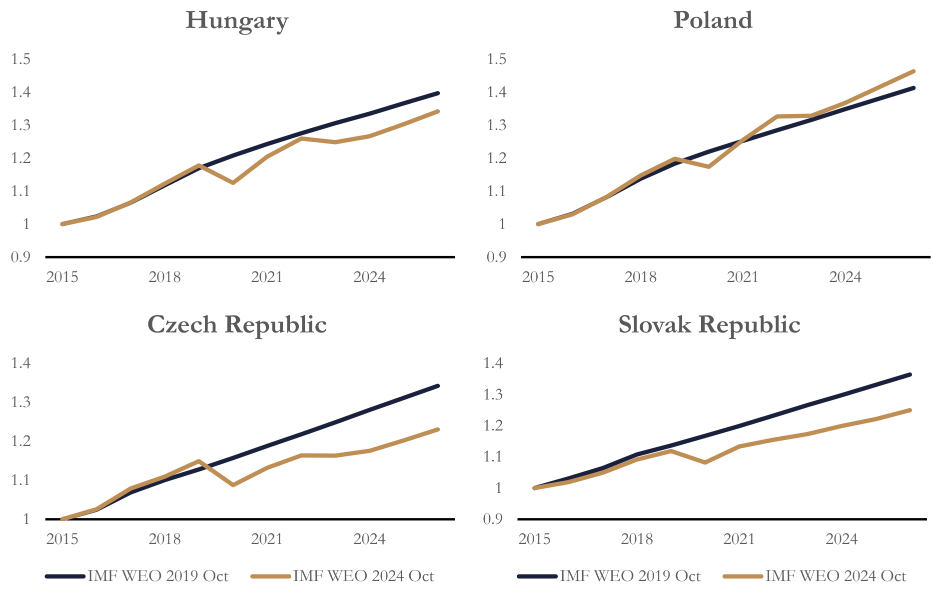


Figure 6.3: ***GDP growth projections in the selected economies: Visegrad countries.*** *Constant price GDP index; 2015=1.0. The dark blue line shows WEO 2019 Oct based projections, while the yellow-brown line shows WEO 2024 Oct data. Source: own work, based on IMF (2019) and IMF (2024).*

countries, have seen higher inflationary pressures in the last few years too (see Figure 6.4).

But there have been other permanent changes too: online sales, that has been increasing its market share even before the pandemic has surged during it and never settled back. In Europe, it now accounts for about 16% of all retail sales, up from 11% before the pandemic (Sevgili et al. 2025). Remote work and WFH, which has too got popular during the pandemic has also settled at higher levels that before (Pabilonia et al. 2024; Fulford 2024). WFH is also reported to contributed to productivity gains in various industries (Pabilonia et al. 2024; Bloom et al. 2024; Bloom et al. 2025). Even though (at least in the US) it has been observed that higher productivity due to hybrid and WFH options, did not lead to higher compensation in parallel (Pabilonia et al. 2024).

In the EU, WFH stabilized at levels higher than pre-pandemic. In the EU27, about 8% more of all employees reported in 2023 to work at least sometimes from home compared to 2019. The change is positive in Visegrad countries as well, Figure 6.5 shows rates between 2017-2023 for the selected countries. Except Poland, where the rate was on EU-average levels even before the pandemic, in all countries the rate of employees who are able to work at least sometimes from home has increased by 3-5% compared to before the pandemic.

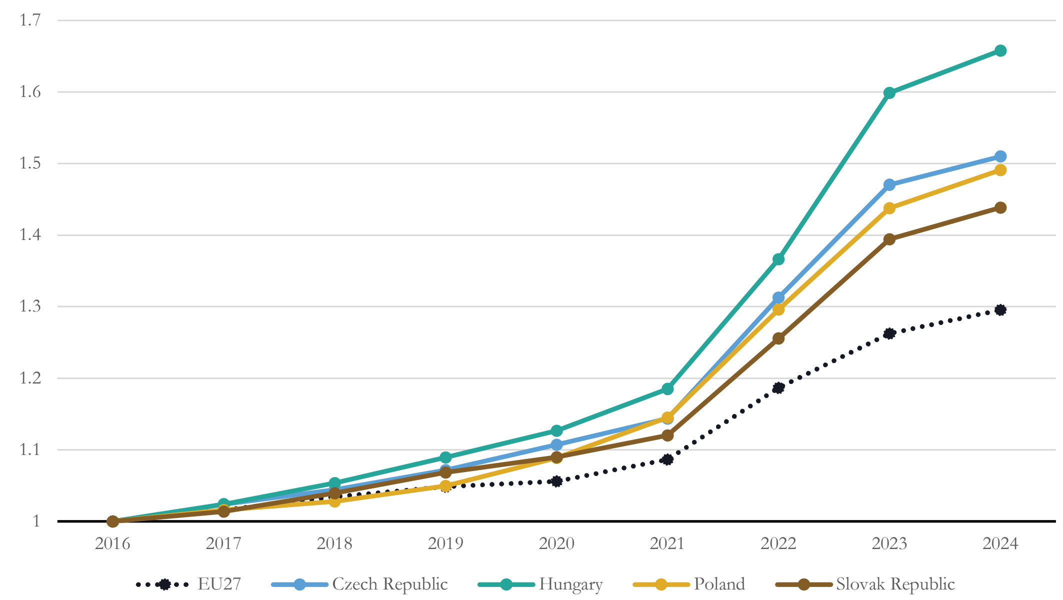


Figure 6.4: ***Consumer price index (HICP) for selected economies, 2016-2024.*** *2016=1.0. Source: own work, based on Eurostat (2025), HICP - annual data (average index and rate of change).*

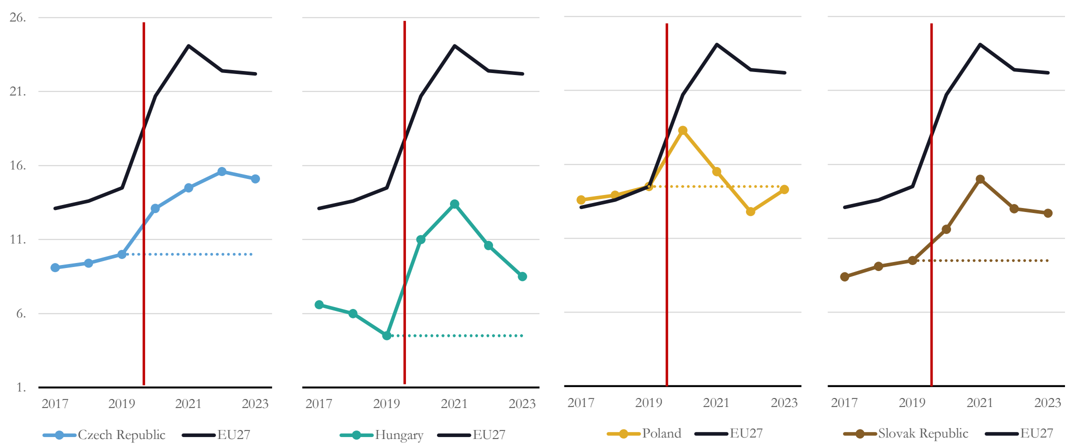


Figure 6.5: ***Percentage of employees reporting at least some WFH 2017-2023 in selected economies.*** *Percentage of all employees (15-64 years). Source: own work, based on Eurostat (2024a), Employed persons working from home as a percentage of the total employment, by sex, age and professional status (%).*

6.4 Looking forward

Where are we in 2025? Even with COVID-19 more-or-less gone, we live in an uncertain world. Volatile geopolitics, international conflict, trade wars, the impacts of climate change and the menace of new epidemics threaten our global economic systems.

For much of the last decade of the 20th century and the first decade of the 21th century we felt that globalisation, international systems and trade have reached a pinnacle, and we are moving toward a truly international world, with most risks mitigated or at least insured. Francis Fukuyama, a political scientist, famously credited with stating that we have reached *"the end of history as such"* (Fukuyama 1989, p. 2). This has, as I have discussed, given rise to a primacy of efficiency and monetary performance because risk was generally expected to be low; therefore higher efficiency meant higher profits and higher performance (returns) were required - as the risk level were low and similar across opportunities.

With the second decade of the 21st century, this has seemingly changed. COVID-19 has been followed by a variety of new uncertainties (and have been preceded by some). *Resilience* is an increasingly important factor, either we are talking about extreme weather events, geopolitical threats or global supply-chains that are disrupted by politics. Unless uncertainties drop to levels seen in the previous two decades, a re-balancing between efficiency and resilience needs to happen in order for the world to be prepared for new shocks. This, coincidentally, also means focusing on building up and maintaining resources (including human resources) rather than trying to maximize their productivity.

Resilience building can and should be more people focused than a focus on efficiency is. For resilient systems, we need resilient employees and redundancies, which could mean more jobs and more support for employees and people in general. We are looking at systems that are, indeed, could be less efficient, however could work better for everyone and withstand more shocks than an efficient system, that always aims to maximise its use of resources.

I believe that in the coming decades, which could be easily be decades when we will face further uncertainties, competitiveness will be even more dependent on resilience and on the good management and maintenance of resources, including human resources. Firms and nations should plan for the long-term, with redundancies included and with people in focus, even if this comes at a price of less efficiency overall. As for, efficiency is meaningless if there are no resources that can be efficient.

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7

Key publications in the topic of the PhD dissertation

7.1 Peer-reviewed publications

Ergon, J., Larsson, M., Finnveden, G., Karlsson, M., Gutzianas, I., and **Kiss-Dobronyi, B.** (2025): Modelling policy packages with combined climate, social, and macroeconomic goals: the Swedish case, *Climate Policy*, Ahead-of-print, DOI:10.1080/14693062.2025.2531098.

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7.2 Other publications

Chikán, A., **Kiss-Dobronyi, B.**. (2022): Inventory principles after the COVID-19 pandemic [In Hungarian]. *Logisztikai Híradó* 32 (5): 10–12.

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7.3 Conference presentations

Kiss-Dobronyi, B., Lewney, R., Chitiga-Mabugu, M., Mbona, N. (2023 Jun): Interactions between recovery and energy policy in South Africa, Third Young Scholars Conference on Structural Change and Industrial Policy, YSI

Kiss-Dobronyi, B (2022 Dec): Advancing a green and fair economic transformation in a crisis-driven World: The role of macro-economic modelling, UN PAGE - UN DCO seminars

Kiss-Dobronyi, B. (2022 Sept): Stocktaking of economic, social, and environmental impacts of sustainable recovery, including impacts on NDC implementation, Socialization of Presidency Studies of Climate Sustainability Working Group, G20 Presidency Indonesia

Chikan, A. & **Kiss-Dobronyi, B.** (2022 Aug): An Inventory Paradigm Revisited in the COVID era, International Symposium on Inventories, International Society for Inventory Research

Chikan, A., Czako, E. & **Kiss-Dobronyi, B.** (2022 April): Connection between supply chain resilience characteristics and firms' performance in the pandemic, IPSERA Annual Conference, IPSERA

Kiss-Dobronyi, B. & Szekeres, M. (2021 Dec): Working from home: occupations and performance, results from Hungary, Pandemic Shock and its Consequences for Business and the Economy, WSB University in Poznan

Kiss-Dobronyi, B. (2021 March): Using the tools we have to estimate the economic impacts of COVID-19, GSI-CE research colloquium, University of Exeter

Pollitt H., **Kiss-Dobronyi, B.** (2021 Feb): Using the tools we have to estimate the economic impacts of COVID-19, Colloquium on Computational Social Science/Computational Data Sciences, George Mason University

Kiss-Dobronyi, B., Pollitt, H., Lewney, R., Kramer, B., Massie, E. & Tuijp, P. (2020 December): Assessment of impacts of COVID19 and crisis recovery packages, Thirteenth IAMC Annual Meeting 2020, Integrated Assessment Consortium

8

Changes to the PhD proposal after the dissertation draft debate

This section lists changes made to the dissertation draft following the dissertation draft debate on Aug 29, 2025.

Nbr	Page	Change
1	67	Added a section to describe how the modelled 'Green Recovery Program' relates to programs implemented by the EU.
2	24	Added a section to clarify the rationale for excluding observations without tertiary education.
3	96-116	Adjusted and corrected bibliography in order to meet requirements of the Rules of Operation of the Doctoral School of Business and Management (16.10.2024). Adjusted the title of the bibliography to 'References'.
4	163	Adjusted Appendix references in order to meet requirements of the Rules of Operation of the Doctoral School of Business and Management (16.10.2024).
5	117	Amended author's list of publications with new publications, corrected details of previous publications.
6	4	Extended *General introduction* to discuss efficiency-resilience trade-off and related hypotheses.
7	ix	Removed JEL codes.
8	4	Changed title of the section 1.2 from 'General introduction' to 'A general overview of the thesis'. Amended the text of the section to discuss the format of the thesis as well as the structure of the Appendices.
9	xiv	Added 'References' and 'Alphabetic index' to the ToC. Removed Appendix tables and figures from the list of tables and list of figures.
10	NA	Adjusted chapter titles based on feedback received.
11	7	Added discussion of the section's structure.
12	viii	Adjusted the abstract based on feedback received.
13	17	Amended the section to describe the relationship to the above presented framework in more detail.
14	5	Amended the section with more explicitly stated general research areas.
15	89	Added a 'Limitations' section, summarising some major limitations of the dissertation.

Continued on the next page

Summary of changes made

Nbr	Page	Change
16	4	Added author CRediT statement to summary table of articles.
17	117	”List of relevant works by the author” and ”Changes to the document” moved out from appendix to their own sections.
18	61	Expanded the discussion of the description of the groups to describe how they relate to Peter A. Hall’s varieties of capitalism concept.
19	15	Added a subsection to discuss *economic resilience* especially focusing on units of analysis and outcome variables.
20	2	Extended the personal introduction to discuss my initial research topic.
21	16, 85, 89	Rewritten and extended the discussion around Chikan’s 2008 and 2018 model. In the conclusion I discuss how the observed phenomena points to necessary extension of the model, while in the limitations and further research part I discuss what further actions would be needed.
22	multiple pages	Revised case capitalization of academic fields.
23	85	Replaced ’people’ with ’employees’ in multiple places to reflect a narrower focus.
24	117, 85	Revised section titles according to supervisor recommendations.
25	16, 85	Revised figure titles in line with supervisor recommendations.
26	87	Added further text to elaborate the discussion of general resilience related implications, as well as its relationship with the original research questions.
27	85	Adjusted figure 6.1 based on supervisor comments.
28	85	Added further description / grouping of the research outcomes based on supervisor comments.
29	90	Extended limitations to discuss the further exploration of *impact channels* identified.

[cont’d] Summary of changes made

Alphabetical Index

Appendices

A

Appendix A

Appendix to the chapter Within a Firm: Employees and Management Issues in the Pandemic.

A.1 Composition of the limited sample

only ISCED11 5-8 categories, N=469

Table A.1: *Composition of the used sample; ISCED11 5-8 categories, N=469; population shares (based on KSH / HCSO data), unweighted and weighted (raking) shares*

Sex	population	unweighted sample	weighted sample
Male	**0.45**	0.36	0.45
Female	**0.55**	0.64	0.55
Age	**population**	unweighted sample	weighted sample
15-24	**0.02**	0.03	0.02
25-54	0.84	0.90	0.84
55-64	0.14	0.07	0.14
Region	population	unweighted sample	weighted sample
Budapest	0.33	0.61	0.33
Pest	0.14	0.04	0.14
Kozep-Dunantul	0.09	0.03	0.09
Nyugat-Dunantul	0.09	0.11	0.09
Del-Dunantul	0.06	0.05	0.06
Eszak-Magyarorszag	0.07	0.05	0.07
Eszak-Alfold	0.11	0.05	0.11
Del-Alfold	0.10	0.08	0.10

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Table A.2: *(cont'd) Composition of the used sample; ISCED11 5-8 categories, N=469; population shares (based on KSH / HCSO data), unweighted and weighted (raking) shares*

Occupation	population	unweighted sample	weighted sample
Managers	0.09	0.27	0.10
Professionals	0.57	0.58	0.59
Technicians and associate professionals	0.19	0.09	0.20
Clerical support workers	0.06	0.05	0.06
Service and sales workers	0.05	0.01	0.05
Skilled agricultural, forestry and fishery workers	0.01	0.00	0.00
Craft and related trades workers	0.01	0.00	0.00
Plant and machine operators and assemblers	0.01	0.00	0.00
Elementary occupations	0.00	0.00	0.00
Armed forces occupations	0.00	0.00	0.00

A.2 Questions used for analysing the role of communication and management on employees resilience

[13] Do you use any of the following in your daily work?

Method	**Yes, more frequently** (3)	**Yes, as usual** (2)	**Yes, started recently** (1)	**No** (0)	**N/A**
Email	☐	☐	☐	☐	☐
Chat	☐	☐	☐	☐	☐
Teleconferencing software	☐	☐	☐	☐	☐
Project management platform	☐	☐	☐	☐	☐
Common network / cloud storage	☐	☐	☐	☐	☐
Other collaboration software	☐	☐	☐	☐	☐

B

Appendix B

Appendix to the chapter Firm Behavior and Performance in the Pandemic.

B.1 Testing for pre-existing group differences

To confirm that the two analysed groups are similar before the shock effect, we have concluded multiple statistical tests. First, we have analysed the regional and employee-number (as a categorical variable) composition of the groups using the Cochran-Armitage and Fisher's exact tests. The test have reported no significant difference between the groups. This was followed by running the same tests for the exact recorded employee number and the age of the firm. The t-test that we have used for this has shown no significant difference for employee number ($t(51) = -1.68$, $p=0.1$), however, the difference between the means (122 vs 220) shows that in the 'weaker performing' group we generally have smaller firms. We did not find a significant difference in terms of age ($t(17) = 16.9$, $p=0.7$). This was followed by testing for differences between revenue pre-2020 (log transformed) and how much have the firms' revenues differed from the industrial averages (Orbis and KSH/HCSO).

Based on the t-test results (Table B.1) there is no significant difference between the group means in most years; there is also no significant difference in mean deviation from KSH/HCSO industry averages, except in 2019. Here the deviation of the 'weaker performing' group is slightly smaller, than the 'average performing' group ($p=0.03$). Nevertheless, we do observe significant difference in terms of deviation from the Orbis industry averages between the two groups. Based on the t-test results (Table B.1) this difference is significant in all years; and it also shows visually (Figure B.1). The magnitude of deviation consistently lower in the 'weaker performing' group. I.e., the Orbis industry average has consistently produced a better fitting prediction for these firms in the past. All-in-all, this means that revenue prediction for 2020 will probably be more sensitive, based on Orbis, for these firms; a smaller change might be able to push the result outside of the accepted threshold. However, as we use the Orbis and KSH/HCSO based predictions in tandem, we assume that this will not be an issue for the final predictions.

B.2 Correlations between highlighted variables

Table B.1: *Results of t-test on selected variables of the groups*

Variable	Year	Degrees of freedom	Test statistic	p-value
Revenue	2015	21.39	-0.74	0.47
	2016	18.99	-0.71	0.49
	2017	19.94	-0.69	0.5
	2018	17.55	-0.4	0.69
	2019	16.52	-0.58	0.57
Deviation from KSH/HCSO industry average	2015	13.74	-0.76	0.46
	2016	15.63	-0.09	0.93
	2017	12.8	-1.46	0.17
	2018	11.46	-1.1	0.29
	2019	11.71	-2.44	0.03***
Deviation from Orbis industry average	2015	11.18	-2.19	0.05***
	2016	17.11	-1.79	0.09***
	2017	10.02	-2.8	0.02***
	2018	7.76	-2.1	0.07***
	2019	7.46	-2.7	0.03***

*Note: *** for $p<0.1$*

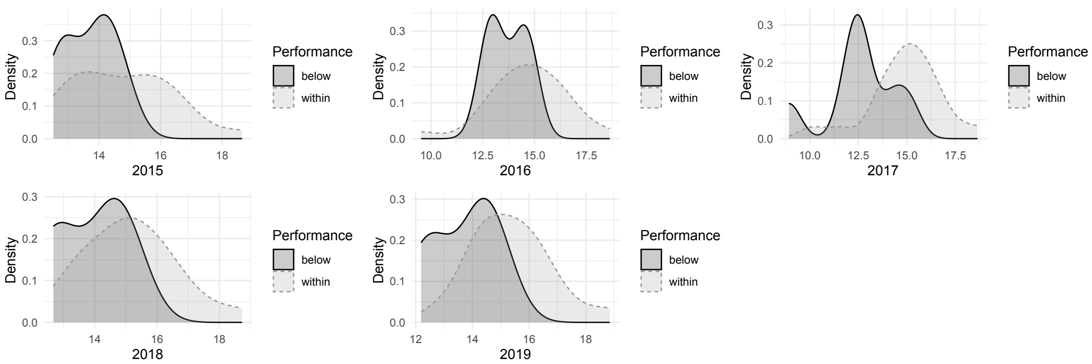


Figure B.1: *Distribution of deviation from Orbis industry averages across the years.*

Table B.2: *Correlation coefficients between variables that show significant differences between the 'weaker' and normal group. Coefficients over 0.2 are shown.*

	v4b	v13f	v42d	v43c	v49h	v50a	v58a	v14b	v32a	v47d	v47e	v47g
v4b		0.51	0.27	0.35	0.46	0.34	0.65		0.43			
v13f	0.51	1.00	0.35		0.43	0.58	0.61	0.31	0.48	0.36		
v42d	0.27	0.35	1.00		0.66			0.27	0.22	0.33	0.45	0.56
v43c	0.35			1.00		0.34	0.24		0.56		0.26	
v49h	0.46	0.43	0.66		1.00	0.25			0.21	0.22	0.47	0.27
v50a	0.34	0.58		0.34	0.25	1.00	0.48		0.50	0.47		
v58a	0.65	0.61		0.24		0.48	1.00		0.60			
v14b		0.31	0.27					1.00			0.27	
v32a	0.43	0.48	0.22	0.56	0.21	0.50	0.60		1.00	0.23		
v47d		0.36	0.33		0.22	0.47			0.23	1.00	0.24	0.64
v47e			0.45	0.26	0.47			0.27		0.24	1.00	0.45
v47g			0.56		0.27					0.64	0.45	1.00

B.3 Further figures of question set results

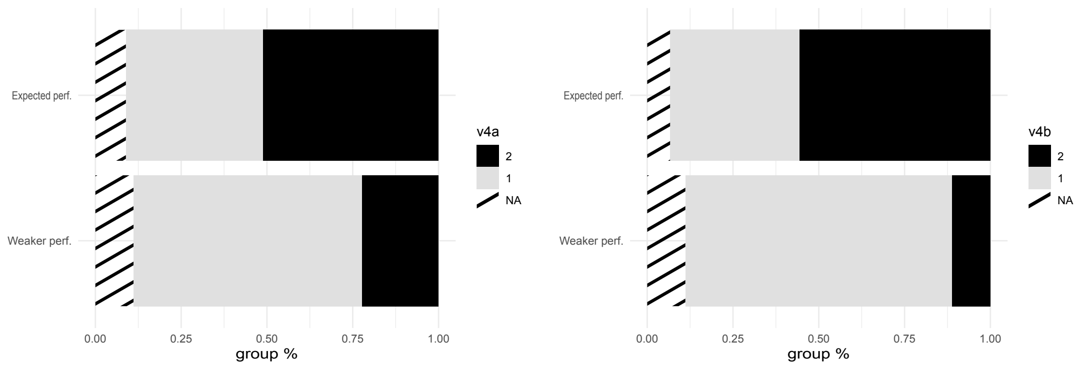


Figure B.2: *V4 question set (owner and family) responses.*

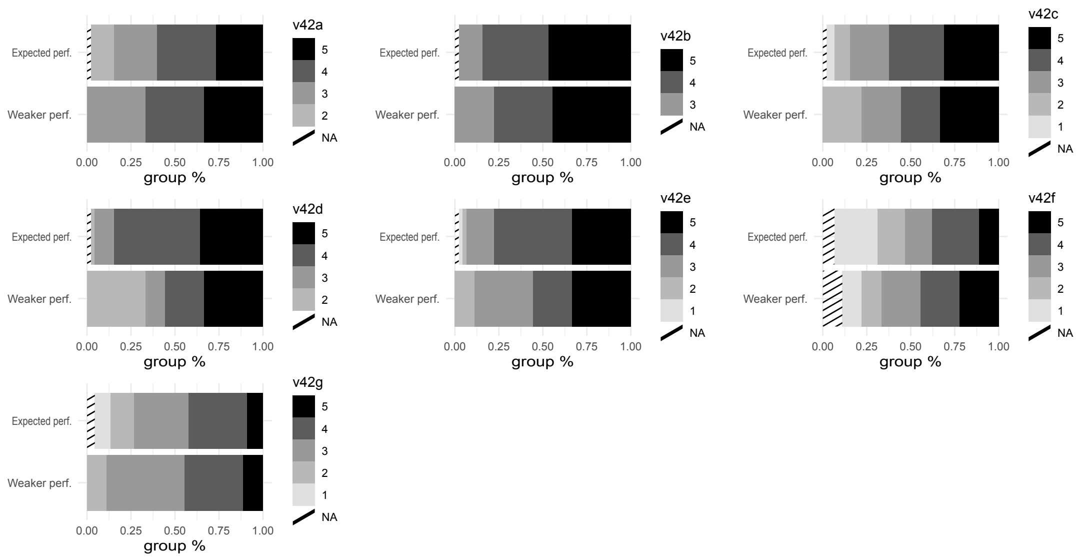


Figure B.3: *V42 question set ("How much influence does the following group has on your environmental practices?") responses.*

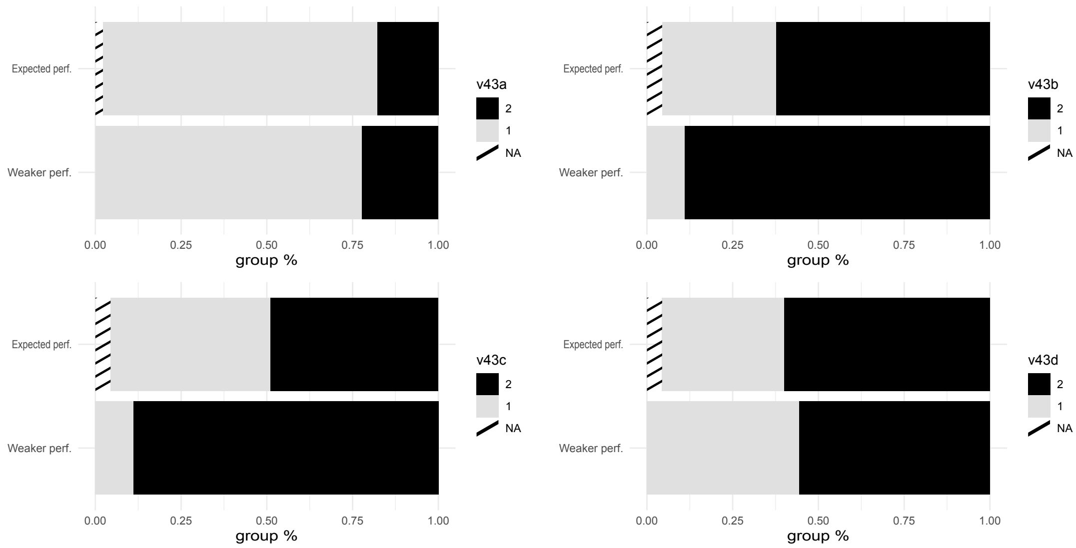


Figure B.4: *V43 question set ("Does your firm employ the following managerial methods?") responses.*

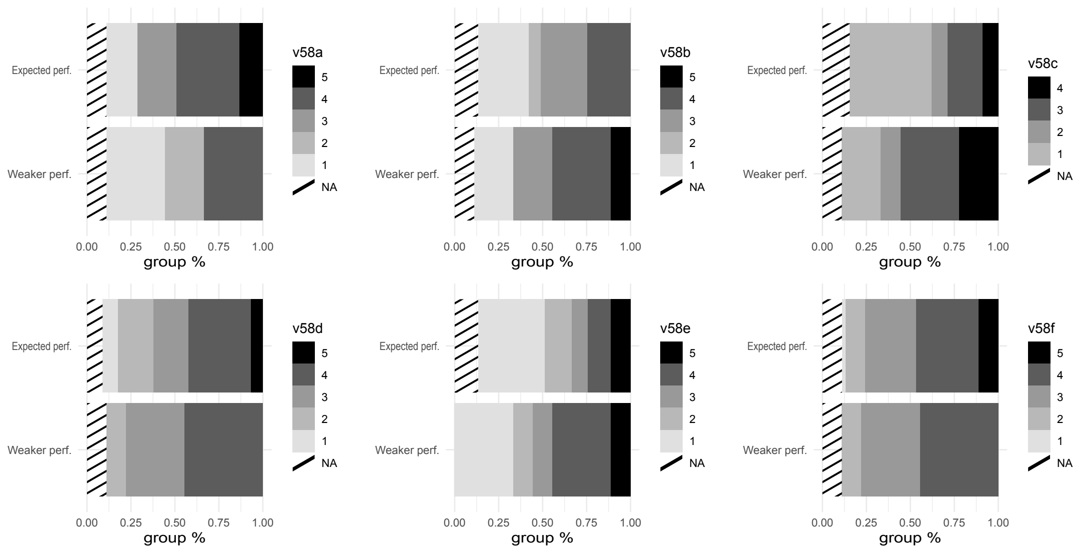


Figure B.5: *V58 question set ("How does your firm addresses labour shortage issues?") responses.*

B.4 Selected / used questions from the CRC questionnaire

V4	**Which statement describes your firm best?**		
		a) yes	b) no
a)	There is a family with at least 50% ownership of the company.	1	2
b)	The owner and/or their relatives actively particpate in the management of the firm.	1	2

Table B.3: *V4 question and potential responses.*

V13	**What do you consider a major risk for your firm?** (1 – not important, 3 – average, 5 – most important)					
a)	shrinking demand	1	2	3	4	5
b)	decline of the customer's ability to pay	1	2	3	4	5
c)	loss of customers (termination, exit from market)	1	2	3	4	5
d)	loss of suppliers or contractors (termination, exit from market)	1	2	3	4	5
e)	input issues (e.g., lack of inventory)	1	2	3	4	5
f)	shrinking financing opportunities	1	2	3	4	5
g)	uncertainty of business environment	1	2	3	4	5
h)	labour shortage	1	2	3	4	5
i)	increased labour costs	1	2	3	4	5
j)	regulatory changes	1	2	3	4	5
k)	new competitors, fiercer competition	1	2	3	4	5
l)	technological changes	1	2	3	4	5
m)	unethical conduct	1	2	3	4	5
n)	hostile acquisition	1	2	3	4	5

Table B.4: *V13 question and potential responses.*

B.5 Test results for all variables

V14	**Please evaluate to what extent the following statements are true for your company! The goal of our company is...** (1 – definitely not, 5 – definitely)					
a)	... to serve our customers.	1	2	3	4	5
b)	... to achieve the highest possible profit.	1	2	3	4	5
c)	... to increase shareholder value.	1	2	3	4	5
d)	... to survive and maintain future opportunities.	1	2	3	4	5
e)	... to achieve substantial growth.	1	2	3	4	5

Table B.5: *V14 question and potential responses.*

V32	**How well the following statements describe your company?** (1 – strongly disagree 3 – undecided 5 – strongly agree)					
a)	Management understands digital challenges and opportunities facing the company.	1	2	3	4	5
b)	The leadership has clearly defined the organisation's digital business strategy.	1	2	3	4	5
c)	The implementation of digital transformation projects is carried out in a defined manner.	1	2	3	4	5
d)	We have allocated appropriate financial resources for planning and executing the digital business transformation.	1	2	3	4	5
e)	Our organisation possesses the technological knowledge and capabilities necessary for digital business transformation.	1	2	3	4	5
f)	Bottom-up ideas for digitalisation are supported in our company.	1	2	3	4	5
g)	We can quickly adapt our digital solutions to meet business challenges.	1	2	3	4	5
h)	We are willing to take risks by introducing innovative digital solutions.	1	2	3	4	5
i)	We keep track of the leading digital solutions in the industry.	1	2	3	4	5
j)	We assess the applicability of new digital technologies to our business needs.	1	2	3	4	5
k)	We are ahead of our competitors in applying digital solutions.	1	2	3	4	5

Table B.6: *V32 question and potential responses.*

V42	**How much influence does the following group has on your environmental practices?** (1 – not important, 3 – moderately important, 5 – very important)					
a)	Administration (government, municipal govt., regulators)	1	2	3	4	5
b)	Owner	1	2	3	4	5
c)	Local citizens	1	2	3	4	5
d)	Customers	1	2	3	4	5
e)	Employees	1	2	3	4	5
f)	Unions	1	2	3	4	5
g)	Environmental groups or organisations	1	2	3	4	5

Table B.7: *V42 question and potential responses.*

V43	**Does your firm employ the following practices?**		
		a) yes	b) no
a)	Quality management system (e.g., ISO 9000)	1	2
b)	Health and safety management system (e.g., OHSAS 18001)	1	2
c)	Environmental Management System (e.g., ISO 14001, EMAS)	1	2
d)	Code of Ethics	1	2

Table B.8: *V43 question and potential responses.*

V47	**How important it is for a good leader to...** (1 – not at all, 2 – slightly, 3 – moderately, 4 – very, 5 – extremely)					
a)	Clearly sets goals, carefully monitors implementation, and intervenes if deemed necessary.	1	2	3	4	5
b)	Clearly and convincingly communicates the goals, discusses the tasks together, and entrusts the implementation to colleagues, who can turn to them if they feel necessary.	1	2	3	4	5
c)	The key performance indicators (KPIs) convey the company's goals to the managers and subordinates.	1	2	3	4	5
d)	Performance indicators (KPIs) are only part of the leadership toolkit; it is necessary for both managers and employees to take ownership of the goals.	1	2	3	4	5
e)	The leader's task is professional guidance, precise direction, and supervision.	1	2	3	4	5
f)	The leader's task is to personalize the goals, set an example, and mobilize towards implementation.	1	2	3	4	5
g)	The leader's tasks include providing emotional and professional support and development for their colleagues.	1	2	3	4	5
h)	The leader's tasks are largely aimed at ensuring that their colleagues perform their tasks as well as possible.	1	2	3	4	5
i)	Building trust is an important leadership task because it enables the creation of innovative solutions.	1	2	3	4	5
j)	In the work organisation trust is based on control and monitoring.	1	2	3	4	5

Table B.9: *V47 question and potential responses.*

V58	**How does your firm addresses labour shortage issues?** (1 – never, 3 – occasionally, 5 – always)					
a)	reskilling and upskilling	1	2	3	4	5
b)	encourage mobility, employees from more distant locations	1	2	3	4	5
c)	recruiting foreign employees	1	2	3	4	5
d)	outsourcing processes	1	2	3	4	5
e)	automatization, employing industrial robotics	1	2	3	4	5
f)	process reorganisation, efficiency improvements (decreasing labour demand)	1	2	3	4	5

Table B.10: *V58 question and potential responses.*

Table B.11: *Fisher- and Cochran-test results for all variables*

Variable	Fisher's exact test (p)	Cochran-Armitage test (p)	# Obs group 1	# Obs group 2	Variable	Fisher's exact test (p)	Cochran-Armitage test (p)	# Obs group 1	# Obs group 2
x_alapitas	0.51	0.76	9	45	v40c	1.00	0.76	9	41
x_agazat	NA	NA	9	45	v40d	1.00	0.96	9	41
x_regio	0.76	0.41	9	45	v40e	0.72	0.62	9	41
x_letszamk	0.19	0.39	9	45	v40f	0.46	0.34	9	41
v1	0.11	0.07	8	43	v40g	1.00	0.75	9	41
v2	NA	NA	8	42	v40h	1.00	0.92	9	41
v3	0.50	0.08	8	44	v41a	0.04	0.28	9	44
v4a	0.14	0.11	8	41	v41b	1.00	0.77	9	43
v4b	0.02	0.01	8	42	v41c	0.37	0.36	9	44
v5a_a	0.43	0.59	5	27	v41d	0.28	0.13	9	44
v5a_b	0.59	0.58	5	27	v41e	0.52	0.26	9	44
v5a_c	0.04	0.62	6	27	v41f	0.17	0.62	9	44
v5b_a	0.38	0.38	6	25	v41g	0.26	0.35	9	44
v5b_b	0.18	0.51	6	24	v41h	0.84	0.70	9	44
v5b_c	0.23	0.75	7	24	v41i	1.00	0.92	9	44
v6	0.83	0.56	5	26	v41j	1.00	0.88	9	44
v7a	0.91	0.46	9	44	v42a	0.84	0.48	9	44
v7b	0.75	0.85	9	44	v42b	0.78	0.65	9	44
v7c	0.46	0.51	9	44	v42c	0.77	0.80	9	44
v7d	0.21	0.09	9	44	v42d	0.03	0.04	9	44
v7e	0.72	0.42	9	44	v42e	0.32	0.39	9	44
v7f	0.39	0.39	9	44	v42f	0.84	0.32	8	42
v7g	0.32	0.67	9	44	v42g	0.97	0.54	9	43
v7h	0.19	0.10	9	42	v43a	1.00	0.78	9	44
v8a	0.61	0.64	9	44	v43b	0.24	0.16	9	43
v8b	0.89	0.45	9	44	v43c	0.06	0.04	9	43
v8c	0.72	0.92	9	44	v43d	0.72	0.68	9	43
v8d	0.25	0.61	9	44	v44	0.63	0.77	9	43
v9	0.69	0.60	6	30	v45	0.42	0.91	8	41
v10	0.74	0.45	7	29	v46a	0.62	0.27	9	42
v11	0.39	0.49	7	28	v46b	0.77	0.49	9	42
v12	0.59	0.61	6	26	v46c	0.55	0.89	9	42
v13a	0.35	0.57	9	44	v46d	0.94	0.51	9	42
v13b	0.15	0.28	9	44	v47a	0.02	0.59	9	42
v13c	0.49	0.11	9	44	v47b	0.23	0.67	9	42
v13d	0.22	0.08	9	44	v47c	0.80	0.85	9	41
v13e	0.66	0.64	9	44	v47d	0.06	0.03	9	41
v13f	0.05	0.04	9	44	v47e	0.05	0.03	9	42
v13g	0.55	0.50	9	44	v47f	0.90	0.85	9	42
v13h	0.30	0.80	9	44	v47g	0.00	0.01	9	42
v13i	0.21	0.75	9	44	v47h	0.68	0.72	9	42
v13j	0.54	0.43	9	44	v47i	0.02	0.36	9	42
v13k	0.00	0.43	9	44	v47j	1.00	0.79	9	42
v13l	0.03	0.15	9	44	v48a	0.33	0.44	9	42
v13m	0.12	0.36	9	44	v48b	0.11	0.25	9	42
v13n	0.20	0.52	9	44	v48c	1.00	0.69	9	42

Table B.12: *(cont'd) Fisher- and Cochran-test results for all variables*

Variable	Fisher's exact test (p)	Cochran-Armitage test (p)	# Obs group 1	# Obs group 2	Variable	Fisher's exact test (p)	Cochran-Armitage test (p)	# Obs group 1	# Obs group 2
v14a	0.81	0.97	9	44	v48d	0.28	0.28	9	42
v14b	0.01	0.00	9	44	v48e	0.10	0.68	9	42
v14c	0.47	0.12	9	44	v48f	0.81	0.70	9	42
v14d	0.85	0.65	9	44	v48g	0.25	0.24	9	42
v14e	0.86	0.79	9	44	v48h	0.65	0.96	9	42
v15	0.75	0.80	9	44	v48i	0.52	0.26	9	42
v16a	1.00	0.65	9	44	v48j	0.61	0.96	9	42
v16b	0.90	0.61	9	44	v48k	0.52	0.45	9	42
v16c	0.29	0.45	9	44	v48l	0.37	0.48	9	42
v16d	1.00	0.72	9	44	v48m	0.89	0.45	9	42
v16e	0.47	0.96	9	44	v48n	0.21	0.49	9	42
v16f	0.41	0.69	9	44	v48o	0.10	0.73	9	42
v16g	0.34	0.27	9	44	v48p	0.68	0.87	9	42
v16h	0.76	0.61	9	43	v49a	0.03	0.66	7	33
v16i	0.23	0.23	9	44	v49b	0.50	0.19	7	32
v16j	0.93	0.99	9	44	v49c	0.11	0.06	7	33
v16k	0.33	0.11	9	44	v49d	0.15	0.06	7	33
v16l	0.94	0.40	9	44	v49e	0.14	0.09	7	33
v16m	1.00	0.64	8	43	v49f	0.23	0.15	7	33
v16n	1.00	0.51	9	44	v49g	0.30	0.52	7	33
v16o	0.54	0.32	9	44	v49h	0.07	0.10	7	33
v16p	0.89	0.44	9	44	v50a	0.08	0.09	6	28
v17a	0.25	0.20	9	44	v50b	0.65	0.54	2	18
v17b	1.00	0.50	9	44	v50c	0.20	0.58	3	16
v17c	0.23	0.22	9	44	v50d	0.09	0.09	5	22
v17d	0.35	0.61	9	44	v50e	0.21	0.33	2	15
v17e	0.32	0.71	9	44	v50f	0.60	0.92	3	18
v17f	0.91	0.99	9	44	v50g	0.58	0.63	5	23
v17g	0.71	0.16	9	44	v50h	0.64	0.38	4	23
v17h	0.29	0.19	9	44	v50i	0.63	0.63	4	21
v17i	0.18	0.20	9	44	v50j	0.06	0.04	2	21
v17j	1.00	0.90	9	44	v50k	0.79	0.68	6	21
v17k	0.24	0.52	9	44	v50l	0.67	0.67	5	30
v17l	0.53	0.46	9	44	v50m	0.80	1.00	7	21
v18a	0.46	0.45	9	44	v51a	0.27	0.16	9	44
v18b	0.56	0.95	9	44	v51b	0.71	0.47	9	43
v18c	0.54	0.53	9	44	v51c	0.72	0.64	9	43
v18d	0.73	0.79	9	44	v52a	1.00	0.40	6	37
v18e	0.79	0.45	9	44	v52b	0.57	0.20	5	35
v18f	0.25	0.89	9	44	v52c	1.00	0.60	4	34
v18g	0.98	0.72	9	44	v52d	0.67	0.53	6	34
v18h	0.90	0.23	9	44	v52e	0.60	0.35	4	30
v18i	0.95	0.66	9	44	v52f	1.00	0.69	3	22
v18j	0.90	0.99	9	44	v53	0.35	0.14	9	38

Table B.13: *(cont'd) Fisher- and Cochran-test results for all variables*

Variable	Fisher's exact test (p)	Cochran-Armitage test (p)	# Obs group 1	# Obs group 2	Variable	Fisher's exact test (p)	Cochran-Armitage test (p)	# Obs group 1	# Obs group 2
v19a	0.70	0.31	9	44	v54a_a	0.24	0.16	5	23
v19b	0.44	0.99	9	44	v54a_b	0.75	0.86	6	24
v19c	0.86	0.89	9	44	v54a_c	0.05	0.96	6	24
v19d	0.71	0.16	9	44	v54a_d	0.19	0.58	6	23
v19e	0.76	0.31	9	44	v54b_a	0.95	0.89	5	26
v19f	1.00	0.71	9	44	v54b_b	0.38	0.81	6	27
v19g	0.54	0.86	9	44	v54b_c	0.50	0.77	6	27
v19h	1.00	0.28	9	44	v54b_d	0.68	0.82	6	27
v19i	0.60	0.73	9	44	v55a	1.00	0.82	9	39
v20a	1.00	0.41	9	43	v55b	1.00	0.76	9	39
v20b	0.48	0.13	9	43	v55c	0.22	0.18	7	36
v20c	0.01	0.19	9	43	v55d	1.00	0.75	7	35
v20d	0.06	0.92	9	43	v56	0.94	0.74	9	43
v20e	0.69	0.79	9	43	v57	0.26	0.78	9	43
v20f	0.57	0.20	9	43	v58a	0.02	0.08	8	40
v21	0.29	0.08	9	43	v58b	0.35	0.23	8	39
v22a	0.69	0.63	9	43	v58c	0.29	0.10	8	38
v22b	0.57	0.28	9	43	v58d	0.88	0.54	8	41
v22c	0.42	0.29	9	43	v58e	0.82	0.45	9	39
v22d	0.38	0.33	9	43	v58f	0.90	0.78	8	40
v22e	0.72	0.64	9	43	v59a_a	1.00	0.64	9	43
v23	1.00	0.83	9	42	v59b_a	0.36	0.19	7	38
v24	0.62	0.66	8	35	v59a_b	1.00	0.41	9	43
v26	1.00	0.49	9	40	v59a_c	0.72	0.57	9	42
v27	NA	NA	2	0	v59b_c	0.25	0.31	3	17
v28	0.36	0.59	9	36	v60a	0.91	0.19	8	42
v29	0.22	0.61	9	39	v60b	0.87	0.86	9	44
v30a	1.00	0.82	9	44	v60c	0.43	0.32	9	44
v30b	0.01	0.86	9	44	v60d	0.90	0.85	9	44
v30c	1.00	0.65	9	44	v60e	0.94	0.71	9	44
v30d	0.81	0.40	9	44	v60f	0.82	0.55	9	44
v30e	0.48	0.21	9	44	v60g	0.58	0.67	9	44
v31	0.25	0.69	9	44	v61a	0.85	0.89	9	44
v32a	0.01	0.03	9	44	v61b	0.82	0.53	9	44
v32b	0.85	0.44	9	42	v61c	0.58	0.40	9	44
v32c	0.87	0.44	9	43	v61d	0.93	0.78	9	44
v32d	0.68	0.32	9	43	v62a	0.90	0.60	9	43
v32e	0.10	0.29	9	44	v62b	1.00	0.90	9	43
v32f	0.97	0.80	9	42	v62c	0.26	0.30	9	42
v32g	0.73	0.58	9	43	v62d	0.50	0.46	9	44
v32h	1.00	0.81	9	44	v62e	0.34	0.70	9	44
v32i	0.78	0.56	9	42	v62f	0.24	0.32	7	18
v32j	0.28	0.72	9	43	v63a	0.67	0.36	9	44
v32k	0.77	0.59	9	42	v63b_a	1.00	0.41	1	9
v33	0.18	0.33	5	30	v63b_b	1.00	0.20	1	9
v34	0.26	0.19	9	43	v63b_c	0.50	0.43	1	9

Table B.14: *(cont'd) Fisher- and Cochran-test results for all variables*

Variable	Fisher's exact test (p)	Cochran-Armitage test (p)	# Obs group 1	# Obs group 2	Variable	Fisher's exact test (p)	Cochran-Armitage test (p)	# Obs group 1	# Obs group 2
v35a	0.71	0.60	9	44	v63b_d	1.00	0.68	1	9
v35b	0.79	0.43	9	44	v63b_e	0.30	0.11	1	9
v35c	0.93	0.38	9	44	v63b_f	0.40	0.13	1	9
v35d	0.38	0.20	9	44	v63b_g	1.00	0.21	1	9
v35e	0.38	0.11	9	44	v63b_h	0.60	0.10	1	9
v35f	1.00	0.98	9	44	v64a	0.42	0.13	9	39
v36a	0.64	0.76	7	41	v64b	1.00	0.56	9	39
v36b	0.28	0.45	8	41	v64c	0.88	0.62	9	38
v36c	0.52	0.94	9	43	v64d	0.58	0.49	9	39
v36d	0.71	0.32	9	42	v64e	1.00	0.80	9	39
v36e	0.48	0.43	9	43	v64f	0.46	0.93	9	39
v36f	0.53	0.79	9	43	v64g	0.17	0.94	9	38
v36g	0.95	0.87	9	43	v64h	0.80	0.57	9	39
v36h	0.21	0.79	9	43	v64i	0.85	0.92	9	38
v36i	0.28	0.76	9	43	v64j	0.72	0.43	9	38
v36j	0.23	0.48	9	43	v64k	1.00	0.67	9	39
v36k	0.81	0.15	9	43					
v36l	0.32	0.09	9	41					
v36m	0.15	0.43	7	36					
v36n	0.85	0.78	8	40					
v37a	1.00	0.94	9	44					
v37b	0.41	0.42	9	43					
v37c	0.67	0.36	9	44					
v38	1.00	1.00	3	15					
v39	0.86	0.37	6	15					
v40a	1.00	0.76	9	41					
v40b	1.00	0.96	9	41					

Table B.15: *ARIMAX specification and relevant parameter estimate p-values for the firms in the sample*

	Orbis					KSH/HCSO				
	(p,d,q)	p-value				(p,d,q)	p-value			
	ARIMA	AR1	MA1	Intercept	X	ARIMA	AR1	MA1	Intercept	X
1	0,0,0				0.00	0,0,0				0.00
2	0,0,0				0.00	0,0,0				0.00
3	0,0,0				0.00	0,0,0				0.00
4	0,0,0				0.00	0,0,0				0.00
5	1,0,1	0.80	0.58	0.00	0.00	0,0,0				0.00
6	0,0,0				0.00	0,0,0				0.00
7	0,0,0				0.00	0,0,0				0.00
8	0,0,0				0.00	0,0,0				0.00
9	0,0,0				0.00	0,0,0				0.00
10	0,0,0				0.00	0,0,0				0.00
11	0,0,0				0.00	0,0,0				0.00
12	0,0,0			0.00	0.00	0,0,0				0.00
13	0,0,0				0.00	0,0,0				0.00
14	0,0,0				0.00	0,0,0				0.00
15	0,0,0				0.00	0,0,0				0.00
16	0,0,0				0.00	0,0,0				0.00
17	0,0,0				0.00	0,0,0				0.00
18	0,0,0				0.00	0,0,0				0.00
19	0,0,0				0.00	0,0,0				0.00
20	0,0,0				0.00	0,0,0				0.00
21	1,0,1	0.51	0.63	0.00	0.45	1,1,0	0.08			0.32
22	0,0,0				0.00	0,0,0				0.00
23	1,0,1	0.83	0.85	0.81	0.00	0,0,0				0.00
24	0,0,0				0.00	0,0,0				0.00
25	0,0,0				0.00	0,0,0				0.00
26	0,0,0				0.00	0,0,0				0.00
27	0,0,0				0.00	1,0,1	0.74	0.70	0.50	0.34
28	0,0,0				0.00	0,0,0				0.00
29	0,0,0				0.00	0,0,0				0.00
30	0,0,0				0.00	0,0,0				0.00
31	0,0,0				0.00	0,0,0				0.00
32	0,0,0				0.00	0,0,0				0.00

Table B.16: *(cont'd) ARIMAX specification and relevant parameter estimate p-values for the firms in the sample*

	Orbis					KSH/HCSO				
	(p,d,q)	p-value				(p,d,q)	p-value			
	ARIMA	AR1	MA1	Intercept	X	ARIMA	AR1	MA1	Intercept	X
33	0,0,0				0.00	0,0,0				0.00
34	0,0,0				0.00	0,0,0				0.00
35	0,0,0				0.00	0,0,0				0.00
36	0,0,0				0.00	0,0,0				0.00
37	0,0,0				0.00	0,0,0				0.00
38	0,0,0				0.00	0,0,0				0.00
39	0,0,0				0.00	0,0,0				0.00
40	0,0,0				0.00	0,0,0				0.00
41	0,0,0				0.00	0,0,0				0.00
42	0,0,0				0.00	0,0,0				0.00
43	0,0,0				0.00	0,0,0				0.00
44	0,0,0				0.00	0,0,0				0.00
45	0,0,0				0.00	0,0,0				0.01
46	0,0,0				0.00	0,0,0				0.00
47	0,0,0				0.00	0,0,0				0.00
48	0,0,0				0.00	0,0,0				0.00
49	0,0,0				0.00	0,0,0				0.00
50	0,0,0				0.00	0,0,0				0.00
51	0,0,0				0.00	0,0,0				0.00
52	0,0,0				0.00	0,0,0				0.00
53	0,0,0				0.00	0,0,0				0.00
54	0,0,0				0.00	0,0,0				0.00
55	0,0,0				0.00	1,0,1	0.94	0.59	0.04	0.49
56	0,0,0				0.00	0,0,0				0.00
57	0,0,0				0.00	0,1,0				0.79
58	0,0,0				0.00	0,0,0				0.00
59	0,0,0				0.00	0,0,0				0.00

C

Appendix C

Appendix to the chapter National Competitiveness Patterns and the Pandemic.

C.1 Pillars of the IMD and the WEF competitiveness rankings and our model framework

Table C.1: *Matching of the pillars of the IMD and the WEF to the key elements of our model framework*

Corresponding pillars of the IMD competitiveness ranking	Key factors of our framework for analyzing national competitiveness	Corresponding pillars of the WEF competitiveness ranking
Basic Infrastructure, Domestic Economy, Scientific Infrastructure, Technological Infrastructure	**Resources**	Infrastructure, Market size, Technological readiness
Attitudes and Values, Education, Health and Environment	**Social-political environment**	Health and primary education, Higher education and training
Business Legislation, Institutional Framework, Public Finance, Tax Policy, Societal Framework	**Government and Regulatory environment**	Institutions, Macroeconomic environment
Employment, Finance, International Trade, International Investment, Labor Market, Prices	**Competitive business environment**	Financial market development, Goods market efficiency, Labor market efficiency
Management Practices, Productivity and Efficiency	**Companies and Value creation**	Business sophistication, Innovation

C.2 Linkage of the steps of the analytical process to the theoretical model

Figure C.1: *Linkage of the steps of the analytical process to the overall model: (1) establishing relationship between government performance and components of competitiveness, (2) clustering countries based on components of their governmental performance, (3) testing whether countries with similar competitiveness, but different governmental structure have performed differently during the COVID-19 crisis*

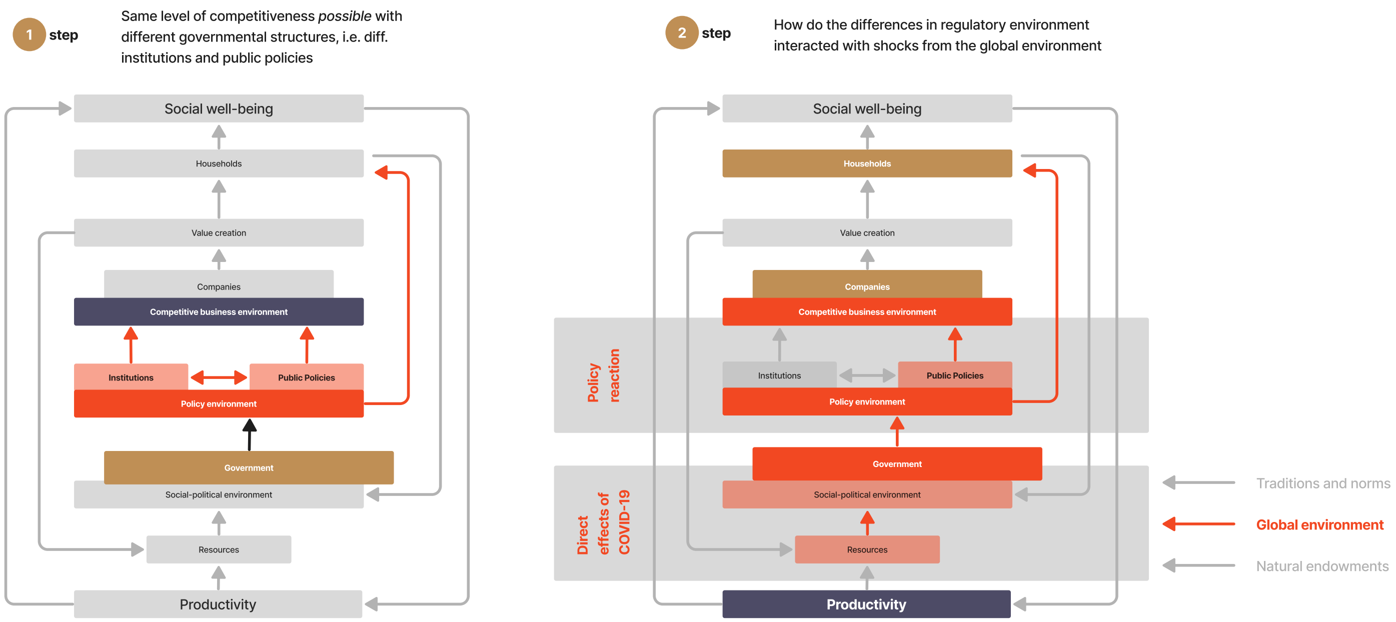


Figure C.2: *Structure of the IMD competitiveness score and its subsequent pillars, this figure has been reproduced from the IMD World Competitiveness Yearbook 2021 edition, the page numbers shown correspond to the page numbers in the report; detailed content of the pillars is described here*

C.3 Adjustments to the IMD competitiveness score

The composition of IMD scores applied in our analysis changes slightly from year-to-year, therefore the raw scores are not directly comparable across years. To alleviate this discrepancy, we standardize scores in each year and exclude outlier countries with extreme values (Argentina and Venezuela). The Z-score method (Glantz et al., 2016) is applied, where x is the observed value, $\hat{x}$ is the mean of the variable, S is the sample deviation:

$$z = \frac{x - \hat{x}}{S} \tag{C.1}$$

Figure Figure C.3 and Figure C.4 below presents the distributions of main variables before and after normalization. Similar transformations are used in the literature to obtain comparable scores (Kiseľáková et al., 2018).

Figure C.3: *IMD scores and component scores across years before and after normalization as described in the text - before*

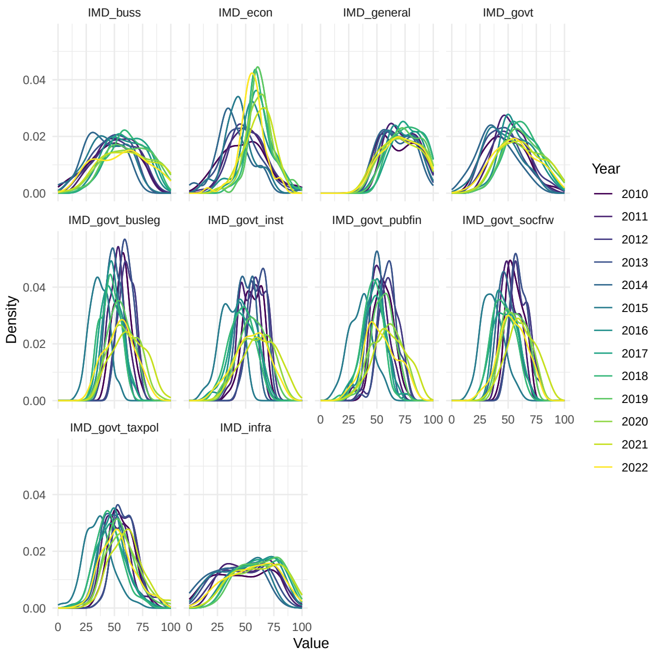
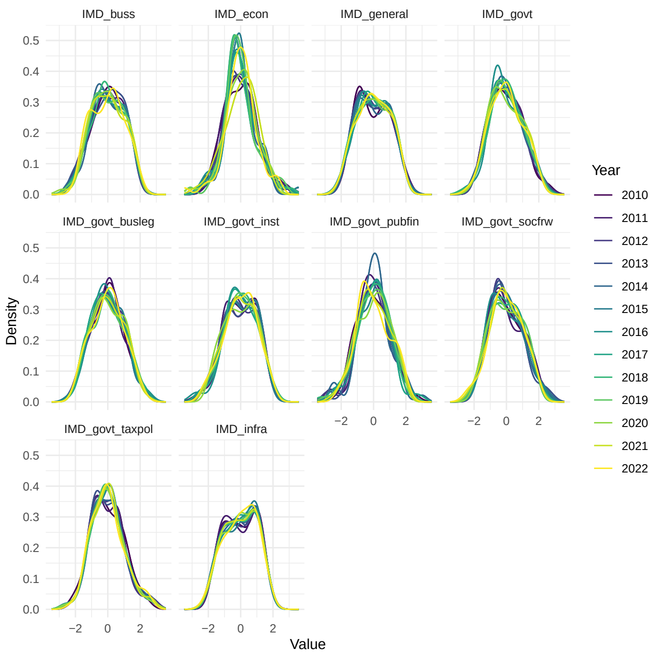


Figure C.4: *IMD scores and component scores across years before and after normalization as described in the text - after*



C.4 Constructing national competitiveness scores excluding government efficiency

We construct the national competitiveness scores excluding government efficiency by running a simple OLS regression, where the dependent variable is the overall national competitiveness score, while the independent variables are the components. Table C.2 shows the results.

Table C.2: *Regression results used for determining component weights*

Dependent Variable:	IMD overall score (z-score)
Model:	(1)
Variables	
Constant	-2.64×10^{-16}
	(0.0053)
Business efficiency (z-score)	0.3228***
	(0.0032)
Government efficiency (z-score)	0.2687***
	(0.0027)
Infrastructure (z-score)	0.3359***
	(0.0020)
Economic performance (z-score)	0.2365***
	(0.0019)
Fit statistics	
R^2	0.99845
RMSE	0.03904
F-test	30,265.9
Wald (joint nullity)	30,265.9

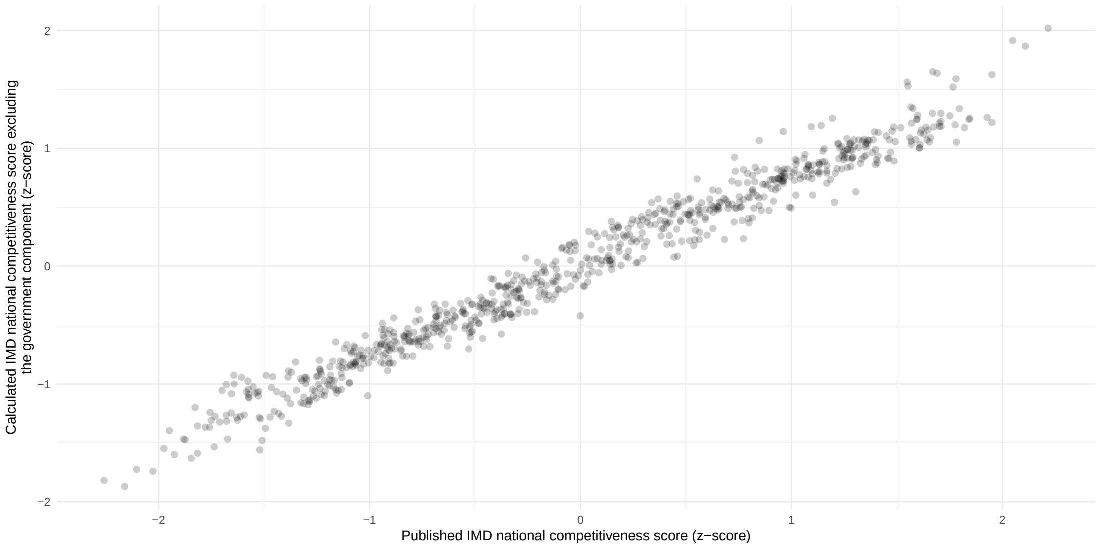
IID standard-errors in parentheses
*Signif. Codes: ***: 0.01, **: 0.05, *: 0.1*

Results of the regression yields weights for the now normalized factor scores (i.e., the weight of government efficiency Z-score is 0.2687 in the overall IMD score), with a high explanatory power (R^2=0.998). See the regression results in Figure A4 in the Annex. The overall score, excluding government efficiency (accounting for the other three key pillars only: business efficiency, infrastructure, economic performance) is derived using the estimated parameters:

$$y = z_{buss} \times .3228 + z_{infra} \times .3359 + z_{econ} \times .2365 \tag{C.2}$$

where y is the new IMD competitiveness score, excluding the government efficiency pillar, z_{buss} is the z-score transformed competitiveness index of the business efficiency pillar, z_{infra} is the score of the infrastructure pillar, while z_{econ} is the score of the economic performance pillar. The defined new y variable has a 0.9852 correlation with the original IMD competitiveness score across all years as shown below on Figure C.5.

Figure C.5: *Correlation between the original IMD competitiveness score (Z-score, x-axis) and the competitiveness score excluding the government efficiency component (y-axis), all relevant years*



C.4.1 The connection between government efficiency and national competitiveness

As a first step of the analysis, we transform the overall national competitiveness index to exclude the government efficiency sub-pillar and establish that there is a stable and positive relationship between perceptions of national competitiveness and government efficiency. However, government efficiency itself is a component of the overall IMD national competitiveness score in the IMD rankings. Therefore, we construct an indicator that excludes Government efficiency from the overall IMD competitiveness score (*IMD_constructed*) and accounts only for the other components instead: Business efficiency, Infrastructure, and Economic performance. Description of how we built this indicator is detailed in the Appendix (see Section 4.2).

The approach of isolating the Government efficiency pillar presupposes that the experimental variable (different governmental configuration) is responsible for the observed differences, whilst the rest of the environment (the other components of competitiveness) remains largely unchanged at least in terms of to focus of our analysis. It is assumed that the five pillars together capture all drivers of competitiveness performance; therefore, by isolating one of them whilst keeping the others unchanged (which are affected by impacts common to all countries in the year of the treatment) we can assess the explanatory power of different governmental configuration in isolation.

We specify two models where the *IMD_govt* score explains the constructed indicator score (*IMD_constructed*), noting that what we measure here is a correlation between the variables rather than causality. Model (1):

$$IMD_{i,t} = \alpha + \beta_1 IMD_{i,t}^{govt} + \epsilon \tag{C.3}$$

$$\tag{C.4}$$

where $IMD_{i,t}$ is the national IMD competitiveness score (normalized, as described in Section C.3) in country i for year t, α is the intercept in the pooled OLS, ϵ is the residual. Finally, $IMD_{i,t}^{govt}$ is the government efficiency pillar score of country i for time period t. And then model (2):

$$IMD_{i,t} = \mu_t + \gamma_i + \beta_1 IMD_{i,t}^{govt} + \epsilon_{i,t} \tag{C.5}$$

where $IMD_{i,t}$ is once more the national IMD competitiveness score; μ_t is the year fixed-effect, γ_i is the country fixed-effect. Model (1) is a pooled OLS model of the panel dataset, while (2) is a fixed effects model, allocating an individual intercept to each of the countries (and years), therefore accounting for country-specific time-invariant effects and effects common to all countries in a single year (i.e., common effects of a global event).

We estimate the models on the full panel and get a positive coefficient in both models for the *IMD_govt* variable, hence indicating that the *IMD_govt* score, even when accounting for constant differences across countries and year-specific common effects, has a strong positive correlation with other components of the overall IMD score. The pooled OLS effect can be understood as a comparison between countries (and time-steps): if a country in general has a higher competitiveness score it is likely to have a higher *IMD_govt* score too (average effect 0.61). While the fixed-effect model can be understood as changes between years in the observed countries, i.e., if the *IMD_govt* score increases across years in a country then the average increase in overall IMD score is expected to increase by about 0.38 too. We take this as an indication that the connection between perceived government efficiency and perceived national competitiveness (based on non-Government efficiency-related factors of competitiveness) is strong in the sample. Although causality cannot be determined, the correlation between the variables is observable and significant. Detailed results of the regressions are shown in Table C.3.

Table C.3: *Panel regressions between the constructed indicator (IMD_constructed) and the IMD Government efficiency score (IMD_govt) with and without fixed-effects*

Dependent Variable:	*IMD_constructed*	
Model:	(1)	(2)
Variables		
Constant	-1.05×10^{-16}	
	(0.0171)	
IMD_govt	0.6085***	0.3845***
	(0.0173)	(0.0377)
Fixed-effects		
Country		Yes
Year		Yes
Fit statistics		
Observations	769	769
R^2	0.61783	0.96684
Within R^2		0.36045
RMSE	0.47448	0.13977
F-test	1,239.9	136.81
Wald (joint nullity)	1,239.9	104.02
F-test, p-value	2.29×10^{-162}	5.55×10^{-40}
F-test (projected), p-value		2.19×10^{-69}
Wald (joint nullity), p-value	2.29×10^{-162}	5.69×10^{-23}

*Signif. Codes: ***: 0.01, **: 0.05, *: 0.1*

C.4.2 Further supporting calculations of the analysis

T-tests of difference between groups

Table C.4: *T-tests of difference between the mean of the groups, number of years between 2010-2022 where the t-tests produce non-significant p-value (>0.1) results*

		H2	L1	M1	M2	H1
1	H1	13	0	0	0	
2	H2		0	0	0	13
3	L1	0		0	0	0
4	M1	0	0		13	0
5	M2	0	0	13		0

Number of years where means difference T-test p-value is higher than 0.1

Allocation of individual countries to clusters

Table C.5: *Allocation of individual countries to clusters*

Small advanced economies	Scandinavian, Northwestern European and Commonwealth economies	East Central European and Developed non-EU economies	Southern and East Central European economies	Developing economies
H1	**H2**	**M1**	**M2**	**L1**
Hong Kong	Australia	Chile	Austria	Brazil
Qatar	Canada	China	Belgium	Bulgaria
Singapore	Denmark	Czech Republic	France	Colombia
Switzerland	Finland	Estonia	Greece	Croatia
Taiwan, China	Germany	Iceland	Hungary	India
UAE	Ireland	Israel	Italy	Indonesia
	Luxembourg	Kazakhstan	Japan	Jordan
	Netherlands	Korea Rep.	Portugal	Mexico
	New Zealand	Lithuania	Slovenia	Peru
	Norway	Malaysia	Spain	Philippines
	Sweden	Poland		Romania
	UK	Thailand		Russia
		USA		Slovak Republic
		Latvia		South Africa
		Cyprus		Turkey
		Saudi Arabia		Ukraine
				Mongolia

Comparison of clusters

Figure C.6: *East Central European and Developed non-EU economies (M1) and Southern and East Central European economies (M2) comparison*

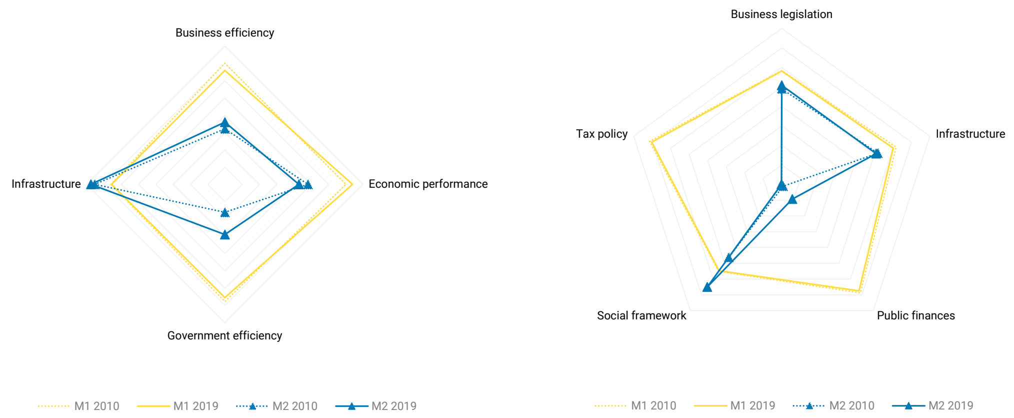
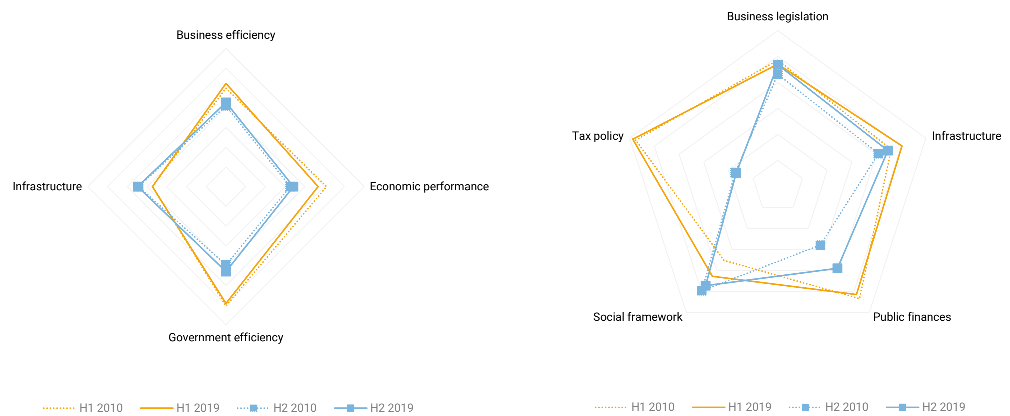


Figure C.7: *Scandinavian, Northwestern European and Commonwealth economies (H2) and Small advanced economies (H1) comparison*



C.4.3 Difference-in-differences further regression results

The following tables present detailed estimation results for the modified difference-in-differences (DiD) models investigated. The setup of the models is as follows:

$$y_{i,t} = \beta_1 covid_t + \beta_2 covid_t \times cluster_i + \gamma_i + \epsilon_{i,t} \tag{C.6}$$

where $y_{i,t}$ is the dependent (LHS) variable of interest that can be overall competitiveness ($IMD\_constructed$) or one of the pillar scores; $covid$ is a dummy variable indicating COVID years, such as $covid = 1$ in years where COVID is present and $covid = 0$ in preceding years, γ_i is the fixed-effect term for the individual countries, while ϵ is the residual. Finally, $covid_t \times cluster_i$ is the interaction term between the presence of COVID and cluster membership, or the modified DiD coefficient. The below table (Table C.6) demonstrates what values this dummy variable can take:

Table C.6: *Explanation table for the interaction dummy*

		Cluster membership	
		Cluster 'A'	Cluster 'B'
COVID year	Yes	**covid_A = 1**	covid_A = 0
	No	covid_A = 0	covid_A = 0

Results for main components of competitiveness

Table C.7: *Regression results of the modified DiD method for clusters H1-H2 across main components*

Dependent Variables:	IMD overall[1]	Infrastructure	Government efficiency	Business efficiency	Economic performance
Model:	(1)	(2)	(3)	(4)	(5)
Variables					
COVID year (*covid*)	0.0248	0.1989**	-0.0738	0.0290	-0.2173
	(0.0664)	(0.0727)	(0.0876)	(0.0679)	(0.2490)
DiD interaction term	0.0377	-0.1881**	0.1806	-0.0157	0.4478*
(*covid* × *clusterH2*)	(0.0868)	(0.0815)	(0.1125)	(0.1283)	(0.2559)
Fixed-effects					
Country	Yes	Yes	Yes	Yes	Yes
Fit statistics					
Observations	233	233	233	233	233
R^2	0.70597	0.95902	0.83710	0.59046	0.74756
Within R^2	0.01836	0.15457	0.03410	0.00079	0.06624
RMSE	0.16340	0.11351	0.21808	0.29803	0.35834
F-test	20.409	198.93	43.681	12.255	25.171
F-test, p-value	3.03×10^{-5}	1.61×10^{-12}	2×10^{-7}	0.00051	8.29×10^{-6}

Clustered (Country) standard-errors in parentheses
*Signif. Codes: ***: 0.01, **: 0.05, *: 0.1*
[1] *also reported as IMD_constructed.*

Table C.8: *Regression results of the modified DiD method for clusters M1-M2 across main components*

Dependent Variables:	IMD overall[1]	Infrastructure	Government efficiency	Business efficiency	Economic performance
Model:	(1)	(2)	(3)	(4)	(5)
Variables					
COVID year (*covid*)	-0.0201	0.0122	-0.0251	0.0501	-0.1709
	(0.0682)	(0.0566)	(0.0935)	(0.1324)	(0.1335)
DiD interaction term	0.1776*	-0.0134	0.2792**	0.0723	0.6713***
(*covid* × *clusterM2*)	(0.0962)	(0.0736)	(0.1258)	(0.2020)	(0.1722)
Fixed-effects					
Country	Yes	Yes	Yes	Yes	Yes
Fit statistics					
Observations	321	321	321	321	321
R^2	0.89466	0.95644	0.78941	0.77614	0.87169
Within R^2	0.05522	0.00086	0.05554	0.01161	0.15390
RMSE	0.17680	0.13832	0.28300	0.33923	0.34135
F-test	106.16	274.44	46.856	43.338	84.924
F-test, p-value	6.06×10^{-13}	9.75×10^{-18}	3.49×10^{-9}	7.49×10^{-9}	7.13×10^{-12}

Clustered (Country) standard-errors in parentheses
*Signif. Codes: ***: 0.01, **: 0.05, *: 0.1*
[1] *also reported as IMD_constructed.*

Testing of pre-treatment parallel trends

Figure C.8: *Testing of pre-treatment parallel trends for the overall competitiveness indicators between the relevant groups (H1-H2)*

(a) *Time-series of IMD score* (b) *Placebo treatment effects*

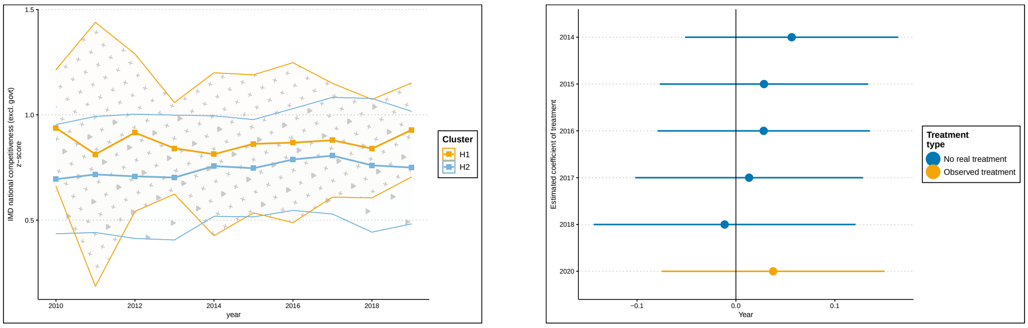
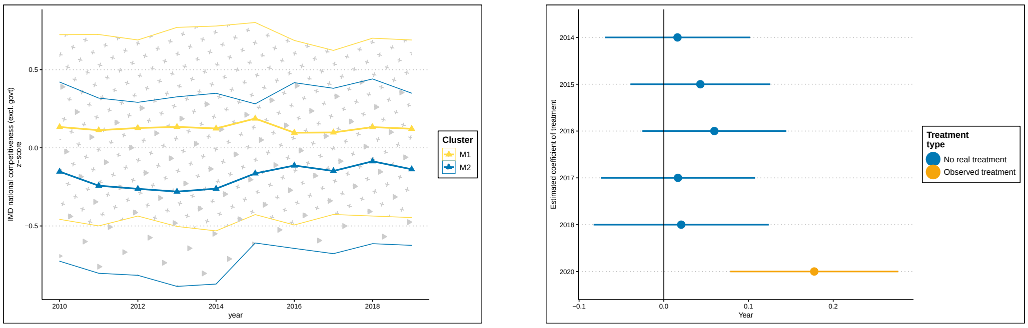


Figure C.9: *Testing of pre-treatment parallel trends for the overall competitiveness indicators between the relevant groups (M1-M2)*

(a) *Time-series of IMD score* (b) *Placebo treatment effects*



M1-M2 economic performance

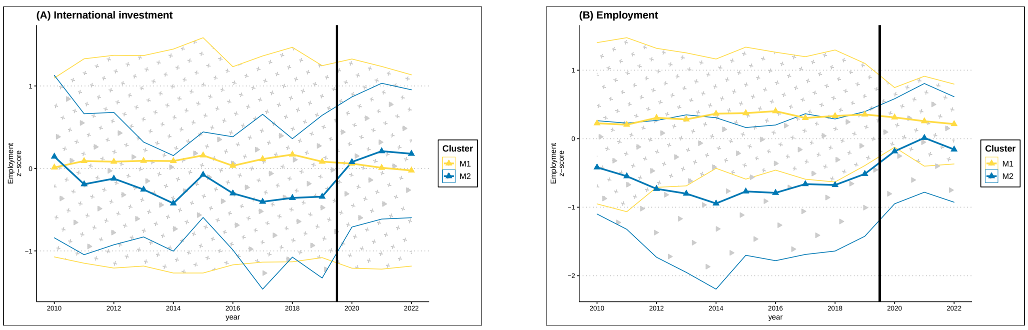
Table C.9: *Regression results of the modified DiD method for clusters M1-M2 across sub-components of the economic performance sub-component*

Dependent Variables:	Domestic economy[1]	International trade[1]	International investment	Employment	Prices
Model:	(1)	(2)	(3)	(4)	(5)
Variables					
COVID year (*covid*)	-0.0195	-0.2616^{**}	-0.1358	0.0061	-0.1621
	(0.1320)	(0.1240)	(0.1228)	(0.1775)	(0.1304)
DiD interaction term	0.2499	0.5565^{***}	0.5242^{***}	0.5701^{**}	-0.0723
(*covid* × *clusterM2*)	(0.1727)	(0.1457)	(0.1800)	(0.2232)	(0.1647)
Fixed-effects					
Country	Yes	Yes	Yes	Yes	Yes
Fit statistics					
Observations	321	321	321	321	321
R^2	0.83864	0.69002	0.83243	0.83823	0.71517
Within R^2	0.02135	0.06965	0.06340	0.13276	0.03247
RMSE	0.42054	0.42830	0.43584	0.39485	0.45098
F-test	64.967	27.825	62.096	64.768	31.386
F-test, p-value	1.25×10^{-10}	4.38×10^{-7}	2.01×10^{-10}	1.29×10^{-10}	1.52×10^{-7}

Clustered (Country) standard-errors in parentheses
*Signif. Codes: ***: 0.01, **: 0.05, *: 0.1*
[1] *parallel trends assumption does not hold.*

Figure C.10: *Sub-components of economic performance pillar over time in clusters M1 and M2, black vertical line indicates COVID starting*

(a) *International investment* (b) *Employment*



C.4.4 References to the Annex

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Kiseľáková, D., Šofranková, B., Čabinová, V. and Onuferová, E. (2018): Competitiveness and sustainable growth analysis of the EU countries with the use of global indexes' methodology. *Entrepreneurship and Sustainability Issues*, 5(3), 581–599. DOI: 10.9770/jesi.2018.5.3(13).

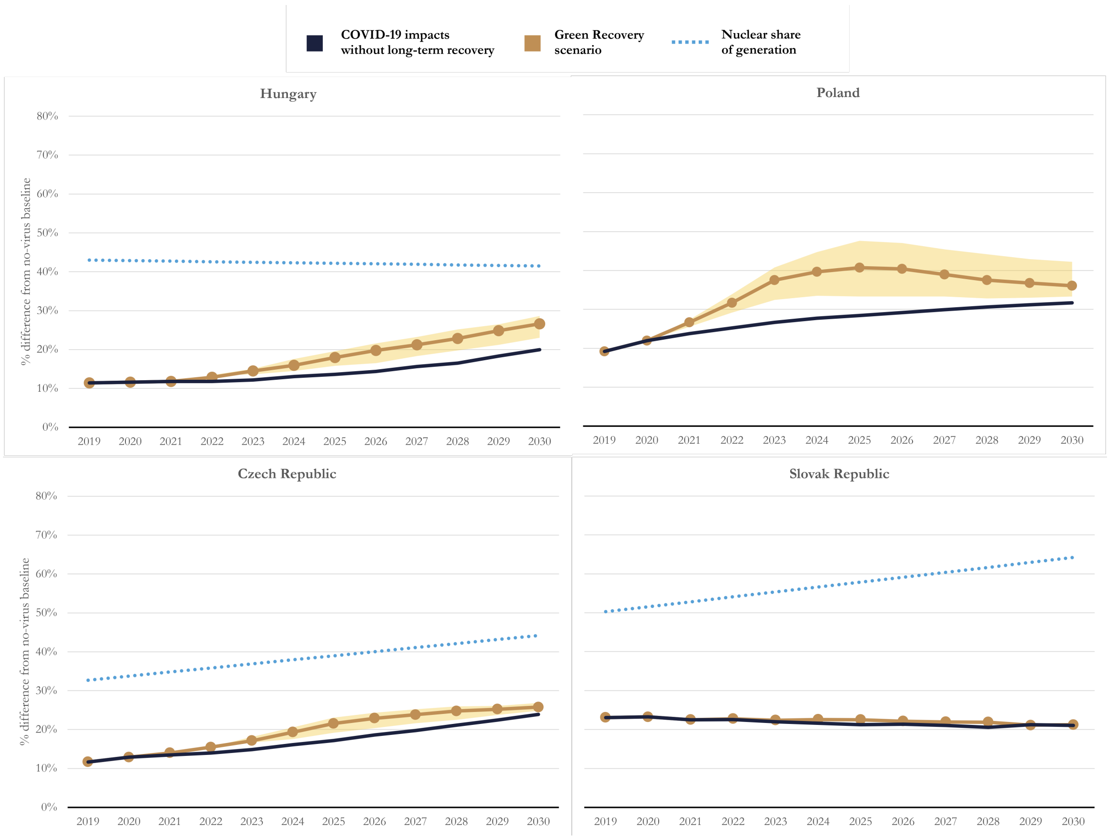
D

Appendix D

Appendix to the chapter Green and Sustainability Issues: Recovery from the pandemic.

D.1 Additional results

Figure D.1: *Renewables in electricity generation - in scenario and baseline. As % share of RES in total electricity generation (GWh) in Visegrad countries. Nuclear generation shown separately.*



D.2 Summary of COVID-19 supply and demand shock assumptions

	Applied supply shock (aggregated on country level) in 2020		
	Mean	Minimum	S.d.
Czech Republic	-2.82%	-12.6%	0.034
Hungary	-3.51%	-15.7%	0.0429
Poland	-3.08%	-13.8%	0.0376
Slovak Republic	-3.57%	-15.9%	0.0436

Table D.1: *Summary table of supply shocks applied to countries*

	Applied demand shock (aggregated on country level) in 2020				
	Transport services	Retail & recreation	Private transport	Air transport	Tourism
Czech Republic	-17.2%	-21.3%	-19.3%	-76.5%	-66.4%
Hungary	-21.5%	-17.4%	-20.5%	-76.5%	-72.6%
Poland	-26.7%	-20.7%	-22.1%	-76.5%	-70.6%
Slovak Republic	-24.7%	-26.8%	-24.3%	-76.5%	-65.6%

Table D.2: *Summary table of demand shocks applied to countries*

	Applied investment shock (aggregated to country level), in % of baseline investment level		
	2020	2021	2022
Czech Republic	-19.6%	-0.9%	-6.1%
Hungary	-22.1%	-5.4%	-5.1%
Poland	-17.1%	-5.5%	-6.5%
Slovak Republic	-20.1%	-6.3%	-4.3%

Table D.3: *Summary of investment shocks applied to countries*

D.3 Selected equations from the E3ME model

This section presents specifications for some of the E3ME econometric equations that are important from the perspective of the present paper. For details on further equations used in the model as well as rationale behind the variables selected, please see Mercure et al. (2018) or the E3ME model manual (Cambridge Econometrics 2019).

D.3.1 Aggregate consumption

Co-integrating long-term equation

$$\begin{aligned} ln(RSC_{t,i}) = \alpha + \beta_1 ln(RRPD_{t,i}) + \beta_2 ln(RRLR_{t,i}) \\ +\beta_3 ln(CDEP_{t,i}) + \beta_4 ln(ODEP_{t,i}) + \beta_5 ln(RVD_{t,i}) + ECM \end{aligned} \tag{1a}$$

Dynamic equation

$$\begin{aligned} \delta ln(RSC_{t,i}) = \gamma + \lambda_1 \delta ln(RRPD_{t,i}) + \lambda_2 \delta ln(RRLR_{t,i}) \\ +\lambda_3 \delta ln(CDEP_{t,i}) + \lambda_4 \delta ln(ODEP_{t,i}) + \lambda_5 \delta ln(RVD_{t,i}) \\ +\lambda_6 ln(RUNR_{t,i}) + \lambda_7 \delta ln(PRSC_{t,i}) + \lambda_8 \delta ln(RSC_{t-1,i}) \\ +\lambda_9 ECM_{t-1,i} \end{aligned} \tag{1b}$$

where

- α and β_1 to β_5 are estimated long-term parameters,
- γ and λ_1 to λ_9 are estimated dynamic parameters,
- RSC is the aggregated consumption in million EUR 2010 prices,
- $RRPD$ is the real gross disposable income in million EUR 2010 prices,
- $RRLR$ is the real rate of interest,
- $CDEP$ and $ODEP$ are the child and old age pensioner dependency ratios,
- RVD is a proxy for household wealth (cumulative sum of investments in dwellings million EUR 2010 prices),
- $RUNR$ is the unemployment rate (percentage of labour force),
- $PRSC$ is the consumer price inflation (percentage terms),
- RSC_{t-1} is the lagged change in consumer expenditures,
- ECM is the error term in the long-run equation and ECM_{t-1} is the lagged error correction term,
- Indexes t and i refer to the year and the region (country in EU) of the observation

D.3.2 Industrial investment

Co-integrating long-term equation

$$
\begin{aligned}
ln(KR_{t,i}) = \alpha + \beta_1 ln(QR_{t,i}) + \beta_2 ln(\frac{PKR_{t,i}}{PYR_{t,i}}) + \beta_3 ln(YRWC_{t,i}) \\
+\beta_4 ln(PQRM^{oil}_{t,i}) + ECM
\end{aligned} \tag{2a}
$$

Dynamic equation

$$
\begin{aligned}
\delta ln(KR_{t,i}) = \gamma + \lambda_1 \delta ln(QR_{t,i}) + \lambda_2 \delta ln(\frac{PKR_{t,i}}{PYR_{t,i}}) \\
+\lambda_3 \delta ln(YRWC_{t,i}) + \lambda_4 \delta ln(PQRM^{oil}_{t,i}) + \lambda_5 \delta ln(RRLR_{t,i}) \\
+\lambda_6 ln(YYN_{t,i}) + \lambda_7 \delta ln(KR_{t-1,i}) \\
+\lambda_8 ECM_{t-1,i}
\end{aligned} \tag{2b}
$$

where

- α and β_1 to β_4 are estimated long-term parameters,
- γ and λ_1 to λ_8 are estimated dynamic parameters,
- KR is real investment expenditure in million EUR 2010 prices,
- QR is real output in million EUR 2010 prices,
- $\frac{PKR}{PYR}$ is the relative price of investment (industry investment price divided by industry output price, both in local currency, 2010 5 1.0),
- $YRWC$ real average labour cost, which is real wage costs divided by employees,
- $PQRM^{oil}$ effect of real oil price (import prices in local currency, 2010 5 1.0),
- $RRLR$ is the real rate of interest,
- YYN actual/normal output (ratio of gross output to normal or potential output),
- KR_{t-1} is the lagged change in investment expenditures,
- ECM is the error term in the long-run equation and ECM_{t-1} is the lagged error correction term,
- Indexes t and i refer to the year and the region (country in EU) of the observation

D.3.3 Industrial employment

Co-integrating long-term equation

$$\begin{aligned} ln(YRE_{t,i}) = \alpha + \beta_1 ln(QR_{t,i}) + \beta_2 ln(YRWC_{t,i}) \\ + \beta_3 ln(YRH_{t,i}) + \beta_4 ln(PQRM_{t,i}^{oil}) \\ + \beta_5 ln(YKNO_{t,i} + YCAP_{t+i}) + ECM \end{aligned} \tag{3a}$$

Dynamic equation

$$\begin{aligned} \delta ln(YRE_{t,i}) = \gamma + \lambda_1 \delta ln(QR_{t,i}) + \lambda_2 \delta ln(YRWC_{t,i}) \\ + \lambda_3 \delta ln(YRH_{t,i}) + \lambda_4 \delta ln(PQRM_{t,i}^{oil}) + \lambda_5 \delta ln(YKNO_{t,i} + YCAP_{t,i}) \\ + \lambda_6 \delta ln(YRE_{t-1,i}) + \lambda_8 ECM_{t-1,i} \end{aligned} \tag{3b}$$

where

- α and β_1 to β_5 are estimated long-term parameters,
- γ and λ_1 to λ_7 are estimated dynamic parameters,
- YRE is total employment in thousands of persons,
- QR is real output in million EUR 2010 prices,
- $YRWC$ real average labour cost, which is real wage costs divided by employees,
- YRH is average hours worked per week,
- $PQRM^{oil}$ effect of real oil price (import prices in local currency, 2010 5 1.0),
- $YKNO + YCAP$ is the stock of knowledge and capital aggregated in million EUR 2010 prices,
- YRE_{t-1} is the lagged change in employment,
- ECM is the error term in the long-run equation and ECM_{t-1} is the lagged error correction term,
- Indexes t and i refer to the year and the region (country in EU) of the observation

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