New Approaches to Economic Challenges

# A Systemic Recovery

Edited by William Hynes, Igor Linkov and Patrick Love

OECD

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BETTER POLICIES FOR BETTER LIVES

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# Preface

We are in a period that could be called the Great Instability, created by a health crisis and ensuing economic crisis, followed by a geopolitical crisis, all against the background of a climate emergency and rapid digital transformation. Individually, each would be a major challenge, but they interact to amplify each other's impacts, and policies to address one question may make others worse. Efforts to save the environment that would make some people already struggling worse off, for example, could provoke a political backlash that threatens social cohesion and makes solving problems more difficult. Similarly, the technological revolution we are living through, while creating major opportunities, also risks leaving some people behind.

The OECD's New Approaches to Economic Challenges (NAEC) initiative has been arguing for a number of years that if we want to find sustainable, equitable solutions to the issues confronting us, we need to see the economy, society and the environment as parts of a complex adaptive system, constantly evolving as they influence and react to each other. In September 2019, before the outbreak of the Covid pandemic, a NAEC conference on "Averting systemic collapse" warned that in today's deeply integrated, highly interconnected world, a small local shock to one system can be amplified and transmitted quickly, causing cascading failures in the systems we have come to rely on in our daily lives.

Unfortunately, that warning turned out to be prescient. Since the start of the pandemic, NAEC has been working with a range of Nobel laureates and other leading researchers and thinkers to propose strategies not just to limit the damage and contain the shock waves from crises, but to ensure that the recovery leaves our systems better able to deal with damage and seize the opportunities that the new situation may offer. The new approach based on complexity theory and systems thinking is however grounded in the OECD's solid tradition of providing evidence-based policy advice. We start with the facts and analyse the data to identify causal relationships before drawing conclusions and proposing solutions.

At the time of writing, we are facing a new crisis, war in Ukraine. Again, the consequences will be long-lasting, at every level from the individual to the global. Our response has to be long-term too. The work summarised in this publication proposes a framework that will help us not just to react to crises, but to be prepared for them. It has its roots in the pre-pandemic analyses of NAEC, as well as a number of conferences, papers and research collaborations instigated since.

The main lessons are now entering mainstream policy analysis and decision making. Resilience is now seen as major policy goal, since it is clear that all systems fail at some point, so the ability to recover from shocks is important, not just the ability to absorb them. There is also less reluctance to admitting that the drive for efficiency, usually defined in purely monetary terms, had a negative influence on resilience, and left many systems without the spare capacity to react to unexpected circumstances. Health systems in some countries nearly collapsed when case number surged due to the coronavirus. Global supply chains are a wonder of technology and organisation, but they could not cope with sudden, unexpected fluctuations in supply and demand.

The former UK Prime Minister Liz Truss summed this up when she said that we have "focused too much on getting cheap oil, cheap electronics, cheap goods at the expense of our freedom and security". The

US President's Emergency Plan for Adaptation and Resilience (PREPARE) will support developing countries and communities in vulnerable situations around the world in their efforts to adapt to and manage the impacts of climate change. Australia has set up a National Recovery and Resilience Agency not just to help communities affected by disasters, but to promote initiatives to reduce risk and lessen the impacts of future shocks.

This report presents a framework and insights for designing policies to assist a recovery. It would be a contradiction for it to set out a policy roadmap. Another important lesson from our analyses of complex systems is that what we do will involve trade-offs between competing claims and unintended consequences of our actions. That means that we have to update our decisions, and perhaps even goals, as circumstances change. We would do well to remember that the origins of our word "governance" lie in the Greek word *kybernan*, "to steer or pilot a ship". Navigating the troubled waters we find ourselves in requires knowledge, experience, and humility. I hope that the findings presented here are a useful aid in that journey.

Mathias Cormann
Secretary-General
OECD

Albert van Jaarsveld
Director General and Chief Executive Officer
IIASA

# Foreword

In September 2018, the OECD's New Approaches to Economic Challenges (NAEC) initiative organised a conference on lessons to be drawn from the 2008 financial crisis. The conference delegates concluded that a new crisis could emerge suddenly, from many different sources, and with potentially harmful effects. Moreover, while policymakers generally focus on how to harden components of vital systems affected by specific threats, such approaches do not often address cascading effects. This analysis led NAEC to organise another conference a year later, on averting systemic collapse.

Within a few months, the mechanisms discussed at these conferences as features and possibilities of our global systems had manifested themselves. A local outbreak of a coronavirus infection in Wuhan led to global consequences, first for health systems, then the economy and society as a whole. The work summarised in this publication has its roots in the pre-pandemic analyses as well as a number of conferences, papers and research collaborations instigated since, including with the Health Division of the Employment, Labour and Social Affairs Directorate, and the Environment Directorate as part of the Horizontal Project on Building Economic and Climate Resilience.

William Hynes, Head of the NAEC Unit, led the project. Igor Linkov of the US Army Corps of Engineers and Carnegie Mellon University inspired the work on resilience that underpins many of the findings. Harris Eyre, William Hynes, Michael Jacobs, Igor Linkov, Patrick Love and Benjamin Trump were contributing authors. The authors would like to thank Alan Kirman and Frans Lammersen for their comments and suggestions on the draft chapters. Former Ambassadors to the OECD Irena Sodin of Slovenia and Erdem Başçı of Turkey offered unfailing support and invaluable guidance to NAEC. Patrick Love and Angela Stuart provided editorial assistance.

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# Executive Summary

Governments have spent over 16 trillion dollars responding to the Covid-19 crisis, while it would have cost only five dollars per person to prepare for an outbreak. A health condition that was being compared to a flu outbreak at the end of 2019 quickly provoked economic and social devastation worldwide, in addition to the health impacts. Policymakers often have a linear view of the world, where pulling the right levers will get the economy and society back on track after shocks and crises. Such an approach ignores how systems interact and how their systemic properties shape this interaction, leading to an over-emphasis on a limited set of characteristics, notably efficiency.

The emphasis on efficiency in the operation, management and outcomes of various economic and social systems was not a conscious collective choice, but rather the response of the whole system to the incentives that individual components face. This has brought much of the world to rely upon complex, nested, and interconnected systems to deliver goods and services around the globe. While this approach has many benefits, the Covid-19 crisis shows how it has also reduced the resilience of key systems to shocks, and allowed failures to cascade from one system to others. A systems approach based on resilience is proposed to prepare socioeconomic systems for future shocks.

## Understanding complex systems

It is no coincidence that financial, environmental, public health, and broader societal crises are occurring simultaneously. Modern society increasingly relies upon complex and interdependent systems, yielding greater efficiency, but increasing vulnerability to disruption cascading from one system to another. To safeguard global well-being, an understanding of the interrelationships between such complex systems is essential to build resilience to future crises and not just withstand them, but be in a better position after the recovery than before.

Treating problems in isolation from each other and trying to optimise one part of the system can cause the system as a whole to become unstable as failures in one part of the network cascade through other parts. The drive for efficiency following the cuts to public services implemented as part of the austerity measures adopted in the aftermath of the 2008 financial crisis left health services unprepared for the surge in demand as the pandemic broke. Over-emphasis on efficiency also ended up by inflicting significant damage on global supply chains. Manufacturers and distributors failed to cope with fluctuating demand as infection, lockdowns and changes in consumption patterns exposed the fragility of just-in-time business models.

Apart from interconnectedness and the fact that decisions may have unintended consequences, a systems approach highlights other aspects of systems that decision makers should keep in mind. Foremost among these is resilience, the capacity of a system to anticipate, absorb, recover from, and adapt to unexpected threats. The need for more resilience is now widely acknowledged, but resilience will be far stronger, and less costly, if it is part of the design of systems from the outset rather the result of an intervention after disaster has struck.

## Recommendations

Recovery and adaptation in the aftermath of disruptions is a requirement for interconnected 21st century economic, industrial, social, and health-based systems, and resilience is an increasingly crucial part of strategies to avoid systemic collapse. Based on NAEC reports and the resilience literature, specific recommendations for building resilience to contain epidemics and other systemic threats include:

- Design systems, including infrastructure, supply chains, and economic, financial and public health systems, to be resilient, i.e. recoverable and adaptable.
- Develop methods for quantifying resilience so that trade-offs between a system's efficiency and resilience can be made explicit and guide investments.
- Control system complexity to minimise cascading failures resulting from unexpected disruption by decoupling unnecessary connections across infrastructure and make necessary connections controllable and visible.
- Manage system topology by designing appropriate connection and communications across interconnected infrastructure.
- Add resources and redundancies in system-crucial components to ensure functionality.
- Develop real-time decision support tools integrating data and automating selection of management alternatives based on explicit policy trade-offs in real time.
- Invest in "brain capital" to meet the increasing demand for advanced cognitive skills in an economy where innovation is a tangible deliverable of employee productivity, but where brain-based issues are increasingly impacting negatively on productivity and well-being.

## Conclusions

The crises we have faced have brought to the fore the importance of action along these lines in several policy domains. Four objectives for economic policy making should be paramount: environmental sustainability; rising wellbeing; falling inequality; and system resilience - understood as the economy's ability to withstand financial, environmental or other shocks without catastrophic and system-wide effects.

# 1 Introduction and Overview

This chapter summarises the trends and system characteristics that enabled the SARS-CoV-2 virus to provoke so much devastation so quickly worldwide. It outlines the main argument of the publication that we have to understand the interactions of multiple systems across different times and places to cope adequately with present and emerging threats to global well-being. Resilience should be seen as a guiding principle in efforts to ensure that systems can continue to function in spite of the inevitable disruptions they will face.

The Covid-19 pandemic exposed and amplified the very trends and system characteristics that enabled a local disease outbreak to spread worldwide, paralysing society and crippling the global economy within a few months of being detected. The impacts of the health crisis cascaded through systems ranging from global supply chains to education. No area of society was left untouched, almost always with negative consequences. Even the temporary improvements in air and water quality were short lived, with little impact on deep-rooted trends that have led to the climate emergency. A study of over 3000 counties in the US for example, found that a small increase in historical exposure to $PM_{2.5}$ microparticles leads to a large increase in the Covid-19 death rate, after accounting for many area-level factors (Wu et al., 2020).

The various contributions to this publication share a common view that to understand the pandemic (and other emergencies facing the planet) an approach based on complex systems theory offers a pragmatic way of studying the multiple interactions acting across multiple time and other scales that determine how the crisis arose and developed. A complexity-based approach is also the most fruitful way of bolstering system characteristics, notably resilience, that will allow society to be better prepared for the next crisis.

A fist lesson from a systems approach is that in describing a given complex system and its interactions with other complex systems, the point in time and the place where the narrative starts strongly influences the description. This in turn shapes the policy advice on ow to deal with similar situations in the future. Starting the Covid-19 story in Wuhan at the end of 2019 would lead one to concentrate on better laboratory standards or stricter control of wildlife trade, depending on what the origins of the coronavirus turn out to be. Starting with the decision to stop funding research on coronavirus vaccines in 2016 casts a different light (Hoetz, 2020). Starting the story a decade earlier gives a different perspective. The coronavirus struck just over 10 years after the 2008 financial crisis, and the impact of that event, and measures taken to deal with it, were still being felt. The recovery after the Great Recession of 2008-9 was among the slowest on record. Central government debt in OECD countries rose from around 30 per cent of GDP countries in 2007 to 75 per cent at the end of 2019 (OECD, 2021). The IMF's Global Debt Database shows that public plus private debt reached $197 trillion in 2019, up by $9 trillion from the previous year (IMF).

One consequence of the austerity policies implemented to manage this debt was a cuts in public services and a drive for "efficiency" that left health services for example without the spare capacity to cope with the sudden surge in patient numbers. An investigation by the WHO's Pan-European on Health and Sustainable Development found that: "Many European health systems have suffered from chronic underfunding and underinvestment in the health workforce, often as a legacy of the 2008 financial crisis" (WHO, 2021). Other public services also found themselves unprepared for the consequences of the pandemic on their workload (and staff). The outbreak caused an explosion in the amount of medical waste, masks for instance, and hospitals produced far more infectious and biomedical waste every day than before the pandemic (Ashraf et al., 2022). Ashraf et al. also highlight the difficulties for municipal waste services in dealing with the increase in the amount of packaging caused by the growth of online shopping, and the potential ecosystem consequences of the vast amounts of disinfectant used to clean surfaces.

The drive for efficiency had unintended consequences far beyond public services. Before the crisis, it was less obvious how trends that enabled global value chains to become more efficient had at the same time made them far less resilient, producing the conditions that made the supply shock worse and contributing to a demand shock as well (McManus, 2021). Supply chains have become both more extensive and more concentrated. Apple buys inputs for its iPhones from 43 countries for example, and the world's biggest semiconductor manufacturer, TSMC (Taiwan Semiconductor Manufacturing Company) had a 55 percent of market share at the start of 2021, followed by Samsung with 17 per cent. A disruption to their operation has almost immediate consequences, as when Samsung's foundry in Texas shut due to power outages in 2021 (Dobberstein, 2021).

The following chapters look in more detail at the issues raised here. Chapter 2 examines how human and other systems interact to produce new situations, and discusses the features of systems that policymakers and their advisors should consider when designing responses to current challenges, as well as strategies

to deal with the risks and opportunities future challenges may present. Adopting a resilience approach means rethinking our priorities, and especially the relative importance of resilience and efficiency. The radical uncertainty associated with complex systems makes it impossible to predict where the next crisis will come from, but our influence on the evolution of our systems must be designed to have resilience as the primary objective, and the means to achieve that have to be constantly adapted over time to provide them with the capacity for recovery and adaptability regardless of the challenges they may face.

Chapter 3 argues that traditional policy approaches ignore how systems interact and how their systemic properties shape this interaction, leading to an over-emphasis on a limited set of characteristics, notably efficiency. The emphasis on efficiency in the operation, management and outcomes of various economic and social systems was not a conscious collective choice, but rather the response of the whole system to the incentives that individual components face. This has brought much of the world to rely upon complex, nested, and interconnected systems to deliver goods and services around the globe. While this approach has many benefits, the Covid-19 crisis shows how it has also reduced the resilience of key systems to shocks, and allowed failures to cascade from one system to others. A systems approach based on resilience is proposed to prepare socioeconomic systems for future shocks.

Chapter 4 defines concepts related to systemic threats and reviews the analytical and governance approaches and strategies to manage these threats and build resilience to contain them. This should help policymakers build safeguards, buffers and ultimately resilience to physical, economic, social and environmental shocks. Recovery and adaptation in the aftermath of disruptions is a requirement for interconnected 21st century economic, industrial, social, and health-based systems and resilience is an increasingly important theme and a crucial part of strategies to avoid systemic collapse.

Chapter 5 explains why a new approach to economic analysis and policy is needed. It sets out the multiple challenges now facing almost all economies and proposes a new set of overarching policy goals: environmental sustainability, a reduction in inequalities, improved wellbeing, and system resilience. Achieving these goals requires policymakers to look ‘beyond growth’. The chapter argues that the dominant approach to economic policymaking over the last forty years, based on an orthodox and subsequently revised model of neoclassical economic theory, is not adequate to address these challenges. It describes the various analytical advances which have been made in economics in recent decades which offer a richer understanding of how economies work. It suggests that overcoming these challenges requires structural rather than incremental reform, and sets out a range of policy approaches, drawn from the new analytical frameworks, which might help achieve these wider economic and social goals.

Chapter 6 presents a conceptual asset, Brain Capital, to inform novel policies. The concept builds on previous work, the Brain Capital Grand Strategy, that considers Brain Capital in-all-policies and offers a comprehensive investment plan and the development of an index or a dashboard. The premise, enablers, and barriers towards a Brain Capital Building Policy Agenda are outlined. Engagement with communities is proposed, and approaches for educating policymakers are described. Brain Capital building policies should be considered in sectors such as human development, migration, gender issues, social justice, multi-cultural affairs, economics, protections, and international relations. Novel approaches for public investment including brain bonds and social impact investing are considered.

The last chapter, Chapter 7, summarises the main conclusions of preceding chapters on the characteristics of the systemic threats facing society and how to deal with them. It notes a shift in thinking among decision makers towards some of the positions argued for by this publication’s authors, notably the need to build resilience into important systems; to pay attention to the human aspects of crises, notably the psychological aspects; and the advantages of a systems approach in identifying and prioritising areas of intervention.

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# 2 A Systemic Approach to Sustainable Recovery

This chapter argues for a systems approach to the challenges posed by, or amplified by, the Covid-19 pandemic. It examines how human and other systems interact to produce new situations and discusses the features of systems that policymakers and their advisors should consider when designing responses to current challenges, as well as strategies to deal with the risks and opportunities future challenges may present. Adopting a resilience approach means rethinking our priorities, and especially the relative importance of resilience and efficiency. The radical uncertainty associated with complex systems makes it impossible to predict where the next crisis will come from, but our influence on the evolution of our systems must be designed to have resilience as the primary objective, and the means to achieve that have to be constantly adapted over time to provide them with the capacity for recovery and adaptability regardless of the challenges they may face.

## Introduction

As countries face the daunting task of economic recovery while still managing the public health risks of the SARS-CoV-2 ('Covid') pandemic, it is inevitable that our economies and societies 'after Covid' will be different from the ones overwhelmed by the virus. Human behaviours and incentives are changing, along with expectations of everything from consumer spending to workplaces, to government programming, to structural policies related to energy, health, and climate science. Calls to 'build back better' arise partly from problems which the crisis exposed, notably inequality: SARS-CoV-2 and its economic consequences have hit the poor and vulnerable the hardest. Simultaneously, our economies have proved less resilient than we had assumed. Reliance on globalised supply chains based on 'just-in-time' efficiencies has been called into question (Fraser, 2021). Many countries' health and social care systems have not been able to cope. The notion that the private sector does things most efficiently fell apart in the middle of the pandemic, when public policy intervened to support health systems, individuals, companies and markets.

We are facing more than one crisis. The long aftermath of the financial crash of 2008 is still not over, with slow productivity growth, a global savings glut and continued financial risk—particularly in the non-bank sector—among the main concerns. The monetary policy response to the global financial crisis by major central banks—slashing interest rates and quantitative easing—punished savers and benefitted those who owned assets. This shifted the return of growth further away from labour to capital, and contributed to social strife and support for populist leaders. There is also the crisis of climate change and wider environmental breakdown.

It is no coincidence that financial, environmental, public health, and broader societal crises are occurring simultaneously. Modern society increasingly relies upon complex and interdependent systems, yielding greater efficiency, but increasing vulnerability to disruption cascading from one system to another. To safeguard global well-being, an understanding of the interrelationships between such complex systems is essential to build resilience to future crises and not just withstand them, but be in a better position after the recovery than before.

The accelerating global environmental crisis is among the most urgent. In 2018, a report of the Intergovernmental Panel on Climate Change (IPCC, 2018) made clear that to hold the average global surface temperature rise to 1.5 degrees Celsius, global emissions of greenhouse gases must be approximately halved by 2030, and reach net zero emissions by around the middle of the 21st Century. That is a transformative task of unprecedented proportions, made even greater by the need to tackle simultaneously a series of other worsening and inter-related global environmental problems, including biodiversity loss, soil degradation, and air and marine pollution.

Many economists and policymakers are hoping that these climate goals can be achieved with technological advances rather than fundamentally changed behaviour. Rapid technological progress may ultimately be the solution, but this will alter incentive structures and social activity within many aspects of our economies, and new patterns of globalisation will therefore emerge. Parallel to each of these trends is demographic change, notably population ageing, which will shift consumption behaviour and exacerbate the global glut of savings that has pinned growth, inflation and rates at lacklustre levels.

These challenges would be considerable in any circumstances, but they come after a period following the global financial crisis when productivity and economic growth were already fragile, still dependent on ultra-low interest rates and hugely expanded central bank balance sheets. Moreover, responding to the pandemic added USD 4 trillion to global debt over 2020, leaving it at a record USD 281 trillion (IIF, 2021). Government support programmes accounted for half of the rise, while global firms, banks and households added USD 5.4 trillion, USD 3.9 trillion and USD 2.6 trillion respectively. The global debt-to-GDP ratio rose by 35 percentage points to over 355% of GDP. This is higher even than the 2008 and 2009 increases of 10 percentage points and 15 percentage points respectively.

Inequalities were already rising in most advanced countries before Covid, but the wealth of the planet's 2 365 billionaires increased by USD 4 trillion, or 54%, during the first year of the pandemic, even as global GDP fell by 3.5% (IPS, 2021. Angus Deaton (2021) shows that when countries are weighted by population, international income inequality also increased. Deaton attributes this to a fall in Indian incomes that was not offset by rising incomes in China.

Most developed economies have seen an increase in under-employment and insecure and precarious work of different kinds, from self-employment and part-time work, typified by the gig economy and very short-term contracts. In some countries, average earnings stagnated, with living standards for many households barely above those of a decade ago, or maintained only via rising household debt. In many cases, the gap between richer regions and those on the periphery has widened. Income inequality did though fall in some European countries after rising initially, perhaps because the policy responses focussed on those towards the bottom of the income distribution who were potentially the most affected by the pandemic (Clark et al., 2020)

Not all high-income countries experienced all of these problems, but many have experienced the political consequences of a decade of economic under-performance and the accompanying global pressures. Popular discontent with politicians and the political system has been rising over a long period in many countries. Trust in established institutions, in experts, and 'elites' has declined, with, according to Edelman (2021), "an epidemic of misinformation and widespread mistrust of societal institutions and leaders around the world … leaving the four institutions – business, government, NGOs and media – in an environment of information bankruptcy". Societies which once experienced high levels of social cohesion are now widely felt to be more fragmented, prone to cultural as well as economic divisions. In many countries large numbers of people report a sense that society has become less fair, with a widening gap between the lives of the richest and the majority, and that in a more globalised world, national societies have somehow 'lost control' of their own destinies. In a Pew survey, participants with different views on globalisation "highlighted their alienation and confusion about what it means to be part of their nations today", with many feeling left behind (Pew, 2020).

At the time of writing, there is still no consensus on the origins of the Covid-19 virus (Zarocostas, 2021), but the mechanisms through which the disease caused such devastation had been considered by the OECD. Before Covid-19 was detected, the New Approaches to Economic Challenges (NAEC) initiative, established by the Organisation in 2012 to draw lessons from the 2008 Global Financial Crisis, brought together policymakers and experts to discuss the fact that "a new crisis could emerge suddenly, from many different sources, and with potentially harmful effects" (NAEC, 2019). NAEC warned that: "Systemic threats are a particular challenge to governments due to their stochastic and relatively low frequency nature", capable of provoking cascades that can trigger systemic degradation or collapse.

In the case of Covid, the initial health crisis soon sparked an economic downturn with impacts on a range of other systems as well, including global value chains, travel, the retail sector, education, and the environment. The World Meteorological Organization's *State of the Global Climate 2020* (WMO, 2021) underlines that "climate-related events already pose risks to society through impacts on health, food and water security, as well as human security, livelihoods, economies, infrastructure and biodiversity". The report concludes that while the drop in emissions due to the economic downturn had little impact on the climate, cuts in food production, transport and economic activity caused by the pandemic exacerbated the effects of extreme weather on communities, particularly those already vulnerable to other risks.

The OECD had been analysing complex systems and their likelihood of generating systemic risks since the late 1990s, as part of its International Futures Programme (IFP). In 2003, the IFP's *Emerging Systemic Risks* concluded that: "In today's highly interdependent and networked world, even a local event can have substantial repercussions in distant regions of the world through its impact on technological or financial networks…" (OECD, 2003). This was borne out five years later when the US subprime crisis evolved into a global financial crisis, resulting in the Great Recession and political and social crises across the globe.

The dynamics of recent crises are similar, as are the governance and political economy questions they raise. In both cases, the warnings were ignored, or at least not acted on sufficiently to avert the considerable damage that followed. At another NAEC conference, one of the most knowledgeable actors in the 2008 crisis, Lehman Chief Global Economist John Llewelyn, expressed concern that the lessons of 2008 had not been learned, in that as the subprime situation evolved, experts were alarmed by what they saw coming, but decision makers preferred to delay significant action (Llewelyn, 2020). He stressed that while in 2008 this concerned the financial system, today it applied to planetary emergencies such as climate change.

This chapter examines how human and other systems interact to produce new situations, and discusses the features of systems that policymakers and their advisors should consider when designing responses to current challenges, as well as strategies to deal with the risks and opportunities future challenges may present. The conclusions will then be discussed in relation to the recovery from the Covid pandemic, and how to make that recovery more sustainable.

## Natural and human system interactions

The notion that there are complex systems has long been employed in the natural sciences (for example, cell biology) and the social sciences (for example, to study phenomena such as urbanisation (Harrison, 2017). The idea is not brand new in economics, either. As NAEC Senior Advisor Alan Kirman points out, the view that the economy is a complex system "can be traced back at least to Adam Smith and a long chain of economists leads from him to Hayek and Simon" (Kirman, 2017). Recognising the complexity of the economy requires paying greater attention to "interactions, unintended consequences, stability, resilience, policy buffers and safeguards" (Hynes, 2017). This applies to other complex systems too, and to the interactions between them.

To best understand the implications of the pandemic, we have to look at system interactions and how social, economic and natural systems can interact to produce unintended consequences. Zoonotic diseases are on the rise, and 600,000 to over 800,000 unidentified viruses exist that have zoonotic potential (Carroll et al., 2018). Virus transmission risk is highest from animal species that have increased in abundance and even expanded their range by adapting to human-dominated landscapes (Johnson et al., 2020). Zoonoses already comprise a large percentage of all newly-identified infectious diseases (as well as many existing ones) according to the WHO (2020).

Seven human-mediated factors are contributing to the emergence of zoonotic diseases according to a joint report by UNEP and the International Livestock Research Institute (2020): increasing human demand for animal protein; unsustainable agricultural intensification; increased use and exploitation of wildlife; unsustainable utilisation of natural resources accelerated by urbanisation, land use change and extractive industries; increased travel and transportation; changes in food supply; and climate change.

The Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) also concludes (IPBES, 2020) that the underlying causes of pandemics are the same global environmental changes that drive biodiversity loss and climate change, including land-use change, agricultural expansion and intensification, and wildlife trade and consumption: "These drivers of change bring wildlife, livestock, and people into closer contact, allowing animal microbes to move into people and lead to infections, sometimes outbreaks, and more rarely into true pandemics that spread through road networks, urban centers and global travel and trade routes. The recent exponential rise in consumption and trade, driven by demand in developed countries and emerging economies, as well as by demographic pressure, has led to a series of emerging diseases that originate mainly in biodiverse developing countries, driven by global consumption patterns".

## Systemic properties

Complex systems are impossible to understand using tools developed to analyse a simple system, which oscillates around an equilibrium and has actors that behave in a linear fashion such that decision-making can be predicted by extrapolating from a typical agent. In complex systems, the environment constantly changes and, in response, actors' strategies evolve as well. New behaviours also emerge with scale; you cannot extrapolate how the system will operate from one actor or a group of actors. It may be possible to know everything about parts of a system at the individual level, but still be impossible to predict on that basis what will happen when the individual is part of a greater whole. A typical example is a flock of starlings. The complex patterns that thousands of birds generate when they form a "murmuration" could never be predicted from observing one bird.

Moreover, complex systems necessarily involve radical uncertainty. This is also called Knightian uncertainty, after Frank Knight, who distinguished between risk—for example, gambling in a casino where we don't know the outcome but can calculate the odds—and what he called "true uncertainty," in which we can't know everything that would be needed to calculate the odds (Knight, 1921). Or, as Keynes (1937) put it, "There is no scientific basis to form any calculable probability whatever. We simply do not know."

Radical uncertainty does not prevent us from taking decisions and performing actions, as individuals, societies or governments. We cannot know the future, but we can imagine it and try to influence it. And the imagined, probable or expected outcomes in turn influence our decisions and actions in the present, which is why we talk of "adaptive complex systems". Even things that may never happen or will only happen decades from now can have an impact on what we do today. As individuals we buy insurance and pay into pension funds; as societies we try to forecast GDP or the impacts of climate change.

In the following, we will look at a number of characteristics that can influence policy thinking and the outcomes of policy decisions, emphasising how the characteristics of complex systems can be both positive and negative

### *Interconnectedness*

The 2008 crisis showed how interconnectedness can have benefits and drawbacks. Global linkages across borders help the world to grow richer, but they also serve as transmission mechanisms for shocks. What started as a financial crisis in the United States sub-prime housing market degenerated rapidly into a global economic crisis with a dramatic collapse of international trade and foreign direct investment. We witnessed the same with the Covid pandemic. Globalisation allowed businesses to optimise and bolster their bottom lines but also became a transmission mechanism for the virus and caused an immediate supply shock in a number of industries.

The impact of interconnectedness on system stability is not straightforward, and can change dramatically over time. In energy grids, for instance, interconnectedness allows electricity to be switched to parts of the network that cannot meet demand from their local power stations. But in February 2021, severe winter storms in Texas caused failures in natural gas equipment that was insufficiently weatherproofed, causing gas production to fall drastically. Power plants did not have backup sources of thermal energy to power the grid, resulting in cascading blackouts and system-wide disruptions (Linkov et al., forthcoming). The state could not import energy from its neighbours because it had implemented a policy of energy autonomy to avoid federal oversight and deregulate its energy sector (Englund et al., 2021). In Europe around the same time, it was interconnectedness rather than a lack of that caused problems. A circuit protector in a substation in Croatia shut down a power line, causing another line to overload and provoking a system imbalance that propagated across the grid and almost caused the electricity system to collapse across the continent (ENTSO-E, 2021).

### *Multiple scales*

We highlighted earlier that system behaviour can change with scale. In addition, many scales may be operating at once. The pandemic presented numerous examples of how multiple scales have to be addressed simultaneously to tackle systemic problems. Measures to fight Covid-19 only work if they go from individual behaviour (wear masks, wash hands, social distance, minimise trips), to cities and regions (cancel public events and concerts, restrict capacity in spaces, close parks), to countries (restrict travel, impose quarantines), to large international blocks (share data, pool resources for a vaccine).

There are different scales in time as well, from the millennia-long geophysical shifts that created the earth, its climate and its creatures to the nanosecond response times in financial markets. Here too, the concurrent operation of these different scales may be important—for example the fast pace of technological change and the much slower pace of regulatory innovation can create vulnerabilities in the system.

Moreover, the pace of systemic change can accelerate rapidly when a tipping point is reached, causing a regime shift. A system may change slowly and steadily over a number of years, then suddenly collapse. This happened to the Northeast Atlantic cod fishery that collapsed in the early 1990s with the loss of 50,000 jobs, and never recovered, despite a ban on fishing seeing some fish come back for a short time (Worm et al., 2009). The short term is therefore no guide to the long term, and the eventual tipping point may occur decades or more after a small change sets an evolutionary process in motion (Chaparro-Pedraza and de Roos, 2020).

The scale of the system may also play a role. Intuitively, one may expect a larger system to be more stable, and it does seem to be the case that larger systems take longer to reach a tipping point that can trigger a regime shift. However, there is some evidence from ecosystems that once the tipping point is reached, change is disproportionately faster in bigger systems because of a domino effect, with habitats and species impacting each other and provoking rapid, cascading collapse (Cooper et al., 2020).

### *Efficiency*

Colloquially, efficiency may be understood as achieving maximum productivity with minimum wasted effort or expense, encapsulated in expressions such as “doing more with less”, applied to health and other services subject to budget restrictions (Harlock et al., 2018). Where waste is treated as ‘lost opportunity’ or ‘unrealised potential’, actors ranging from private businesses to urban planners to economic policy analysts all seek to identify ways of increasing systemic efficiency by either reducing waste or increasing output per unit of energy invested within a given activity. Generally, efficiency measures are based on eliminating unneeded redundant systems or resources that have little or no discernible value in the short to medium term.

This may be a reasonable strategy if externalities are low and disruptions are minimal and predictable. When conditions change, or a sudden disruption occurs, a lack of redundant capacity or alternative systemic configurations may leave a business, government, household, or other unit unable to cope with losses in core system functions, as the Covid pandemic showed. The concentration of industrial capacities and economic activity into smaller and more efficient sectors produced highly lucrative yet fragile supply chains and economic exchanges. While this provided considerable opportunities, it also made economic and other systems such as health services vulnerable to sudden and unexpected disruption, as the result of either an external shock, the way the system has self-organised, or a combination of both (Juttner and Maklan 2011; OECD and FAO 2019). The pandemic is not the first example of how extremely efficient supply chains can also be fragile at the same time. The 2011 earthquake and tsunami in Japan, for example, exposed the limits of just-in-time supply chain organisation, and highlighted the importance of flexibility, diversification, and adaptability (Fujimoto 2011; Golan et al., 2020).

### *Risk and resilience*

All systems require a certain level of resilience to function, with that level changing according to the needs and degree of importance of such systems to society. In financial systems for example, data is backed up to more than one place, while power supplies for the servers may have what is called 2(N+1) architectures, meaning they have double the capacity needed for uninterrupted operation plus an extra capacity. Other data centres may only have N+1, the capacity to support a single failure. A core problem is that risk and resilience are fundamentally different concepts, yet are often conflated. The risk framework considers all efforts to prevent or absorb threats before they occur, while resilience focuses on recovery from losses after a shock has occurred. The US National Academy of Sciences (and others) define resilience as "the ability to anticipate, prepare for, and adapt to changing conditions and withstand, respond to, and recover rapidly from disruptions." (NAS, 2012). In this definition, adapt and recover are resilience concepts, while withstand and respond are risk concepts, thus the risk component is clearly added to the definition of resilience.

Risk assessment and management is typically undertaken on a threat-by-threat basis in order to derive a precise quantitative understanding of how a given threat exploits a system's vulnerabilities and generates harmful consequences. Such an exercise works well when the universe of relevant threats is thoroughly categorised and understood, yet is limited when reviewing systemic risk to complex interconnected systems because it does not consider how linkages and nested relationships with other systems leave a given system vulnerable to cascading failure and systemic threat. In other words, risk analyses usually fail to consider the third and fourth round effects of events transmitted through systems, which can be even more dramatic than the original.

Resilience-based approaches, which inherently review how the structure and activities of systems influence one another, help us to understand and even quantify a web of complex interconnected networks and their potential for disruption via cascading systemic threat. Resilience emphasises the role of recovery post-disruption as much as absorption of a threat and its consequences. This mindset is grounded upon ensuring system survival, as well as a general acceptance that it is virtually impossible to prevent or mitigate all categories of risk simultaneously, and before they occur. Resilience practitioners seek to use limited financial and labour resources to prepare their system for a wide variety of threats, all the while acknowledging that, at some point, and regardless of how well the system plans for such threats, disruption will happen.

For systemic threats, balancing efficiency and resilience is a matter of survival, where critical systems (water, energy, communications, security, food, etc) must be maintained above a basic needs level in order to ensure that a disruption in one area does not cascade to many others. It could also be argued that resilience is a dynamic form of efficiency, allowing the system to continue functioning to some extent rather than collapsing. It is clear that resilience is desirable (like efficiency), but the question arises of how to confer resilience on a system.

There are two broad approaches to answering that question: resilience by intervention and resilience by design (Linkov et al., 2021; Hynes et al., forthcoming). Social and economic systems should strike a balance between the two, but economic recovery from the 2008 crisis and the Covid pandemic has relied mainly on massive government interventions to shore up the financial sector and protect businesses. From January to October 2020, fiscal stimulus packages against SARS-CoV-2 totalled 3.4% (Saudi Arabia) to 28.31% (Japan) of GDP (IMF, 2021). These interventions allow governments to prevent systems from collapsing, and influence how society might 'bounce forward' after the crisis. A 'hands-off' approach to economic recovery may yield structural reforms, fiscal consolidation and creative destruction.

However, although these interventions may improve national and international economies, cascading disruptions, as seen in the Covid pandemic, mean that losses snowball. While financially quantifiable, these losses are not easily recovered and their cost may become unbearable politically or for markets, or

both. Moreover, the success of interventionist policies depends on impeccable timing and a precise identification of where to intervene. A badly-targeted intervention may yield poor returns or even inhibit long-term sustainability in job creation, sectoral growth, and international trade.

Resilience by intervention must therefore be complemented by resilience by design to incorporate intentional resilience into economic systems without compromising long-term efficiency or other economic goals. This approach sees resilience as a practical philosophy and methodology to analyse complex adaptive systems and systemic risks and understand how systems absorb threats and maintain their inherent structure and behaviour. More specifically, resilience is used as a global state of preparedness, where targeted systems can absorb unexpected and potentially high consequence shocks and stresses (Larkin et al., 2015).

## Towards a systemic recovery

In order to promote positive social and economic change post-Covid, a range of policies have to be integrated, including education, demographic, employment, well-being, and technology and innovation policies. Lifelong education, for example, will keep populations healthier, more physically and cognitively active, and more connected to society and the labour market (Hynes et al., 2020). Some authors go further, arguing that a "brain capital strategy" is required in the post-Covid economy since most new jobs will demand cognitive, emotional, and social skills, not manual skills (Smith et al., 2021).

Once again, the OECD was already looking at issues that the crisis would highlight before the Covid pandemic struck. In 2018, Secretary-General Gurria convened a high-level Advisory Group to examine the converging planetary emergencies linked to the environment, the economy, and social and political systems, and invited them to rethink the role of the economy in improving the well-being of people and the planet. The Advisory Group's report concluded that we have to stop seeing growth as an end in itself, but rather as a means to achieving societal goals, including environmental sustainability, reduced inequality, greater wellbeing and improved resilience (OECD, 2020). This requires updating the philosophy, tools and methods underpinning the analysis that influences economic decision-making, and adopting an approach which recognises the rootedness of economic systems and behaviour in the relationship between people, social institutions and the environment.

In consequence, economic policy should have four paramount objectives:

- Environmental sustainability – understood as a path of rapidly declining greenhouse gas emissions and environmental degradation, consistent with avoiding catastrophic damage and achieving a stable and healthy level of ecosystem services.
- Rising wellbeing – understood as an improving level of life satisfaction for individuals, and a rising sense of improvement in the quality of life and condition of society as a whole.
- Falling inequality – understood as a reduction in the gap between the incomes and wealth of the richest and poorest groups in society, a reduction in rates of poverty, and a relative improvement in the wellbeing, incomes and opportunities of those experiencing systematic disadvantage, including women, members of ethnic minorities, disabled people, and those in disadvantaged geographic communities.
- System resilience – understood as the economy's ability to withstand financial, environmental or other shocks without catastrophic and system-wide effects.

### *States and markets*

Implementing such an approach would have profound implications for the role of the state. In 1986, US President Ronald Reagan joked that "The nine most terrifying words in the English language are: I'm from

the Government, and I'm here to help" (Reagan, 1986). A year later, UK premier Margaret Thatcher would argue that "there's no such thing as society… people must look after themselves first" (Keay, 1987). The sentiment underlying these remarks was in tune with an approach that promoted deregulation, government disengagement and free market-based solutions to problems. However, by the time the Covid pandemic broke out, this thinking had changed, in part because of the massive government help provided during and after the 2008 crisis. In March 2020, French President Emmanuel Macron declared that: "What this pandemic reveals is that there are goods and services which have to be made independent of the laws of the market. To delegate our food, our protection, our ability to take care of our way of life to others is a folly. We have to take back control" (Macron, 2020).

The question is not state versus market, but how to create synergies between them. Governments are the only human system big enough to coordinate the response to global systemic threats and planetary emergencies, while businesses and markets can provide the goods, services, and expertise needed to transform policy visions into concrete improvements in well-being. Speaking at a NAEC seminar in 2018, Marianna Mazzucato suggested a way to harness the strengths of both (NAEC, 2018). Mazzucato argued that missions can provide the means to focus research, innovation and investments on solving critical problems, while also spurring growth, creating jobs and resulting in positive spill-overs across many sectors. By promoting public research and innovation, and investments in new strategic areas that have the possibility to bring together different actors across different sectors, it is possible to galvanise private sector investment by defining growth opportunities.

She quoted the example of the Apollo Program and the space race to show what it is possible to achieve by mobilising nations' intellectual, financial and industrial resources. Even if Apollo had failed to land a man on the Moon, it would still have transformed modern life and the economy. In addition to the most obvious applications of space-based technologies such as computers, mobile phones or weather satellites, space R&D benefitted a wide range of products, from cordless tools to baby food (NASA, 1996). The development of vaccines against Covid is a more recent example of publicly-funded research being vital to the development of a new product.

## Conclusion: Rethinking priorities

A fundamental challenge to governance is understanding the system as a complex network of individual and institutional actors with different and often conflicting interests, values, and worldviews. Superimposed on this governance network are potential risk events with ill-defined chains or networks of interrelated consequences and impacts. A resilience mindset acknowledges that the infinite variety of future threats (and opportunities) cannot be adequately predicted and measured, nor can their effects be fully understood. Adopting such an approach means rethinking our priorities, and especially the relative importance of resilience and efficiency. When you try to optimise one part of a complex system, you can end up destabilising the system as a whole. This principle is evident in global supply chains, surely one of the most efficient components of the international economy. When a highly optimised workflow is disrupted by shocks such as Covid-19, "Maybe just-in-time needs a dose of just-in-case" (Sodin, 2020).

There is a need to shockproof key global value chains to prevent a natural or political disaster triggering potentially catastrophic cascading collapse. This requires an understanding of corporate and market structures, and the effects of concentrations of financial and corporate power. It also means understanding how changes in competition policy and trade policy in recent decades contributed to making today's systems so fragile, and how to use these same policy tools to devise solutions (Hynes and Lynn, 2021).

The system of regulation and subsidy should be designed to promote de-concentration and redistribution of key industrial capacities, such as semiconductors, chemicals, and other capital-intensive goods and components, as well as health-related products needed to cope with the next pandemic. The goal should

not be national self-sufficiency, rather to distribute capacity so that a disruption only affects a minor portion of the total supply of any particular vital good or component.

The radical uncertainty associated with complex systems makes it impossible to predict where the next crisis will come from, but this should not stop us learning the lessons of the past to prepare a systemic response for the future. One lesson from Covid-19 is that crises do not repeat themselves. The fact that we were able to contain previous coronavirus crises such as SARS led to a sense of complacency in some instances about our ability to contain any future crisis. We cannot afford to be complacent about the other grave crisis we are facing: the climate emergency. In systemic terms, this is not a shock, with all that implies of a sudden, unexpected occurrence, but more like a stress. Systems analysis teaches us that stresses such as global warming are non-linear. The system may continue to function more or less normally for a long period and only degrade slowly, but it can then reach a tipping point from which it cannot recover, and collapse can then be extremely rapid.

Covid-19 shows that we have to act now, because we simply don't know how changes in one system may evolve and impact other systems, or in this case how a mutation in a virus could cripple the world economy. We can anticipate, however, that serious damage to a natural system, such as biodiversity loss, or significant changes, such as sea level rise or increased occurrence of extreme weather, will have serious impacts on economic and social systems too.

As we recover and reconfigure systems, we must be aware that future systemic shocks and upheavals may arise from any number of origins, and in particular may be of our own making. While we have no reasonable way to anticipate and prepare for the broad universe of threats, we can analyse those to which we have contributed and diminish the practices that made this happen. This is particularly true of climate change. The basic lesson is that our influence on the evolution of our systems must be designed to have resilience as the primary objective, and the means to achieve that have to be constantly adapted over time to provide them with the capacity for recovery and adaptability regardless of the challenges they may face.

In the next stage of this work, NAEC will build on the insights from a systems approach to look at the forces shaping specific systems, including the environment, the financial system, employment, the agro-food system, global production systems, and communication networks. We will use the lessons from this analysis to discuss how to conceive an integrated approach to dealing with planetary emergencies.

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# 3 A systemic Resilience Approach to Dealing with Covid-19 and Future Shocks

This chapter argues that traditional policy approaches ignore how systems interact and how their systemic properties shape this interaction, leading to an over-emphasis on a limited set of characteristics, notably efficiency. The emphasis on efficiency in the operation, management and outcomes of various economic and social systems was not a conscious collective choice, but rather the response of the whole system to the incentives that individual components face. This has brought much of the world to rely upon complex, nested, and interconnected systems to deliver goods and services around the globe. While this approach has many benefits, the Covid-19 crisis shows how it has also reduced the resilience of key systems to shocks and allowed failures to cascade from one system to others. A systems approach based on resilience is proposed to prepare socioeconomic systems for future shocks.

## Introduction

> *"Everything we do before a pandemic will seem alarmist, everything we do after a pandemic will seem inadequate."*
>
> *US Health and Human Services Secretary Michael Leavitt in 2007*

Recent decades have emphasised efficiency in the operation, management and outcomes of various economic and social systems. This was not a conscious collective choice, but the response of the whole system to the incentives that individual components face. As a result, much of the world now relies on complex, nested, interconnected systems to deliver goods and services. While this has provided considerable opportunities, it has also made the systems we rely on in our daily lives (e.g., international supply chains) vulnerable to sudden and unexpected disruption (Juttner and Maklan, 2011; OECD and FAO, 2019). In complex systems, tensions exist between efficiency and resilience, the ability to anticipate, absorb, recover from, and adapt to unexpected threats. Resilience is a focus of specific parts of some systems, for instance military and health systems, but some systemic risks are the consequence of attempts to maximise efficiency in subsystems leading to suboptimal efficiency at higher levels.

The Covid-19 outbreak is the first global pandemic to be caused by a coronavirus, leading to a crisis with considerable losses in terms of health but also to much of the global economy, with high social costs. The pandemic has reminded us bluntly of the fragility of some of our most basic human-made systems. Shortages of masks, tests, ventilators and other essential items left frontline workers and the general population dangerously exposed to the disease itself. At a wider level, we witnessed the cascading collapse of entire production, financial, and transportation systems, due to a vicious combination of supply and demand shocks.

In time, the international community will overcome the crisis and begin the recovery phase. The OECD response to help them in this process has been twofold: address immediate concerns, and propose an approach to dealing with the longer-term issues the pandemic highlights. In the short term, that means identifying the people and activities most affected, assessing how measures to help them will impact others, and underlining that difficult trade-offs between health, economic, social, and other goals are inevitable. In the longer term, an approach that reacts to the systemic origins and impacts of major shocks is needed if policies are to be effective.

The Covid-19 crisis also shows how important it is to keep resources in reserve for times when unexpected upheavals in the system prevent it from functioning normally. Furthermore, given the interdependence of economic and social systems, the pandemic also highlights the need for strengthened international cooperation (building on existing frameworks for emergency preparedness) based on evidence, to tackle systemic threats and help avert systemic collapse[1]. Helbing, (2012) and others have noted that the consequences of failing to appreciate and manage the characteristics of complex global systems and problems can be immense.

### The Covid-19 outbreak

The New Approaches to Economic Challenges (NAEC) Group Conference in September 2019 on "Averting Systemic Collapse" (OECD, 2019a) identified how growing complexity and interdependence has made various systems (economic, public health, cyber, etc.) susceptible to widespread, irreversible, and cascading failure. Striving for maximum efficiency and optimisation, such systems have neglected resilience against disruptions whose shocks may leave governments, the public, and the environment in a weakened state. More specifically, the concentration of industrial capacities and economic activity into smaller and more efficient sectors, up to the international level, has produced highly lucrative yet fragile

supply chains, and economic exchanges whose disruptions could have significant effects in unexpected areas.

Such notions have been thoroughly described by leading economists and scholars since the onset of the 2007-2009 Financial Crisis, yet primarily in an abstract context. A key question was not whether systemic risk would cause substantial cascading losses to the international economy, but what type of disruption would trigger such a chain of events in the first place. One answer is the coronavirus outbreak. Declared a pandemic by the WHO on 11 March 2020, Covid-19 quickly spread globally. The NAEC conference on "Integrative Economics" on 5-6 March 2020 (OECD, 2020a) highlighted that the outbreak was an example of a long-standing message of NAEC. We are not living in a linear, Newtonian world where actions cause predictable reactions. We are in fact part of a complex system of environmental, socio-political and economic systems that we are constantly reconfiguring and that is constantly affecting us. In such a world, a small change can be transmitted and amplified by the interconnectedness of the system to have enormous consequences, far beyond the time, place, and scale of the initial perturbation. We saw this in 2007-2008 when problems in the US national home loans market escalated into a financial crisis that almost destroyed the global banking system. Over a decade later, we are still suffering the consequences of the 2008 crisis because it provoked an economic recession and widening inequalities that in turn caused political and social upheaval.

The Covid-19 crisis is another illustration of how systems change each other. The initial cause, as in previous coronavirus outbreaks, was probably the transmission of an animal virus to humans. When we look in more detail at how this can happen, we find that a range of social, economic, and environmental changes contribute to creating the conditions where a zoonosis can become so damaging, from changing land-use patterns and agricultural practices to wildlife trade. But we should not stop at the immediate interactions. We could argue that the 2020 health crisis was made far worse by the 2008 financial crisis, or more precisely, the austerity measures that left many health systems without the basic human and other resources needed to cope with a sudden, unexpected rise in the number of patients.

Covid-19 also shows how subjective or cultural factors such as trust in institutions and willingness to follow their advice and instructions, the sentiment of belonging to a community or the type of neighbourhood, can influence how a disaster unfolds. A full understanding of such factors requires an approach based on integrative economics, which calls on the insights and methods of the range of disciplines needed to paint a realistic picture of how the economic system is shaped and helps shape the larger "system of systems" it is part of. Furthermore, systems thinking allows us to identify the key drivers, interactions, and dynamics of the economic, social, and environmental nexus that policy seeks to shape, and to select points of intervention in a selective, adaptive way. Critically, this allows us to emphasise the importance of system resilience to a variety of shocks and stresses, allowing systems to recover from lost functionality and adapt to new realities regarding international economics, societal needs, and human behaviour and the risks of a more unpredictable climate.

For example, the nuclear power industry in OECD countries relies on a safety philosophy known as "integrated defence in depth." This framework requires consideration of not just reactor design and hardware performance but also the human and organisational elements (e.g. emergency response organisations) necessary for safe reactor operation (NEA, 2016). This framework, consistent with integrative economics, assesses overall system resilience, while recognising that one must consider a variety of complex, interconnected variables. Energy supply security, that demands a policy response from government, may offer additional insights. Most electricity systems are, as a result, resilient by law: mandatory levels of additional dispatchable capacity are kept in reserve should the output of some technologies, or individual plants, become variable.

The ability to react to changing demand is crucial in health care systems too. Ferguson et al. (2020) provided simulations of Covid-19's diffusion which indicated that the United Kingdom's health service would be overwhelmed and might face 500,000 deaths if the government took no action. This led to the implementation of restrictions on social movement. Using a similar modelling approach, simulations for the United States suggested 2.2 million deaths if no actions were taken. After it was shared with the White House, new guidance on social distancing was issued. Epidemiologist Joshua Epstein, from New York University's School of Global Public Health, outlined the global spread of pandemics with a focus on Covid -19 in which the interaction between the infection dynamics (created by the pandemic) and the social dynamics (created by fear) - what he terms a "coupled contagion" - produce volatile outcomes. Individuals contract fear through contact with the disease-infected (the sick), the fear-infected (the scared), and those infected with both fear and disease (the sick and scared). Scared individuals - whether sick or not - withdraw from circulation with a certain probability, which affects the course of the disease epidemic proper. If individuals recover from fear and return to circulation, the disease dynamics become rich, and include multiple waves of infection, such as occurred in the 1918 Influenza Pandemic (see figure 3.1 below) (Epstein, 2014).

### Figure 3.1. Susceptible individuals (blue curve) self-isolate (black curve) through fear as the infection of disease proper grows (red curve)


Source: Epstein JM, Parker J, Cummings D, Hammond RA (2008) Coupled Contagion Dynamics of Fear and Diseas: Mathematical and Computational Explorations, PLOS ONE 3(12): e3955.https://doi.org/10.1371/iournal.pone.0003955.

One could push the argument further, using the example of financial system. The two contagions - the virus and fear - operate in tandem and the behaviour of individuals is changed. The movements in capital markets engendered by the change in decisions of market participants, who were originally affected neither by the virus or fear of it, may set off an epidemic of market movements. This can lead, as we have observed recently, to a crash of unprecedented proportions.[2]

## What are the impacts?

### Economic

The OECD Interim Economic Outlook released on 2 March 2020 (OECD, 2020b) showed how restrictions on movement of people, goods and services, added to containment measures such as business closures, cut manufacturing and domestic demand sharply in China, and how the impact on the rest of the world was growing through business travel and tourism, global supply chains, commodities, and loss of confidence.

The initial direct impact of the shutdowns could be a decline in the level of output of between one-fifth to one-quarter in many economies, with consumer expenditure potentially dropping by around one-third. This is far greater than anything experienced during the 2008 financial crisis. And this estimate only covers the initial direct impact in the sectors involved and does not take into account any additional indirect impacts. Nonetheless, it is clear that the direct impact of the shutdowns imposed on many economies will weaken short-term growth prospects substantially, equivalent to a decline in annual GDP growth of up to 2 percentage points for each month of containment, not taking into account the potentially large indirect impact (loss of confidence etc.)[3] If the shutdown continued for three months, with no offsetting factors, annual GDP growth could be between 4-6 percentage points lower than it otherwise might have been. However, the worst potential impacts may be offset by measures such as the USD 5 trillion in fiscal spending the G20 countries agreed to inject into the global economy at their summit on 26 March 2020.

The Covid-19 epidemic and measures to counteract it are likely to disproportionally affect poorer people. The OECD survey *How's Life? 2020* shows that 36% of people in OECD countries are financially vulnerable, meaning they lack the financial assets needed to avoid falling into poverty if they lost 3 months of their income (OECD, 2020c). This figure climbs to over 60% in some OECD countries. Those working in the "gig economy" are among the most exposed to the economic fall-out. These workers often work on short contracts, sometimes with weak or no social protections, with limited options for working remotely, and with risks of job loss and forgone earnings if they have to remain away from their place of work due to illness, quarantine, or government- mandated closures of specific activities. Anti-virus measures will affect them significantly since they are often employed in occupations demanding a high degree of contact with a wide range of clients, such as restaurants, taxis, and delivery services.

Measures to compensate people and firms for lost earnings, involving postponement of taxes, and debt repayments and government paid leave for people in countries which do not have paid sick leave, will alleviate the situation. But in economies dominated by short-term contracts and where poorer people have little or no savings, no amount of monetary stimulus will re-energise demand. Furthermore, informal workers (except agriculture), who make up 60% of employment globally and 90% in developing countries will likely suffer massive layoffs due to the supply-demand shock even before the severity of the pandemic reaches them.

A re-examination of social protection systems and social contracts might be needed in the longer term. Nevertheless, as an immediate and practical response, conditional cash transfers were scaled up very effectively following the Global Financial Crisis and even in LDCs, food for work programmes and other forms of social protection can provide some relief. On the supply side of the economy, firms that have had to reduce their activities will take time to restart production and contribute to global supply chains.

In the longer term, the following impacts could be especially serious for the economy.

The first is the impact on international relations and the vectors of globalisation. China's merchandise trade was down 17% in the first two months of 2020. While trade may rebound when the situation improves, there may be longer term, structural effects: firms may retreat from globalisation, seeking shortened supply chains and suppliers located in countries that seem less prone to disruption or they may reshore manufacturing. This would have consequences for production structures, jobs, and income in different

parts of the world. This adds business reasons to the more political reasons that have already led to a backlash against globalisation in recent years, partly because globalisation hasn't delivered well-being for all, and partly because a number of countries have embraced trade protectionism and border controls. This is worrying when international co-operation is literally vital in coordinating the response to Covid-19 and future systemic threats. Unfortunately, the mechanisms that might provide a coordinated international response do not exist, except for limited monetary arrangements.

The international financial system is already seeing the impacts of Covid-19, with increased volatility and sharp drops in share prices. If these falls are the beginning of a longer downward trend, there is a direct negative wealth impact on asset holders. This may in particular affect funded pensions and pensioners' living standards. Further easing of monetary policies by central banks (especially by the ECB where deposit rates are already negative) may reinforce the income effect for pensioners or push savers to higher risk investment. On the other hand, low interest rates may further fuel inflation in assets that are considered safe havens (real estate, gold, government bonds) making inequalities in wealth worse. Covid-19 has exposed the vulnerability in financial markets, with corporate debt doubled since the 2008 financial crisis to now reach a record 47% of GDP. These companies will struggle to repay the debt given the lockdown and breakdown in supply chains.

Once again, the shadow of 2008 falls over the outlook today. The IMF's Global Debt Database shows that total global debt (public plus private) reached USD 188 trillion at the end of 2018 (IMF, 2020), up by USD 3 trillion when compared to 2017 (and up by over USD 90 trillion from 2007).[4] The global average debt-to-GDP ratio (weighted by each country's GDP) edged up to 226%in 2018, 1 percentage point above the previous year. Despite efforts to reduce fiscal deficits, many governments still have high levels of debt following their interventions to deal with the financial crisis and its aftermath, and sovereign spreads for some countries are starting to widen. Private debt, encouraged by low interest rates, is even more worrying. In advanced economies IMF data show that the corporate debt ratio has gradually increased since 2010 and it is now at the same level as in 2008, the previous peak. In several major economies debt is, or was, increasingly used for financial risk-taking (to fund distribution of dividends, share buybacks, and merger and acquisitions). Much of the debt is high speculative-grade debt, and a significant fraction of corporate debt is now rated BBB, the lowest investment grade rating. Almost half of all US corporate bonds maturing in the next five years are below investment grade. Global household debt is over USD 47 trillion, compared to USD 35 trillion going into the 2008 crisis.

### *Health and social impacts*

The elderly are the most affected, but the effects on them do not depend on biological factors alone. A number of factors contribute to the total impact. The elderly are exceptionally exposed to death from the disease, but also risks arising from isolation and weak social ties, compounded by the fragmentation of health and social care services. Nearly one-third of adults aged 65 and older in many G20 countries are estimated to live alone (and twice as many elderly women live alone compared to men, and they generally have lower pensions). Older people are almost three times more likely to lack social support than younger people, and if they do fall ill, it may take longer to detect, and care at home may be impractical. This is, of course, highly dependent on the country in question, and older people are much better cared for in those with a better social safety net.

School closures are the main impact on children and young people, but the capacity and adaptability to compensate for the projected loss in learning varies according to socio-economic profiles of students and schools, with those from low-income and/or single-parent families likely to be the most affected by the closure of schools and childcare facilities as well as a full transition to digital learning. The PISA 2018 surveys reveal that on average across OECD, only 69% of 15-year-old socio-economically disadvantaged students - as opposed to 90% of advantaged students - have a quiet place to study at home and a computer to use for schoolwork (OECD, 2018). The poorest children will also suffer by being deprived of school

meals and other support measures based on schools. During the Covid-19 epidemic, despite government efforts, online courses and classes will be difficult to access for disadvantaged students. Tackling the digital divide between students from different backgrounds, by providing them with free or affordable devices and internet access for example, would provide an example of how action to tackle a crisis could make a system more resilient, and better suited to its mission than before, what we call "bouncing forward" below. Ultimately, resilience in education could be developed through building of skills and competencies in individuals and groups, but this requires a differentiated strategy to make up for the unequal starting conditions.

### *Comparing country responses to Covid-19*

Evidence-based policy relies on data, but in the case of Covid-19, the basic statistics on the number of cases are unreliable due to insufficient testing, unreported cases, asymptomatic cases, and countries deliberately under-reporting cases. The OECD is however tracking four key measures that health systems in member countries are putting in place in response to the epidemic, while emphasising that data on the cost-effectiveness of containment and mitigation policies is still limited (OECD, 2020d). The measures tracked are: ensuring access of the vulnerable to diagnostics and treatment; strengthening and optimising health system capacity to respond to the rapid increase in caseloads; digital solutions and data to improve surveillance and care; and R&D for accelerated development of diagnostics, treatments and vaccines.

Success in dealing with the epidemic depends on a combination of socioeconomic and political factors that include the state of the health system before the outbreak, social norms, the rapidity and intensity policy responses such as lockdowns, and testing.

Korea combines a number of the characteristics that appear to favour an effective response, for example a tradition of wearing face masks to prevent spreading colds and other diseases. Legislation had already established a comprehensive framework to address infectious diseases and coordinate government and lower-level responses, including on how to allocate resources and collect data. In a statement issued on April 15, the Korean government explained its success as a result of the third of the measures the OECD is tracking, digital solutions: “Mobile devices were used to support early testing and contact tracing. Advanced ICTs were particularly useful in spreading key emergency information on novel virus and help to maintain extensive ‘social distancing’. The testing results and latest information on Covid-19 was made available via national and local government websites. The government provided free smartphone apps that flagged infection hotspots with text alerts on testing and local cases.” (Government of Korea, 2020)

Germany’s first outbreak of locally transmitted Covid-19 was around January 22, a month before Italy’s first reported case, but Germany has recorded just over 2000 deaths at the time of writing, compared with nearly 18,000 in Italy. The German government attributes some of its success to its National Pandemic Preparedness Plan (Government of Germany, 2020). The response included a health ministry information campaign and widespread testing. Deutsche Welle (DW), Germany’s international broadcaster, suggests that the way health care is managed under country's federal system of government may explain some of the country’s success, with hundreds of health officials overseeing the pandemic response across the 16 states, rather than one centralised response from the national health ministry.

The importance of regional authorities is also highlighted in Italy, where the Veneto region has been successful, thanks to broad testing of symptomatic and asymptomatic cases, active tracing of possible positives, and a strong emphasis on home diagnosis and care to reduce the load on hospitals. Central government does have to recognise its responsibilities though.

Comparing what we know of successes and failures so far enables the OECD to draw some policy conclusions for health care management:

- The Covid-19 crisis demonstrates the importance of universal health coverage as a key element for the resilience of health systems. High levels of out-of-pocket payments may deter people from

seeking early diagnosis and treatment, and thus contribute to an acceleration in the rate of transmission.

- Planning for a "reserve army" of health workers, which was introduced in several countries after previous epidemics, has proven to be very useful to provide additional support to the regular workforce and allows for a more flexible management of human resources across regions.
- Crisis situations like the coronavirus epidemic can provide opportunities to change the traditional roles of different health care providers and expand the roles of some providers like nurses and pharmacists, so that they can take on some of the tasks from doctors and thereby allow them to spend their time more effectively on the most complex cases.
- Strategic reserves of masks and other protective equipment may be considered to avoid exposing doctors and other health workers to high risk of infections.
- Use routine and big data for early warning and surveillance as well as digital diagnosis and take advantage of digital technologies to advise the public and limit physical contacts as well as to monitor people who have been diagnosed.
- Use new approaches, including through AI and machine learning, to accelerate and improve the effectiveness of R&D efforts. For example, explore whether drugs used for one pathology could be useful in treating others.
- Prepare fast-track regulatory and emergency approval pathways for new diagnostic tests and treatments. Regulatory agencies should also agree that they will co-ordinate their efforts internationally to ensure that evidence used for approval in one jurisdiction is sufficient for others, rather than applying different standards.
- Governments should allocate public funding to build capacity to produce vaccines and treatments before regulatory approval, in exchange for commitments from industry to make products widely available and accessible at moderate prices once approved.
- Avoid international competition to access the first lots of vaccines or treatments, to ensure that any effective vaccine or treatment is first supplied to where need is the highest and where it can have most impact.
- New incentive mechanism, such as global innovation funds, market entry rewards, and advance purchase commitments, may be required to finish the development process of products being developed for Covid-19 to prepare for future crises if the immediate need for these products disappears.

## Resilience strategies and policies to deal with shocks

In addition to the health care system, how should we deal with the considerable shock that Covid-19 places upon international markets, social activity, and governance? How can we address the cognitive and especially behavioural effects of fear at the individual and collective level, which can trigger substantial slowdowns in economic activity, as well as the systemic effects that strain various sectors of international trade and governance?

Two overarching philosophies and methodologies are available for stakeholders to draw upon. Until recently, the consensus would have insisted upon preventing a threat from happening in the first place or substantially mitigating its consequences after the event if absolute prevention or avoidance is impossible. As the basis of conventional risk management (i.e., to prepare for and absorb shocks), this option is politically appealing at the onset, as it offers the possibility that unacceptable risks may be bought down before they cause serious problems.[5] In a world of rapid feedback loops and increasingly nested systems where cascading failures are inevitable, however, such options might be ineffective at protecting economic and social systems and calming perturbations, or would be ruinously expensive to implement to the extent

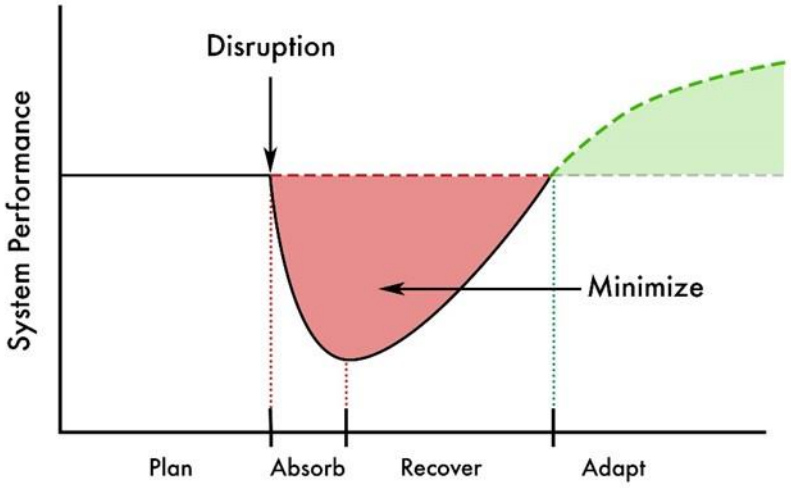
needed to assure policymakers and other stakeholders of adequate protection (Michel-Kerjan, 2012; Linkov et al, 2019). Risk management is too often construed as a means of maintaining the leanest possible operations in the name of efficiency, and consequently, reducing redundancy to zero. Without redundancy, there is much greater vulnerability and little or no ability to absorb shocks, which in turn can quickly turn into failures.

The second approach is one that accepts the inherently uncertain, unpredictable, and even random nature of systemic threats and addresses them through building system resilience.[6] Rather than rely solely upon the ability of system operators to prevent, avoid, withstand, and absorb any and all threats, resilience emphasises the importance of recovery and adaptation in the aftermath of disruption. Such a mind-set acknowledges that the infinite variety of future threats cannot be adequately predicted and measured, nor can their effects be fully understood. Resilience acknowledges that massive disruptions can and will happen – in future, climate disruption will likely compound other shocks like pandemics – and it is essential that core systems have the capacity for recovery and adaptation to ensure their survival, and even take advantage of new or revealed opportunities following the crises to improve the system through broader systemic changes. The Covid pandemic for example provides an opportunity to address other emergencies such as climate change more effectively. This is sometimes characterised as not just bouncing back, but "bouncing forward" (Linkov, Trump, and Keisler, 2018; Ganin et al, 2016; Ganin et al, 2017).

Interconnectivity between systems is one of the structuring and determining features of the modern world, which is becoming ever more complex and dynamic. This is a product of economic opportunity as well as global political interconnectedness, and has brought considerable benefits to much of the global population. An instinctive reaction to the Covid-19 outbreak would be to limit or reduce such interconnectedness, yet such sweeping policy changes would not better protect countries or international markets against future systemic threats. Instead, an emphasis upon developing resilience within the international economic system is a necessary evolution for a post-Covid-19 world, where systems are designed to facilitate recovery and adaptation in the aftermath of disruption.

Complementing risk-based with resilience-based approaches for the management of epidemics, as well as for other systemic threats, is a necessity. Risk management of a system driven by resilience as a goal would identify those uncertainties (unpredictable risks) likely to have an effect on resilience The resilience we are talking about here, however, is not resilience in the traditional sense the OECD tended to use, meaning the capacity to resist downturns and get back to the same situation as before. There is an awareness that the systemic threats modern societies face are increasingly difficult to model, and are often too complex to be solved for the "optimal response" using traditional approaches of risk assessment that focus primarily upon system hardness and ability to absorb threats before breaking. The new approach to resilience will focus on the ability of a system to anticipate, absorb, recover from, and adapt to a wide array of systemic threats (see figure 3.2 below).

### Figure 3.2. System Performance and Resilience




Source: US National Academy of Sciences (NAS) (2012)

The NAEC report "Resilience Strategies and Policies to Contain Systemic Threats" defines concepts related to systemic threats and reviews the analytical and governance approaches and strategies to manage these threats (including epidemics) and build resilience to contain their impacts. This aims to help policymakers build safeguards, buffers and ultimately resilience to physical, economic, social and environmental shocks.

## Recommendations

Recovery and adaptation in the aftermath of disruptions is a requirement for interconnected 21st Century economic, industrial, social, and health-based systems, and resilience is an increasingly crucial part of strategies to avoid systemic collapse. Based on NAEC reports and the resilience literature, specific recommendations for building resilience to contain epidemics and other systemic threats include:

1. Design systems, including infrastructure, supply chains, and economic, financial and public health systems, to be resilient, i.e. recoverable and adaptable.
2. Develop methods for quantifying resilience so that trade-offs between a system's efficiency and resilience can be made explicit and guide investments.
3. Control system complexity to minimise cascading failures resulting from unexpected disruption by decoupling unnecessary connections across infrastructure and make necessary connections controllable and visible.
4. Manage system topology by designing appropriate connection and communications across interconnected infrastructure.
5. Add resources and redundancies in system-crucial components to ensure functionality.
6. Develop real-time decision support tools integrating data and automating selection of management alternatives based on explicit policy trade-offs in real time.

Procedurally, a complement to such resilience-based approaches is included in the International Risk Governance Centre's *Guidelines for the Governance of Systemic Risks* (IRGC 2018). The IRGC highlights a multi-step procedure to identify, analyse, and govern systemic risks, as well as better prepare affected

systems for such risks by mitigating possible threats and transitioning the system towards one of resiliency-by-design. The IRGC's cyclical process for the governance of systemic risk includes:

1. Explore the system, define its boundaries and dynamics.
2. Develop scenarios considering possible ongoing and future transitions.
3. Determine goals and the level of tolerability for risk and uncertainty.
4. Co-develop management strategies dealing with each scenario.
5. Address unanticipated barriers and sudden critical shifts.
6. Decide, test and implement strategies.
7. Monitor, learn from, review and adapt.

The purpose of the IRGC exercise is not to generate a deterministic model that applies to any and all systems - this is neither possible nor helpful. Instead, it is designed to produce more introspective, collaborative, and multi-system viewpoints regarding the threats that may be lingering along the peripheries of systems, as well as where a system's critical functions or resilience challenges should be improved within future strategic management opportunities.

An example of applying similar approaches to disease epidemics is presented in Massaro *et al*. (2018). The methodological resilience framework discussed above was applied to the analysis of spread of infectious diseases across connected populations. They monitor the system-level response to the epidemic by introducing a definition of engineering resilience that compounds both the disruption caused by the restricted travel and social distancing, and the incidence of the disease. They confirm that intervention strategies, such as restricting travel and encouraging self-initiated social distancing, reduce the risk to individuals of contracting the disease. However, given the expected repercussions of restricted population mobility for critical functionality of the economy, consideration could be extended to address how to keep the system resilient even under necessary and life-saving measures such as lockdowns.

So although containment measures are unavoidable to slow down the epidemic's progression, such measures may drive the system into negative health and economic outcomes. Multiple dimensions of a socio-technical system must be considered in epidemic management, based on treaties like international health regulations which govern infectious disease response internationally and set out a framework for analysing contingency plans at the national and international levels. For Covid-19, this implies that countries should resist the temptation to self-isolate from their international partners in an attempt to build national self-reliance. Viruses do not respect borders or administrative silos and the response to them has to be international and inter-sectoral. Multilateral action, as called for by G20 and G7 Leaders, will make governments' initiatives far more effective than if countries continue to act alone. The encouraging examples of medical equipment, personnel, best practices, and even hospital capacity being shared among countries can motivate and justify an integrated, multilateral approach to helping national and international systems to recover better. One way of doing it is to protect existing ODA commitments, targeting supports to health systems and vulnerable people in developing countries. Multilateral funds are efficient and effective ways of disbursing funding fast to places where it is most needed, but the cooperation and mechanisms to encourage international coordination that emerged in tackling Covid-19 should not be allowed to fade when the crisis ends.

Governments are considering a wide variety of political and economic policies to safeguard and recover lost economic and societal functions due to the Covid-19 pandemic. OECD's value-added to this exercise is to identify strategic opportunities to shape intermediate and future policy in a manner that not only preserves and recovers from this crisis, but also improves national and international economic systems. Policy actions to facilitate recovery must be analysed and selected now, and any policy decisions in the short term will shape not only the nature of economic recovery in the next year, but the economic and political priorities of economic globalisation as well. Policy choices made for the recovery will also have a

strong influence on the world's ability to avert dangerous climate change, as well as to become more resilient to the climate impacts already locked in.

In recovering from the Covid shock, the OECD can use economic models and other analytical resources to assess the efficiency of different regulatory policies discussed below. These immediate needs are of critical importance. Equally important will be OECD inputs to develop strategic priorities and building resilience in national and regional responses to the crises. In both cases, policy interventions and priorities to address Covid-19 must incorporate principles of system resilience to systemic disruption now, for not doing so will limit future socioeconomic recovery for the next decade at least.

Systems thinking is the most powerful tool we have at our disposal to accomplish this task, if it is part of a trilogy completed by anticipation and resilience. On a theoretical level, systems thinking shows that crises are an intrinsic characteristic of complex systems such as public health or financial markets. In practical terms, policymakers must factor in the certainty that sooner or later all systems fail, including the ones they are making policy for. So they have to be prepared, even if preparation does not appear to be cost effective until the crisis happens. The excuse that dangers are clear only in hindsight does not stand up to objective scrutiny. Major simulation exercises in OECD countries predicted accurately how a crisis like Covid-19 could unfold[7], but they were not acted on, or not sufficiently, judging by what has happened.

Resilience is a safe option in intangible domains such as financial systems too. Many people saw the present financial crisis coming and many experts pointed to debt as a major contributing factor to system fragility. A policy approach based on systems thinking would accept that although we do not know what the trigger of the next crisis will be, we do know it will come and that certain factors can make it more likely and more damaging, and that there are better policy options than waiting for it to happen then paying for bailouts.

Finally, a systems approach is in tune with the OECD's repeated calls to "break down silos". We are seeing how a health crisis does not remain simply a health crisis for long. It can quickly spread to other systems that at first sight seem to be unconnected. In a world where an ecosystem in a Chinese province can trigger a global economic crisis, we have to abandon our traditional, linear, compartmentalised way of making and applying policy, and cooperate pragmatically at local to international levels.

## Strategic policy interventions for Covid-19

### *Recovery and building resilience in the local economy*

*Strategic Need:* Preserve and Recover from Disruptions to Local Economies.

*Policy Response:* Identify interventions to improve business recovery post-Covid-19. Funding should be prioritised based on immediate needs for economic recovery at the system level that includes consideration of local demand and regional/global supply chain and impact of the region to regional, state, and global economy.

*Economic Action*: Prioritise and invest within critical economic sectors and businesses based upon value-added to local community (i.e., the dollar/euro yielded for taxes, salaries, local spending per dollar/euro invested into the company)

*OECD Response:* Assist governments (both national and local) to prioritise (a) critical economic sectors, and (b) critical industries/businesses that have a socially and economically net-positive contribution to society. Any low-interest loans or targeted investment/disbursement should be targeted, rather than prioritising businesses or industries with social or economic net negatives/harms to broader society (i.e., high downstream costs with low immediate benefits via exploitative wages and sending money outside of the local economy). For example, renewable energy should be subsidised, industries based on extraction should not.

### *Household Resilience*

*Strategic Need:* Bolster consumer/household resilience to shock

*Policy Response:* Identify interventions to improve household recovery post-Covid-19. As the core of economic growth, individual households need to be provided resources/support at the system level across necessary goods, services, and social/cognitive support. Optimisation should be based on individual/community resilience to avoid the impact of shocks and optimise recovery.

*Economic Action:* Revisit recommended assumptions upon household budgets, and identify areas of required slack/redundancy in household spending/savings.

*OECD Response:* First, analyse government stimulus proposals based upon their ability to meet all or most of the critical household needs of various segments of the population disrupted by the crisis.[8] Second, adopt recommendations to prevent household brittleness or fragility to shock (high cost of core essentials like housing, food, utilities, education, public health, etc.). Identify governmental investments and policy options to mitigate rising cost concerns of core industries and incentivise 'slack', or household savings to accommodate disruption of lost wages.

### *Company/Business resilience*

*Strategic Need:* Prevent Company Bankruptcies, Layoffs, and/or Shutdown While Complying With Pandemic Response Requirements.

*Policy Response:* Identify critical companies whose disruptions and layoffs would reduce national capacities to deliver goods and services in a non-linear fashion (i.e., lost synergy, social capital, institutional memory, etc.)

*Economic Action:* Targeted loans and investments into select companies and large corporations whose disruptions are not easily recoverable, and losses in institutional memory/social capital would have long-term ramifications.

*OECD Response:* Identify industries who historically have had difficulties in recovery post-disruption (i.e., the 'Dot Com Bubble', the September 11th Terrorist Attacks, the Financial Crisis/Great Recession of 2007-2009, etc. Within those industries, identify economic interventions (low/zero-interest loans or other investment) that have policy requirements of keeping sections of their labour force on payroll throughout the crisis and during recovery. Require the company to cover a portion of their payroll (i.e. 1 day each week), with government investments covering the majority of that time (i.e. 4 days each week). Labour covered by government investment should be in full compliance with WHO recommendations regarding social distancing and pandemic response requirements. This proposal will prevent mass lay-offs of high-intensity corporations that require considerable institutional and technical knowledge to operate; and remove the need for such workers to seek new economic opportunities for lost wages and remain in compliance with pandemic response requirements.

## Conclusion: Anticipate, prepare and build resilience

A resilience mind-set acknowledges that the infinite variety of future threats cannot be adequately predicted and measured, nor can their effects be fully understood. Adopting such an approach means rethinking our priorities, and especially the role of optimisation and efficiency. The science of systems engineering teaches us that when you try to optimise one part of a complex system, you can end up destabilising the system as a whole. We see that in global supply chains, surely one of the most efficient components of the international economy. The French Minister for the Economy, Bruno Le Maire, argues that that there will be a before and after Covid-19 for the world economic system: "We need to draw all the conclusions

from this epidemic on the way globalisation is organised, and notably value chains" (Le Maire, 2020). When your highly optimised workflow is disrupted by shocks such as Covid-19, maybe just-in-time needs a dose of just-in-case.

When Bill Gates in 2015 said that "We are not prepared for the next outbreak" (Gates, 2015) and suggested creating an army of specialists from many disciplines to meet whatever crisis or epidemic might arise - 27 million people viewed his talk but as he said in 2020, nobody in power heard the message. We are now in the midst of a systemic upheaval foreshadowed at the NAEC Group meeting in September 2019 on Averting Systemic Collapse which pointed out that "a new crisis could emerge suddenly, from many different sources, and with potentially harmful effects". The radical uncertainty associated with complex systems makes it impossible to predict where the next crisis will come from but that does not stop us learning the lessons of the past to prepare a systemic response for the future. One lesson from Covid-19 is that crises do not repeat themselves. The fact that we were able to contain previous coronavirus crises such as SARS led to a sense of complacency in some instances about our ability to contain any future crisis.

We cannot afford to be complacent about the other grave crisis we are facing: the climate emergency. In systemic terms, this is not a shock, with all that implies of a sudden, unexpected occurrence, but more like a stress. Systems analysis teaches us that stresses such as global warming are nonlinear. The system may continue to function more or less normally for a long period and only degrade slowly, but it can then reach a tipping point from which it cannot recover, and collapse can then be extremely rapid. Covid shows that we have to act now, because we simply don't know how changes in one system may evolve and impact other systems, in this case how a mutation in a virus could cripple the world economy. We can anticipate however that serious damage to a natural system, such as biodiversity loss, or significant changes such as sea level rise or increased occurrence of extreme weather, will have serious impacts on economic and social systems too. And all the while we have to keep in mind that the next crisis may not have "natural" origins. It could for example be a due to a failure of telecommunication systems due to cyberattack or accident.

In the spirit of Gate's call, the OECD has to help its Members to better anticipate, prepare and build resilience for future crises. There are four specific areas where NAEC could contribute, working with OECD Directorates, Committees and Members:

- Further developing systemic resilience approaches at the OECD, building on existing NAEC work (Linkov et al, 2018; Linkov et al 2019).
- Promoting the use of systems thinking and anticipation (including through the OECD-IIASA Task Force) to better understand the interactions, tipping points, feedback loops and multiple equilibrium which systems of all types are subject to.
- Encouraging the use of new analytical tools and techniques to simulate the dynamics of crises using network and agent-based models to better understand how shocks emerge and propagate whether a pandemic, financial crisis, collapsing production networks, environmental shocks or social breakdown.
- Working with the Open Markets Institute to swiftly develop a set of principles and rules policymakers can use to shock-proof all vital human-made systems and engineer these systems in ways that make them more transparent, accountable, and more open to forms of innovation that will empower us to deal with other pressing crises.

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## Notes

[1] The WHO inter alia has developed a strategic framework for emergency preparedness. After this epidemic crisis, no doubt the international community would have to reflect very seriously about how to bring health emergency preparedness to a new (much higher).

[2] Another very clear and interesting contagion model, highlighting the role of social dynamics, lags and threshold effects in recurrent waves of measles in Africa (due in part to lulls in vaccination) (Schelling, 1998).

[3] OECD Assessment (27 March 2020)

[4] OECD's Sovereign Borrowing Outlook also emphasises increase in public debt and persistent low interest rates as destabilising factors: http://www.oecd.org/finance/Sovereign-Borrowing-Outlook-in-OECD-Countries-2020.pdf

[5] This is not to discount the importance of risk management. A stronger risk approach would, for example, have led to complete development of a SARS vaccine, on the grounds that a coronavirus outbreak of some sort was likely at some point, and the costs of completion would have been trivial in comparison.

[6] For example, the protective function of buffers, the psychological and organisational functions of slack (see Shafir & Mullainathan or the adaptive function of redundancy by design (there are many examples of this in biology and engineering).

[7] For example, Crimson Contagion in the US or Exercise Cygnus in the UK

[8] Ministers of Social Affairs mandated the OECD to develop a framework for assessing households' risks and identify how the policy package should be adapted to better help them addressing these risks. A Strategy is also being developed to collect the required additional data.

# 4 Resilience Strategies and Approaches to Contain Systemic Threats

This chapter defines concepts related to systemic threats and reviews the analytical and governance approaches and strategies to manage these threats and build resilience to contain them. This aims to help policymakers build safeguards, buffers and ultimately resilience to physical, economic, social and environmental shocks. Recovery and adaptation in the aftermath of disruptions is a requirement for interconnected 21st century economic, industrial, social, and health-based systems and resilience is an increasingly important theme and a crucial part of strategies to avoid systemic collapse.

## Introduction

Modern society proceeds on the assumption that a number of complex systems will work reliably, both individually and in their interactions with other human and natural systems. This bold assumption generally holds true. Yet this assumption is being challenged by the scientific community and, increasingly by policymakers too, on the basis and improved understanding of how systems work, and by drawing on the lessons of disruptive historical events.

The immense variety of complex systems gives rise to an equally vast array of systemic risks, identifying which is made more difficult by the characteristics of the systems in question. It is possible though to characterise the nature of these threats as involving a process of contagion that spreads individual failures to the system as a whole, and where disruption in one area can cascade through the system as a whole. The key insight here is that interconnectedness brings many benefits, but it also poses new problems and can intensify the danger from existing threats. Moreover, although the consequences of a systemic threat being realised may be dramatic, the probability of this event occurring may be small. This combination of high impact, low probability, and propagation that is hard to predict makes the task of the policymaker trying to address systemic risk arduous. It requires a different approach to dealing with risks and potential system failures.

This chapter argues that resilience can provide a philosophical and methodological basis to address systemic risk in a more useful way than traditional approaches based on risk management. Resilience approaches emphasise the characteristics and capabilities that allow a system to recover from and adapt to disruption. For a resilience approach to be useful to policymaking, the domains of resilience have to be identified, along with the potential sources of system collapse.

The risks associated with the trends most likely to influence our economies and societies in the future, notably AI and digitalisation, are not amenable to traditional approaches and will present challenges that we cannot anticipate or prepare to meet using traditional tools. The following sections look at how to define systemic threats and how to understand a growing global concern. The chapter will then look at the diverse nature of systemic threats and introduce the need for resilience as a philosophy and tool to understand and address systemic threats. The next section discusses how to use history as a lens to look at civilisational collapse or survival amidst systemic threats. The practical implications and methods for identification and management of systemic threats are then outlined, before concluding with a discussion of future systemic challenges facing society.

## Systemic threats, a growing global concern

### *Defining systemic threats*

Systemic threats have been defined in numerous ways such as Centeno *et al*. (2015) “the threat that individual failures, accidents, or disruptions present to a system through the process of contagion”. The International Risk Governance Center contends that systemic threats arise when “systems [...] are highly interconnected and intertwined with one another”, where a disruption to one area triggers cascading damages to other nested or dependent nodes (IRGC, 2018). Further, IRGC (2018) states that “external shocks to interconnected systems, or unsustainable stresses, may cause uncontrolled feedback and cascading effects, extreme events, and unwanted side effects”, implying that the potential for cascading disruption is a growing and critical concern for many facets of daily life.

Systems susceptible to systemic risks are intertwined with one another in a series of nested relationships. Renn (2016) describes how such interconnectivity facilitates stochastic, non-linear, and spatially interspersed causal structures that, if triggered, contribute to a ‘domino effect’ that can permanently alter

a broader infrastructural, environmental, or social system. Due to this nature, “there is a high likelihood of catastrophic events once the risk arrives” (IRGC, 2018).

Certain triggers of systemic threats can be violent and forceful, jarring a relatively stable and sustainable system into an altogether different configuration. Such events are generally ‘low-probability yet high-consequence’, and are difficult to predict via conventional modelling techniques. Once the acute disruption occurs, a chain reaction of systemic shift occurs until a new stasis is achieved. Other triggers are more chronic in nature, for example gradual climactic shift or slight overfishing within a given ocean or sea. These are initially limited in impact, yet can eventually be overwhelming and unstoppable in their effect. IRGC’s *Guidelines for the Governance of Systemic Risk* (2018) states that such threats are best addressed early through the detection and interpretation of weak signals, although further notes that slow-moving chronic systemic threats can be nearly imperceptible in their earliest stages.

Key to slow-moving chronic threats is the notion of *transitions.* Lucas et al. (2018) and Pelling (2012) frame these transitions as ‘tipping points’ where a system edges towards a critical inflection point that may foster a transformation from one system permutation in favour of another. If breached, tipping points can cause feedback loops and nonlinear effects that cause a system to shift and change in an increasingly dramatic form.

Systemic threats are characterised by their capacity to percolate across complex interconnected systems - either through an abrupt shock, or gradual stress (IRGC, 2018). Systemic threats are particularly difficult to model and calculate via a risk-based approach due to a mixture of the weak signals of the potential risk event plus the nested interaction effects by which a systemic threat disrupts a system in an indirect manner. For example, the, 2008 financial crisis began as a collection of relatively contained failures of financial firms, which ended in a substantial financial collapse across much of the world.

### *The diverse nature of systemic threats - the need for resilience*

Many systems would benefit from a resilience-based approach, particularly systems with inherent nested interdependencies with others, or those prone to low-probability, high-consequence events that are difficult to accurately predict or model. Resilience helps these systems prepare for disruptions, cope with and recover from them if they occur, and adapt to new context conditions (National Academy of Sciences (NAS), 2012; Linkov and Trump, 2019).

Resilience has been used as a metaphor to describe how systems absorb threats and maintain their inherent structure and behaviour. More specifically, resilience is used as a global state of preparedness, where targeted systems can absorb unexpected and potentially high consequence shocks and stresses (Larkin et al., 2015). Common usage of resilience causes scholars to infer several principles of what resilience actually means. The first principle includes the positivity of resilience, or the notion that resilience is an inherently beneficial goal to achieve. The second includes the measurement of resilience by characteristics believed to apply to a given system - effectively driving an inductive approach to resilience thinking (Bene et al., 2012). Third, resilience thinking is often viewed in a context-agnostic framework, where principles of resilience can be applied to various situations and cases interchangeably.

We define resilience as the capability of a system to recover in the midst of shocks or stresses *over time.* Recovery implicates multiple interactions between factors, and across scales and sub-systems, that are usually unexpected and complex in nature. Given such concerns, resilience differs from traditional methodological approaches of protecting against risk, where these uncertain and complex shocks and stresses that affect targeted systems are inherently outside of the design of the system’s intended purpose. Preparation for such events contains only limited guidance, and promoting traditional risk approaches such as bolstering system hardness is often excessively difficult and prohibitively expensive. Resilience allows us to address these concerns within a framework of resource constraints and the need to protect against low probability, high consequence events, sometimes described as ‘black swans.’ In other words,

resilience is preferred to traditional risk management strategies where a systems-theory of protecting against risk is required, and where the potential risks in question are highly unlikely yet potentially catastrophic in nature.

Resilience affords greater clarity on systemic threats by focusing upon the inherent structure of the system, its core characteristics, and the relationship that various sub-systems have with one another to generate an ecosystem's baseline state of health (IRGC, 2018). Walker et al. (2004) define ecosystem equilibria as a characteristic of "basins of attraction", where the components and characteristics of a system drive it towards a baseline state of health and performance. For example, the Pacific Ocean ecosystem has a tremendous diversity of flora and fauna whose roles in complex food webs have been reinforced by millions of years of evolution and adaptivity; a localised oil spill may damage small points of ecosystem health but is unlikely to dramatically and permanently shift the species dynamics and food webs across most of the Ocean. However, constant exposure microplastic or other pollution can jolt system equilibria in a manner that favours a differing basin of attraction. Unfortunately, we are moving in that direction already, where huge regions of oxygen-depletion in the Pacific Ocean are contributing to 'dead zones' where virtually no marine life can survive.

Basins of attraction are comprised of complex interconnected and adaptive systems that are constantly under stress, yet only shift to a new equilibrium if a tipping point has been breached and the system is trending towards a new basin. Resilience-based approaches can help us understand when and how certain ecosystems might shift from one steady-state to another (Linkov et al., 2018), as well as define the biological and ecological drivers which cause an ecosystem to arrive at a steady equilibrium altogether.

## Resilience as a philosophy and tool

### *Resilience for complex systems*

As a term, resilience has centuries of use as a descriptor in diverse fields. The modern application has centred upon analysing how systems bounce back from disruption. This seems simple enough at first glance, yet the methodological application and analysis of how systems do, in fact, bounce back post-disruption can be quite challenging.

A, 2012 National Academy of Sciences (NAS) report on disaster resilience defines resilience as the ability of a system to perform four functions with respect to adverse events: planning and preparation, absorption, recovery, and adaptation. Nevertheless, quantitative approaches to resilience have neglected to combine those aspects of the NAS understanding that focus on management processes (planning/preparation and adaptation) with those that focus on performance under extreme loadings or shocks (absorption and recovery). Advancing the fundamental understanding and practical application of resilience requires greater attention to the development of resilience process metrics, as well as comparison of resilience approaches in multiple engineering contexts to extract generalisable principles.

A core problem is that risk and resilience are two fundamentally different concepts, yet are being conflated. The Oxford Dictionary defines risk as "a situation involving exposure to danger [threat]", while resilience is defined as "the capacity to recover quickly from difficulties." The risk framework considers all efforts to prevent or absorb threats *before* they occur, while resilience is focuses on recovery from losses *after* a shock has occurred. However, the National Academy (2012) and others define resilience as "the ability to anticipate, prepare for, and adapt to changing conditions and withstand, respond to, and recover rapidly from disruptions." In this definition, adapt and recover are resilience concepts, while withstand and respond to are risk concepts, thus the risk component is clearly added to the definition of resilience. Further, approaches to risk and resilience quantification differ. Risk assessment quantifies the likelihood and consequences of an event to identify critical components of a system vulnerable to specific threat, and to harden them to avoid losses. In contrast, resilience-based methods adopt a 'threat agnostic' viewpoint.

We understand resilience as the property of a system and a network, where it is imperative for systems planners to understand the complex and interconnected nature within which most individuals, organisations, and activities operate. Risk-based approaches can be helpful to understand how specific threats have an impact upon a system, yet often lack the necessary characteristic of reviewing how linkages and nested relationships with other systems leave one vulnerable to cascading failure and systemic threat. Resilience-based approaches serve as an avenue to understand and even quantify a web of complex interconnected networks and their potential for disruption via cascading systemic threat.

Resilience is both a philosophy and a methodological practice that emphasises the role of *recovery* post-disruption as much as *absorption* of a threat and its consequences. This mindset is grounded upon ensuring system survival, as well as a general acceptance that it is virtually impossible to prevent or mitigate all categories of risk simultaneously, and before they occur. Methodologically, resilience practitioners seek use limited financial and labour resources to prepare their system for a wide variety of threats - all the while acknowledging that regardless of how well the system plans for such threats, disruption will happen.

Risk assessment and management is concerned with accounting for systemic threats, but this typically on a threat-by-threat basis to derive a precise quantitative understanding of how a given threat exploits a system's vulnerabilities and generates harmful consequences. Such an exercise works well when the universe of relevant threats is thoroughly categorised and understood, but has limitations when reviewing systemic risk to complex interconnected systems. Resilience complements traditional risk-based approaches by reviewing how systems perform and function in a variety of scenarios, agnostic of any specific threat.

Some theoretical and empirical implications of the definition of resilience above have to be taken in consideration. They are seldom, or are not explicitly, included in assessment.

### *Time and experiential learning*

Linkov et al. (2014) outlined resilience as a function of system performance over time, which we extend to argue that system resilience includes the past experiences that a given system has encountered that have stressed its capacities for service delivery or normal function. In other words, exposure to previous shocks and stresses can have a direct effect upon the system's ability to recover from future shocks and stresses. Coupled with the ability of a system to absorb shocks and stresses while still maintaining important functions, recovery serves as an essential component to judge whether a system is resilient in the face of challenges. This phenomenon is driven by the *adaptive capacity* of a system. Systems that have been exposed to shocks and stresses are more likely to have the experience and memory to adapt in the face of new and emerging challenges, like the human body producing antibodies to infections.

### *The shifting capacity of a system*

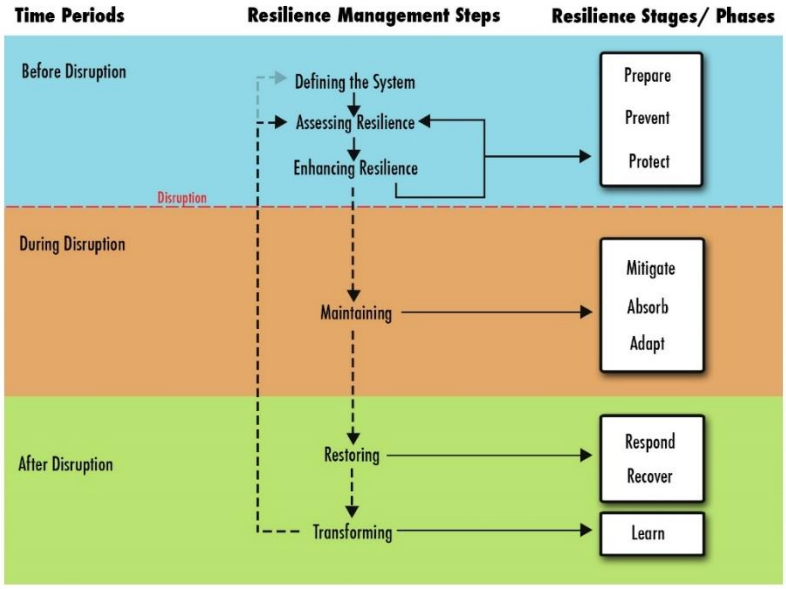
Stresses can occur throughout the system's development. Individual strategies can both improve an individual system's resilience to certain stresses while also increasing the system's brittleness in the face of certain shocks. In other words, it is possible for a system to become increasingly adaptive, yet also become increasingly brittle and susceptible to disruptions from shocks and stresses. For example, while investment markets continually adapt and develop resilience to external shocks, they become increasingly brittle through growing system complexity and appetite for risky investments. These actions are individually rational (i.e. investors seek to grow profits by approving riskier trades that are generally sound but have a higher chance of failure), yet can increase the potential for the market as a whole to enter recession as a large enough aggregate of investments fail and companies enter default. In this way, the stock market slowly trends towards brittleness in a rational manner over time.

## How resilience addresses systemic threats

The key question resilience practitioners seek to answer is “how can I make sure my system performs as well as possible during disruption, and recovers quickly” (Figure 4.1)? More specifically, “How can I make sure my system is not vulnerable to cascading disruption posed by systemic threats”?

These questions are particularly salient for the study of complex systems, where large organisations like hospitals rely upon the smooth operation of various connected systems and subsystems to function properly (the energy grid, information systems, patient administration, medical supply chains, etc.). Regardless of the situation to which it is applied, resilience requires one to think in terms of how to manage systemic, cascading threats, where a disruption to one subsystem can trigger dramatic changes to other connected systems. This is a complex task with few formalised answers, but a central requirement for analysts is to frame resilience as a function of both time and space due to the multitemporal and cross-disciplinary view by which one must review systemic threats.

### Figure 4.1. Role of Resilience in Systems, Emphasising Importance of Combating Disruptions




### *Stages of resilience*

Resilience is less a singular moment when a disruption causes losses, but instead a process of how a system operates before, during, and after the threat arrives. System resilience is an ever-changing characteristic whereby a system’s core functions are constantly shifting to deal with threats.

Most conventional, risk-based approaches emphasise the plan/prepare and withstand/absorb phases to identify, assess, and prevent/mitigate threat (Linkov et al., 2018). Regardless of whether a specific threat is considered, these stages focus upon identifying and interpreting signals associated with threats to a system; exploring the structure and connections that a system has with others; and identifying strategies that preserve a system’s core capacity to function regardless of the disruption that occurs (Patriarca et al., 2018; Park et al., 2013).

While the plan/prepare and absorb/withstand stages are important to help a system address threats before they occur and as they arise, resilience approaches must also consider how a system performs after the threat has arrived. This includes recovery and adaptation. Recovery includes all efforts to regain lost system function as quickly, cheaply, and efficiently as possible. Adaptation centres on a system’s capacity

to change and better deal with future threats of a similar nature. Dealing with recovery and adaptation constitute the main additions by resilience to risk analysis, assessment, and management, and force stakeholders to take account of percolation effects due to disruptions. The role of adaptation and recovery is the focus of resilience analyst. A system with a robust capacity for recovery can weather disruptions that would otherwise break even the most hardened of system components.

### *Domains of resilience*

The spatial component of resilience requires one to consider how a disruption to one system can trigger consequences in others - including those that have indirect or unapparent linkages to the disrupted system.

Alberts and Hayes (2003) identify four different Network-Centric Operation (NCO) domains important to a system's agility, or what they later define as "the ability to successfully effect, cope with, and/or exploit changes in circumstances" (Alberts and Hayes, 2006). Each domain is impacted in a different yet equally important manner when a critical event or disruption arises, and success in one domain may not guarantee the same outcome in the other areas.

The physical domain represents where the event and responses occur across the environment and is typically the most obviously compromised system in the midst and aftermath of an external shock or critical risk event. Elements here can include infrastructural characteristics ranging from transportation to energy or cyber networks (DiMase et al., 2015). The physical domain of resilience thinking generally includes those infrastructural factors that are most directly impacted by a hazardous event, where the other domains include outcomes and actions that are a response to damage to physical capabilities and assets. In this domain, the objective of resilience analysis is to bring the infrastructural or systems asset back to full efficiency and functionality.

The information domain is where knowledge and data exist, change, and are shared, including public or private databases, which are increasingly under potential attack from private hackers and other aggressive opponents (Osawa, 2011; Zhao and Zhao, 2010). Another growing target for information domain-type risks includes stored online communications (Murray et al., 2014; Berghel et al., 2015; Petrie and Roth, 2015). For this domain, the objectives of resilience management are to prepare information assets for a variety of potential attacks while also assuring that these systems will react quickly and securely to such threats in the immediate aftermath. In this way, risk preparedness, risk absorption, and risk adaptation make information and cybersecurity resilience a growing priority for a variety of governmental and business stakeholders (Linkov et al., 2013; Collier et al., 2014; Bjorck et al., 2015).

The cognitive domain includes perceptions, beliefs, values, and levels of awareness, which inform decision-making (Linkov et al., 2013; Eisenberg et al., 2014). Along with the social domain, the cognitive domain is the "locus of meaning, where people make sense of the data accessed from the information domain." (Linkov et al., 2016). Such factors are easy to overlook or dismiss due to a reliance upon physical infrastructure and communication systems to organise the public in response to a disaster, yet perceptions, values, and level of awareness of the public concerning strategies to overcome shocks and stresses are essential to the successful implementation of resilience operations (Wood et al, 2012). In other words, without clear, transparent, and sensible policy recommendations that acknowledge established beliefs, values, and perceptions, even the best-laid plans of resilience will fail. A robust accounting for the cognitive domain is particularly important for instances where policymakers and risk managers may have a disconnect with the local population. For such cases, policy solutions which may seem simply common sense to the policymaker or risk manager and assumed to be robust, may be rejected by locals as contrary to established custom or practice.

The social domain is characterised by interactions between and within the entities involved. Social aspects have impacts on physical health (Ebi and Semenza, 2008). For example, individuals or communities can have better recovery in the face of epidemic when they also have strong social support and social cohesion.

The social domain also ties into the information domain in regard to trust in information. When the community does not trust the source of information, they often do not trust the information itself or have to take the time to verify it (Longstaff, 2005).

While the physical and cognitive domains attract a lot of attention in both overall resilience and hazard-specific resilience, the information domain is of great importance for overall functioning, given its impact on citizen response. Not all individuals understand and interpret information the same way and attention has to be paid to getting information out effectively and in a timely fashion during a crisis. Adequate information is crucial in real time for authorities to make informed and appropriate decisions. As important as information is in itself, human interpretation of data is important, since raw numbers can be misleading if not considered in its context. The way in which authorities and citizens handle information should be evaluated with careful consideration for the communities being discussed.

For smaller communities, organisations, and businesses, discussions of resilience may centre on the ability of local governments and communities to address long-term concerns such as the impact of climate change (Berkes and Jolly, 2002; Karvetski et al, 2011), ecological disasters (Adger et al., 2005; Cross, 2001), earthquakes (Bruneau et al., 2003), and cybersecurity (Williams and Manheke, 2010), as well as other hazards. For larger communities and governments, such concerns are similar yet often more complex and varied in nature, involving hundreds to potentially thousands of stakeholders and the interactions of various systems.

These domains often overlap. For example, information has to be shared over physical infrastructures and within social groups. A focus on domains ensures that a policymaker or risk manager acquires a holistic understanding of their policy realm and are able to understand how a shock or stress could trigger cascading consequences that were previously difficult to comprehend.

## History as a lens for civilisational collapse or survival

Though systemic threats and civilisational disruption are framed as 21st Century concerns, they also help frame reasons why previous civilisations collapsed or survived in the midst of extreme disruption. Learning from past events can allow us to identify why some societies, economies, or ecologies persisted despite disruption, while others collapsed in the face of an adverse event.

### *Defining and understanding collapse in history*

Collapse is a particularly difficult term to succinctly define in a manner that various disciplines and scholars would appreciate. For example, collapse could refer to elimination, as happened to the Austro-Hungarian Empire after World War I, or it could refer to civilisations that were fundamentally changed by disruption, despite their persistence and ability to survive in a differing form, such as the Eastern Roman Empire surviving for nearly a thousand years after its Western counterpart.

For our purposes, collapse refers to the permanent breakdown of complexity in the socioeconomic network of a given state. Significant disruptions such as economic collapse or invasion represent situations where activities requiring significant resources or energy to operate are not able to continue. In these situations, societal complexity decreases in the face of disruption until it reaches a sustainable inflection point, thereby reforming and rebuilding into an entirely new configuration.

In the face of severe disruption, the order and stability provided by a complex society is lost and replaced by increased levels of disorder and anarchy. In a workshop sponsored by the Princeton Institute for International and Regional Studies Global Systemic Risk project, (PIIR GRS) loss of civilisational complexity and order was seen as not necessarily due to the extreme degradation of the nodes of civilisational systems (centres of commerce, religious houses, or centres of legal and judicial authority), but may also be triggered by a disruption of the linkages between those nodes (transportation networks,

trade routes, communications systems, environmental conditions that prevent collaboration of civilisations due to changing climactic conditions). Historical civilisational collapse is viewed as a systemic exercise, where such disruptions are understood as a disruption of a basic nested system requirement (i.e., a link between nodes) that the society cannot survive without in its current form. Disruption to that nested system requirement cascades into other systemic losses and even collapse and contributes to a reformation of a society or civilisation in an entirely new manner.

To address systemic threats' potential to trigger collapse, core questions discussed by Princeton Institute for International and Regional Studies (PIIRS) Global Systemic Risk (GSR) research included: How fragile are the connections between all the system nodes? How could these be disrupted? How could such disruptions lead to a catastrophic breakdown? What would the costs associated be and for whom? These questions require one to acknowledge that societal collapse is almost always due to a multivariate causal explanation - no single event or cause is responsible for the society's disruption and fall. Instead, multiple interlocking disruptions trigger feedback loops that amplify the effect of the disruption upon societal systems.

### *Sources of collapse*

Princeton's PIIRS GSR notes that one of the most common sources of collapse is the failure of political authority. This can take two stages: its most obvious stage is the breakdown of the monopolisation of control over the means of violence. Authority and the administration of justice is increasingly localised to a regional or even household level, increasing the uncertainty that an encounter would lead to a legitimised violent outcome with few options for adjudication by a higher power. In its most Hobbesian stage, it is literally "all against all" where "mere anarchy is loosed upon the world."

A much more important breakdown might precede or succeed this: the diminishing of the idea of communal legitimacy. All systems rely on some understanding of "rules that need not be spoken." This can range from the epistemological authority to ethical authority, to bureaucratic authority. Other sources of collapse might be crises in economic production and consumption or the collapse of infrastructures. Another form of collapse might involve the cultural and physical segregation of individual. Today, technology makes it almost impossible not be aware of what is going on thousands of miles away and to have at least intermittent contact with people around the world. But while multiple connections are usually a sign of order, they can also lead to contagion.

The most common forms of collapse might be summarised as the Biblical four horsemen: war, conquest, famine, and plague.

### *What collapses when?*

One of the most common critiques of the "collapse" literature is that it has a binary bias—civilisation and barbarism, that it occurs very quickly, and that once it does, it leaves little comprehensible residue. (Thus, the common Armageddon trope of post-apocalyptic savages not understanding what a car is or what buildings were for.) We can think of the following as critical variables of the "timing" of collapse.

What survives? Just because a large system with a clear hierarchy collapses does not mean that daily life at the household level is disrupted. Those at the social bottom may not even recognise that anything has happened for some time. The key task here is to measure the territorial/demographic scope of fragmentation and aggregation. This is particularly useful for comparing parts of a previous system that undergoes dramatic change, but with very different consequences, as in the example of the West/East Roman Empire(s).

How long does it survive? With the new interest in resilience, we can also imagine a series of cycles of fragmentation and aggregation as the system reorganises itself. Thus, a "civilisation" or a cultural system may persist in its individual branches following a systemic "collapse."

When we think of a collapse, we often imagine it in a short time span—a day as in the case of nuclear aftermath, a generation in terms of an eroding empire. But the velocity of a collapse may vary across time and space and we need to recognise "stages" or "tipping points." We can also think of cycles. Holling (2001) provides a theoretical model of the cycles of ecosystem organisation that attest to "adaptive capacity."

### *Why does it collapse?*

When collapse is due to exogenous causes, nothing about the society would lead one to expect a collapse, but the entry of some other factor or event such an invasion or natural cause such as environmental change destroys the basis of the system. On the other side of causality, the system collapses because of its own endogenous qualities. For example, it depends too much on a tightly knit and complex base, which cannot endure, or an elite becomes corrupt and no longer does the system maintenance required by its function in a society. Helbing (2018) focuses on the degree of interdependence and the possible limits of organisation. Downey et al. (2016) identified a "boom-bust" cycle in the European Neolithic that seems to indicate a loss of resilience due to the introduction of agriculture.

## Systemic threats in history

While contemporary technology and the level of global integration may be new, many of the systems, mechanisms, dynamics, and foundations of civilisation (food, water, health, trade, transportation, peace, security, and dependence on technologies) are the same. Different historical failures may have systemic commonalities that have not yet been studied from an interdisciplinary point of view.

We may begin with Joseph Tainter's definition of social complexity: "the size of a society, the number and distinctiveness of its parts, the variety of specialised roles that it incorporates, the number of distinct social personalities present, and the variety of mechanisms for organising these into a coherent, functioning whole" (Tainter, 1988). The maintenance of this complexity requires ever more amounts of physical and social energy to maintain, and this in and of itself becomes an increasing strain on society. Peter Turchin (2015) has a similar fascination with what he might call "organisation" as described in *Ultrasociety*. This may be best expressed by the exponential increase in both population and per capita energy use that has endangered our survival as a species. In short, we take for granted an unprecedented level of social organisation in the modern world, the fragility of which is a critical topic of study.

The second motivation follows the work by Kai Erikson (1977) and his belief that social life may sometimes be best understood through the prism of catastrophe. The argument is simple: if we wish to understand the most important social structures, we might best analyse what happens when these and their supporting institutions disappear. How much crime without police, how much illness without medicine, how much exchange without markets? When significant aspects of society come apart, we can better appreciate what they contributed to the status quo ante and how societies evolve to deal with their development. We have significant amounts of historical analysis of catastrophes, but have mined relatively little of this for sociological insights.

## Identification and management of systemic threats

### *Methodological input requirements for risk and resilience of systemic threats*

Risk quantification is an essential element of any risk or resilience management tool. Along with a consideration of the scope and severity of the hazards that may accrue from a given activity, classification efforts largely depend on the type and abundance of information available. A decision maker is unlikely to

consecrate significant time and resources to promoting a costly and time-intensive classification effort for a project with a small and inconsequential universe of potential negative outcomes. Likewise, decision makers would be less hasty in their efforts to push early-stage risk classification forward without thorough analysis (although there are tragic and famous cases to the contrary). While early stage classification efforts are imperfect in focus due to their unavoidably subjective nature, they generally serve as a reflection of the realities facing decision makers and stakeholders.

For cases where more objective information is available, risk quantification allows for greater precision with the risk classification effort (assuming, of course, that the data and model used are both relevant and rigorous). This precision is derived from robust sources of lab or field data that, if produced in a transparent and scientifically defensible manner, indicate statistically significant trends or indications of risk and hazard. Over time, multiple trials and datasets with similar indications ultimately contribute to risk profiles that establish best practices. As new studies and information become available, these best practices may be improved or updated to sharpen existing perceptions of risk. Because of this, the process of improving risk classification for a given project or material is continuously evolving. Just because quantitative information provides for more objective judgment, however, does not indicate a total absence of subjectivity in the risk classification process.

There are many instances where objective data is not available, for example because acquiring information may be legally or morally irresponsible, the application in question may be too novel for rigorous experimentation to have taken place, or the available data may be outdated or irrelevant for the particular risk application at hand. Such concerns are common with respect to new or emerging technologies or future risks. Under these limitations, risk and resilience managers are required to turn to qualitative information, for example expert opinion - a process which can set risk priorities in order if done correctly.

Regardless of the approach chosen to classify risk, resilience analysis quantification requires several component parts for it to be conducted in a transparent and defensible manner. These characteristics include (Merad and Trump, 2020) the availability of an outlined and transparent dataset, derived qualitatively or quantitatively; a framework or approach to process the data in a scientifically defensible and easily replicable fashion; pre-established notions of resilience success and failure, or various gradients of both; and considerations of temporal shifts that may strengthen or weaken system resilience in the midst of a variety of factors, including those which are highly unlikely yet particularly consequential.

Dataset requirements do not strongly differ from more traditional risk assessment or other decision analytical methods. Risk and resilience analysis requires a dataset with a clear connection to the host infrastructure or system and the various adverse events that could threaten it, along with a consideration of how recent and relevant the data may be to decision making. Regardless of the type of data collected (qualitative, quantitative, or a mix of the two), the dataset must have a clear and indisputable connection with the resilience project. This should be a relatively simple exercise, however, as the dataset is either collected directly by the resilience analysts for their given project or is acquired from a similar project's data collection activities. Where no quantitative data is available, qualitative information may be classified in such a way as to serve as a temporary placeholder to allow analysis to continue (Vugrin et al., 2011). In this way, the type or quality of data available can directly inform the method chosen to process available information for resilience analysis (Francis and Bekera, 2014; Ayyub, 2014).

After acquiring a dataset, the next requirement of resilience quantification is a framework to process that data. Method selection is driven by a variety of factors, notably the quality and robustness of available data as well as statutory requirements for output and transparency (Francis and Bekera, 2014; Linkov et al., 2014).

A crucial step is the imposition of pre-determined notions of system success or failure. This is consistent with virtually any other branch of scientific inquiry, where users must establish some notion of 'goodness' or 'badness' that they seek to identify prior to data manipulation and results classification. Such efforts to establish system resilience success and failure could be generalist in nature (as in, deploying categorical

variables or quantitative cut-off points that signify a positive or negative performance under certain stressors) or specific (as with the use of extensive quantitative data to inform precise points of system failure, as with the use of levees in flood management). Opting either way is at the discretion of the resilience analyst and their stakeholders, in line with the degree of precision needed to assess system resilience. Some stakeholders may be satisfied with answers such as "there is a moderate probability that system x could fail under condition y", while in other cases, stakeholders may need to know the exact conditions and points at which degradation and/or failure occur. Generally, with more information available and the more potential the system has of incurring damage to society if broken, the greater the precision needed to assess systemic resilience success or failure.

The great challenge of resilience analysis and decision making is to consider a wide range of time horizons over which hazards and challenges could arise to shock a system, project, or infrastructural asset, where such events may not be projected to be possible until several years, decades, or even centuries into the future. Given this, an analyst should seek to discuss shifting preferences, threats, and system capabilities over time with stakeholders and managers to gain a more accurate view of how a system may be challenged and behave in the midst of an external shock, with additional considerations with regards to how those systems could evolve and become more resilient over time.

One solution is to use a structured framework for selection metrics and organising the assessment. The individual performance factors are kept separate for more easy interpretation but can be aggregated to a single score, if relevant. The Resilience Matrix, described in the next section, provides a two-dimensional approach to selecting metrics, rather than a one-dimensional list of factors. More specifically, the Resilience Matrix explicitly incorporates the temporal phases of the event cycle, identified in the National Academy of Sciences definition of resilience: prepare, absorb, recover, and adapt.

### *A semi-quantitative approach: Resilience Matrix*

A matrix assessment methodology affords users the capability to construct a framework that compares various decision metrics on a broad, 'big picture' level of resilience thinking and decision making. Resilience matrix approaches assist local level stakeholders and policymakers focused on resilience performance, as well as broader and regional emergency response teams who seek to institute resilience thinking to "adopt a more holistic view of resilience necessary to reduce the impact of an adverse event" (Linkov et al., 2013). Collectively, the development and execution of resilience matrices will provide robust and transparent policy guidance for national policy goals, while also offering improvements to large-scale system resilience for areas ranging from industry to energy to medicine (Kelic et al., 2013; Rosati et al., 2015; Roege et al., 2014).

### Figure 4.2. Resilience Matrix (RM)

| | PREPARE | ABSORB | RECOVER | ADAPT |
|---|---|---|---|---|
| Physical | | | | |
| Information | | | | |
| Cognitive | | | | |
| Social | | | | |

Note: The y-axis includes domains of resilience, the x-axis includes stages of resilience as established by the US National Academy of Sciences (NAS)
Source: Linkov et al. (2013)

Resilience corresponds to a system's ability to perform critical functions in the midst of catastrophic and unexpected happenings. Described by Linkov et al. (2013), a resilience matrix collectively provides a unifying framework to assess system resilience which may be applied productively to societies and groups, when seen as systems (Figure 4.2). Linkov et al.'s (2013) formal Resilience Matrix (RM) classifies four general resilience domains of complex systems that include a mixture of physical infrastructure and more abstract capabilities and takes into account the performance of these domains throughout the event's occurrence and disruption. The RM does not define specific metrics or attributes to use, but it gives guidelines to select the appropriate measurements to judge functionality from the perspective of a broader system. The RM guidelines diverge from the accomplishments of different community resilience progressions by taking advantage of a stakeholder-driven approach to characterise signs and ranges of system progression that are directly related to the community. Progression is characterised in relation to the necessities of the local environment rather than against the advancement of some generalised or national goal, which could or could not be acceptable in the local setting.

Cutter et al. (2014) reflect the difficulty to specify values of community resilience that are accepted nationally, and no clear formulation for the approval of an external source of values of community resilience is given at this time. As a consequence, the acceptability and usability of any resilience judgment can only be assessed by the community in which it is utilised. Stakeholders are prompted to incorporate values from those identified by other resilience assessment strategies, where accessible, as important signals which connect the RM with other formulations to balance the strength of both approaches. The RM's simplified guidelines promote other strong attributes as well. Interdependences are ubiquitous in all systems, but the time and cost it takes usually prohibits the investigation and modelling of all of these dependencies.

The basic idea underlying the use of the RM is that to create resilience, achievement in all sectors of the system must be identified. This is different from the methodology of solutions which maximise singular factors of the system. A consequence of such a narrow focus is that failures in the system can lead to cascading effects; the collapses of communities in light of calamities are frequently an effect of overflowing collapses from critical components in the system that are not identified as such. To be resilient on any scale, singular time steps cannot be relied upon to restore functionality. Even though the real relationship between system factors may not be revealed, by improving the resilience of all aspects of the system, performance can be kept or quickly restored. The Resilience Matrix methodology includes a set of guidelines for the resilience judgment for systems that has already been produced for cyber, energy, engineering, and ecological systems.

The RM consists of a framework to conduct assessments regarding the performance of complex and of incorporated systems or projects across varying focal points. Generally, risk matrix frameworks consist of a 4x4 matrix, "where one axis contains the major subcomponents of any system and the other axis lists the stages of a disruptive event" (Fox-Lent et al., 2015). Next, matrix rows include the four primary domains to be considered within any systemic evaluation project, including physical, information, cognitive, and social (Alberts and Hayes, 2003). Additionally, matrix columns illustrate the four steps of disaster management, including the plan/prepare, absorb, recover, and adapt phases of resilience management as outlined by the National Academies of Science (Committee on Increasing National Resilience to Hazards and Disasters, 2012). Altogether, these sixteen cells give a basic description of the performance of the system throughout an adverse event.

In order to begin a resilience assessment utilising the matrix approach, Fox-Lent et al. (2015) recommend: (1) clearly outline the system or project's boundaries along with an array of hazard and threat scenarios that could impact the system; (2) enumerate critical system functions and capabilities that must be maintained throughout a crisis or shock; (3) select indicators for each critical function and subsequently compute performance scores in each matrix cell; and (4) aggregate all cells of the matrix—if necessary—to provide an overall system resilience rating, which will provide information about the system's ability to respond to and overcome the effects of an external shock.

The RM method can be scaled to any observable system (from local to national to international). The system can be portrayed as business, a neighbourhood community, a city, or even broader as an entire region. Each part of the matrix serves as a signal of the performance of the system's given necessary function. Rather than figure a set of universally accepted values, the RM receives data based on local experience to find signals that have to do with the local problem. These indicators should take into account some of the necessary characteristics of resilient systems that have been proclaimed by others - modularity, dispersion, redundancy, flexibility, adaptability, resourcefulness, robustness, diversity, anticipation, and feedback response (Park et al., 2013; Frazier et al., 2010) - and take into account where each attribute is most reasonable with the system that is being observed. To act as a screening function, the RM allows for the utilisation of the most convenient and most significant data, whether it involves a numerical aspect or a qualitative aspect.

Ultimately, the resilience matrix approach offers a potential framework to compare and contrast various decision metrics from multiple disciplines that reside in the same matrix cells. In this way, such an approach will greatly assist those focused upon improving system and infrastructural resilience performance alongside those people required to prepare for and respond to emergencies. Resilience thinking allows its users to take on a holistic view of the process of bolstering systemic resilience properties by ensuring that the given system is adequately prepared for a host of potential challenges and that a variety of domain and temporal horizons are considered throughout the resilience evaluation process.

### *A quantitative approach: Network science*

Network science approaches for resilience are rooted in the premise that resilience necessarily has a temporal dimension. Holling (2001) points out that there are two conceptual ways to characterise resilience. The first, more traditional paradigm, concentrates on stability near an equilibrium steady state, where resistance to disturbance and speed of return to the equilibrium are used to measure the property. The second paradigm emphasises conditions far from any equilibrium steady state, where instabilities can flip a system into another regime of behaviour. The former group of methods define resilience from the engineering perspective, while the latter are termed ecological resilience. What is common between both paradigms is that they look at the dynamics of a system taking place in time: engineering resilience specifically mentions "speed of return to the equilibrium", while ecological resilience looks at a "steady state" of a system. Another common property of both paradigms is the assumption that the state of a system needs to be measured at some points in time so that it is possible to determine whether the system has returned to the original equilibrium. Finally, it is important to notice that resilience is defined with respect to a disturbance or instability. With those three prerequisites in mind, quantitative approaches to resilience characterisation investigate the evolution of a system in time both under normal conditions and under stress.

Most complex systems may be decomposed into simpler components with certain relationships between them. For example, transportation infrastructure may be represented as a set of intersections connected by roadways; global population may be mapped to a set of cities connected by airlines, railways, or roads; ecological systems can be decomposed to a set of species with food-chain relationships. In cases where such a decomposition is possible, it is often convenient to deploy methods developed in a branch of mathematics called graph theory, or network science. Network science represents a system under study as a set of points, called nodes, connected with relationships referred to as links. Dynamics of a system is then defined as a composition of individual node states, which in turn depend on their neighbouring nodes as well as on internal and external factors.

An important question is whether the approach should be threat agnostic or not. Threat agnostic approaches (Ganin et al., 2016; Linkov et al., 2018) maintain that resilience is defined regardless of a specific threat that hits the system. The rationale here is that it is often impossible to predict what hits the system, how much of a disruption will ensue, and what the likelihood of a threat scenario is. The opposite

group of methods define resilience by modelling a specific threat. These methods often imply and require that a probability be assigned to each threat as well as that an algorithm be defined to model how a threat affects the network. While in the world of perfect knowledge, these approaches may offer a more realistic way to prioritise resilience-enhancing investments, they appear to conflate resilience analysis with risk analysis. Ganin et al. (2016) argue that risk and resilience analyses should be complementary, but separate, and claim that resilience analysis is, in part, motivated by the imperfect knowledge about the threat space.

Networks may be “directed” and “undirected”. In undirected networks, links do not define a node serving as an origin or a destination. Both nodes are equivalent with respect to the relationship defined by the link. An example of such a relationship is friendship in a social network. In a directed network, nodes are not equivalent with respect to the link. In a transportation network for example, a road may take traffic from point A to point B but not necessarily the other way round. Mixed networks may contain both directed and undirected links.

Another important class of networks are interconnected networks. In the case of two interconnected (coupled) networks, system nodes may be logically separated into two sets or layers corresponding to each network. Consider for example, a power distribution system and an information network controlling it. In this case, links among power nodes may represent transmission lines and links among computers may define cyber connections. Notably, computers need power to function while the power distribution is controlled by the cyber system. This interdependency may be defined with links going from nodes in one layer to nodes in the other and vice versa.

One of the most resilience-relevant problems studied in graph theory is connectivity. It is argued that the state of the system is defined by the size of the network’s largest connected component. The larger the set of connected nodes is, the better the system is able to function. Well-known classical results here are based on percolation theory, where nodes and/or links are removed at random and the connectivity of the remaining sub-network is analysed. Percolation theory establishes that the distribution of links among network nodes (degree distribution) is a key characteristic in determining network robustness (Kitsak et al., 2010; Linkov et al., 2013). Yet, percolation modelling typically results in a point estimation of connectivity, or robustness, after a random removal of a certain number of nodes or links and does not look at system dynamics. One step towards resilience quantification is to look at the stability of connectivity between nodes in multiple percolations. As nodes or links are removed at random, different disruptions disconnect different sets of nodes. Based on a graph’s degree distribution, Kitsak et al. (2010) answer the questions of what nodes will be connected in multiple percolations, what the likelihood is, and how the size of the persistently connected component changes with the number of percolations.

As we said earlier, resilience can be either defined as engineering or ecological. The next group of approaches we look at builds on the engineering definition. Specifically, those frameworks aim at modelling both a disruption and a system’s recovery process and define a performance function of the system. For example, Ganin et al. (2016) define a system’s critical functionality as “a metric of system performance set by the stakeholders, to derive an integrated measure of resilience”. Critical functionality serves as a function of time characterising the state of the system. Resilience is evaluated with respect to a class of adverse events (or potential attacks on targeted nodes or links) over a certain time interval. A control time (Kitsak et al., 2010) can be set *a priori,* for instance, by stakeholders or estimated as the mean time between adverse events.

Performance functions capture both the absorption and recovery resilience phases defined by the National Academy of Sciences but stop short of a giving a straightforward way to address planning and adaptation. Moreover, these approaches often need to be tailored to a specific system so that its disruption response is captured meaningfully. Finally, it is not always possible to enumerate, let alone, model, all possible disruptions in the class of adverse events considered.

Applications of performance function methods to realistic systems include studies of malware spreading in a computer network (Linkov et al., 2019), where the authors studied the trade-off between over regulation and under regulation of computer users, arguing that too many rules may result in some rules being neglected and, in fact, result in a lower resilience. Another example is epidemic modelling in a metapopulation network (Massaro et al., 2018), where it was found that travel restrictions may be harmful to a system's resilience. Specifically, critical functionality was defined based on the number of people infected and the number of people restricted from travel. Insufficient travel restrictions were shown to only slow down the epidemics without significant changes to the final number of infections. As people movement was diminished for a longer period of time, resilience was lower than that without any restrictions.

An example of a mixed approach to resilience evaluation is given by Ganin et al. (2017). The authors quantified an urban transportation system's efficiency through delays experienced by auto commuters under normal conditions, and resilience as additional delays ensuing from a roadways disruption. The approach borrowed from engineering resilience by allowing traffic redistribution, which may be viewed as recovery, and from ecological resilience by studying the resulting steady state equilibrium achieved by the system. The authors evaluated resilience and efficiency in 40 real urban areas in the United States. Networks were built by mapping intersections to nodes and roadways to links. The authors proposed graph theory inspired metrics to quantify traffic loads on links. Based on the loads they evaluated delays. The results demonstrated that many urban road systems that operate inefficiently under normal conditions are nevertheless resilient to disruption, whereas some more efficient cities are more fragile. The implication was that resilience, not just efficiency, should be considered explicitly in roadway project selection and justify investment opportunities related to disaster and other disruptions.

## Conclusion: Making resilience useful for decision makers

Due to its relative infancy for determining risk and system robustness, no single method has been solidified as the 'go-to' approach for conducting resilience analysis. Generally speaking, this would be a significant limitation for the quantitatively and methodologically driven, who view standardisation as the ability of resilience to be generalised to a variety of fields and cases seamlessly. In this, proponents of standardisation are not entirely wrong, as the sheer diversity of cases in which resilience thinking is proposed requires some movement towards consistency and method objectivity. However, rather than developing and implementing a single standard for resiliency across disciplines and countries, a more effective approach would be to further a suite of methods and tools that can be utilised and modified based upon a country, company, or discipline's institutional, political, economic, and cultural incentives and needs.

The main barrier to furthering this suite of methods is the lack of a formal definition or centralised governing body. Resilience thinking and resilience analysis possesses different meanings for different disciplines, which will only become more entrenched and divided as time passes. Should no consensus definition be reached, there still remains the possibility that some shared meaning may be accepted in different types of resilience methodologies, which require something of a shared language to convince their audience that their method's findings are legitimate and acceptable.

For qualitative methods, tool development is a bit easier due to a reduced reliance upon strict mathematical tools and more upon the need to acquire information for an emerging topic of high uncertainty and risk. Despite the different and specified needs of various disciplines when utilising qualitative approaches to resilience thinking, the general approach expressed by most users is one of user-defined categorical metrics which are filled out by a pre-determined list of subject experts or lay stakeholders. In such an exercise, the opinions of experts serve as indicators of risk and system resilience and offer a context-rich view of resilience decision making for a particular case. In this way, qualitative methods share a common function of eliciting feedback from the world at large and processing results in a transparent and meaningful

way, making qualitative methodologies inherently generalisable despite intellectual differences across disciplines.

We would argue that the main hurdle towards resilience-based method and tool development for qualitative methods centres on their overall acceptance by the quantitative community. Across various disciplines, criticisms have been levelled at qualitative methodologies' lack of objectivity in pursuit of scientific understanding, with quantitative methods and mathematical approaches being easier to accept and verify (Mahoney and Goertz, 2006; King et al. 1994). However, we contend that as resilience is used to tackle cutting edge emerging systems and systemic threats, quantitative information may not always be available or useful to resolve a context poor situation (Ritchie et al., 2013; Trump et al., 2018). In this way, qualitative research in resilience thinking and analysis will help bridge initial gaps in risk understanding by offering an expert-driven view of a system's resilience for a given array of external shocks and challenges.

Semi-quantitative methods may help assuage the concerns of the quantitatively driven due to the use of mixed qualitative and quantitative data in evaluating resilience decisions. Specifically, risk matrices categorise available objective data into a small set of classification factors that inform overall resilience decision making - allowing for a transparent and scientifically defensible method of conducting resilience analysis. While some information is lost in the transformation of quantitative data to qualitative categorical metrics, this method can simplify resilience-based decision making by breaking down systemic factors into a small number of easily understood subsets. Additionally, this method allows its users to integrate qualitative information and elicited expert opinion alongside available data, bringing additional context to the available dataset. This approach has a slightly steeper learning curve than traditional qualitative research methods; resilience matrices require some fundamental understanding of the math behind matrices as well as understanding of proper use (to avoid the garbage-in, garbage-out problem that haunts any decision analytical tool), which may prevent some from placing such matrices in their resilience tool kit.

Quantitative methods like network science enjoy perhaps the greatest level of trust amongst lay stakeholders due to the perception of objectivity and raw scientific explanatory power in a variety of applications. Under the assumption of correct math, lay stakeholders can physically witness the transformation of data into rigorous findings of risk and benefit and may ultimately help pave the way to notions of causality for a particular application of resilience management. Where valid data is plentiful, quantitative methods can go a long way towards advancing most fields in science, let alone resilience thinking. However, incompleteness or lack of clarity in existing data can put a damper on research, and even the mathematical method used to generate objective outcomes may in itself be inherently subjective. An additional concern includes the even steeper learning curve than qualitative or semi-quantitative methods; users are frequently tasked with mastering advanced formulas or computer programs even prior to looking at a dataset. Often, implementation of such methods will require a model to be custom-built by an external consultant or academic. This is not to discourage the use of these methods - their contribution to science is extensive and frequently proven across virtually all fields - yet we must note the drawbacks of quantitative-only approaches to resilience along with the complications that their users will face in the midst of high uncertainty and context-poor information limitations.

By its nature, resilience classification is difficult. If it were not so, there would be little need to discuss the pros and cons of differing ideologies of resilience practice. However, when used properly, these methods can do much good through their ability to inform complex and uncertain resilience analysis and decision making by providing some structure for any methodological venture (Jackson, 2018). More methods have and will undoubtedly continue to creep into the field as more disciplines come to embrace resilience thinking, making full method standardisation unlikely. Yet this may open the door for shared fundamental concepts of resilience analysis across ideological and theoretical divides. In other words, each individual discipline will transform resilience to fit its own needs, yet these methods will serve as the cornerstones of a structure that will allow resilience thinkers to have a shared philosophical discussion.

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# 5 Beyond Growth

This chapter explains why a new approach to economic analysis and policy is needed. It sets out the multiple challenges now facing almost all economies and proposes a new set of overarching policy goals: environmental sustainability, a reduction in inequalities, improved wellbeing, and system resilience. Achieving these goals requires policymakers to look 'beyond growth'. The chapter argues that the dominant approach to economic policymaking over the last forty years, based on an orthodox and subsequently revised model of neoclassical economic theory, is not adequate to address these challenges. It describes the various analytical advances which have been made in economics in recent decades which offer a richer understanding of how economies work. It suggests that overcoming these challenges requires structural rather than incremental reform, and sets out a range of policy approaches, drawn from the new analytical frameworks, which might help achieve these wider economic and social goals.

## Introduction

Critiques of dominant economic analyses intensified sharply in the wake of the 2008 Global Financial Crisis and the protracted recovery that followed. It became clear that conventional economic theories and policies had been found wanting. Many OECD economies were beset by rising inequalities, slower productivity growth, increasing corporate concentration, rising debt levels, environmental degradation, and financial instability. These issues connected to a prevailing narrative based on the primacy of growth that stressed market liberalisation and deregulation together with fiscal discipline, low tax rates and curbing social welfare benefits. That narrative not only abetted the failure to address acute social and environmental challenges, but also failed on its own terms: the growth of productivity and per capita incomes has been increasingly anaemic in recent decades.

This chapter points to a new narrative, based on a broader conception of economic progress, richer frameworks for economic, social and environmental analysis and a wider set of policy objectives. It urges a move away from the traditional emphasis on GDP growth to a multi-dimensional conception of economic progress comprising environmental sustainability, rising human well-being, falling inequality and system resilience. The prioritisation of efficiency objectives may have undermined the resilience of societies by overlooking equity and sustainability objectives. The Covid-19 pandemic exacerbated previous trends, with clear asymmetric impacts among different income groups. Embracing a multidimensional set of objectives would enable assessment of trade-offs and complementarities, as well as identification of unintended consequences, to better guide policy choices and decision making.

We have to move away from simplistic assumptions such as homogeneous, rational, utility-maximising agents interacting in timeless self-equilibrating markets, and move towards further engagement and experimentation with complexity, path-dependence, bounded rationality, economic power, multiple equilibria and non-equilibrium outcomes. We should see modern economies as complex adaptive systems, constantly evolving and reorganising, rather than a series of deviations from a stable equilibrium with the ability to self-stabilise when hit by shocks.

The chapter was largely written before the Covid-19 outbreak, but its key lessons are sharpened and amplified by the pandemic and the economic and social crisis it precipitated. The new growth narrative heralded in this report is useful not only to understand this latest crisis, but also to think about how to emerge from it. The many calls now heard to ‘build back better’ arise partly from problems which the crisis has itself exposed. Despite clear and recent warnings from scientists and public health officials, few countries were ready for a pandemic of this kind (Global Preparedness Monitoring Board, 2019). Our economies proved less resilient than we had assumed. Many countries’ health and social care systems have not been able to cope. Reliance on globalised supply chains based on ‘just-in-time’ efficiencies has been called into question (Financial Times, 2020a). Almost everywhere the crisis has revealed the impact of inequality: Covid-19 and its economic consequences have hit the poor and vulnerable the hardest (Financial Times, 2020b).

But the crisis has also created new opportunities. The emergence of clean air in many cities round the world during lockdowns saved many lives even as others were lost (World Economic Forum, 2020). Nature found new places in which to flourish. The enforced reduction in consumption and commuting led many people to question what kind of lifestyle best contributes to wellbeing. Perhaps most of all, governments found that in a crisis they can intervene in their economies at huge scale and speed. The macroeconomic arguments over government spending and debt are of course not over, but the consensus that a crisis of this magnitude justifies such intervention is notable (Ilzetzki, 2020).

The pandemic arrived after a decade in which western economies have experienced a succession of crises. The aftermath of the financial crash of 2008 is still not over, with stagnant productivity and continued financial risk among the most obvious problems. The financial crisis exacerbated inequalities which

contributed in many countries to political conflict and instability. There is a deepening crisis of climate change and wider environmental breakdown.

It is almost certainly no coincidence that so many deep problems have occurred at the same time. At the very least, we should seek to understand not just their individual causes but their inter-relationships. And in doing so, examine the nature of the economic system and economic policies from which these crises have arisen - or at least which have not prevented them.

To do this we have to start from an understanding of the nature of challenges which, even before the Covid-19 crisis, our economies were experiencing. Accelerating environmental crisis is the most urgent. The 2018 report of the Intergovernmental Panel on Climate Change made clear that to hold the average surface temperature rise to 1.5 degrees Celsius, global emissions of greenhouse gases must be approximately halved by 2030, and reach net zero by around 2050 (IPCC, 2018). That is a transformative task of unprecedented proportions, made greater by the need to tackle simultaneously a series of other worsening - and inter-related - global environmental problems, including biodiversity loss, soil degradation, and air and marine pollution (UNEP, 2019).

Rapid technological change is transforming many aspects of our economies. Automation technologies, particularly artificial intelligence, are changing both the numbers and kinds of jobs economies generate and the ways they are organised, leading to concerns about the 'future of work'. In various sectors, major multinational companies, including digital platforms, have grown to positions of market dominance unrivalled in the modern era, raising questions about both their economic and social impact and the implications for public policy (OECD, 2019a). In many countries there is increasing debate about the impact of new technologies on issues ranging from democracy to mental health (OECD, 2017).

New patterns of globalisation are also emerging. Investment and trade continue to shift to the south and east of the world. The 'financialisation' of most advanced economies has continued, with higher levels of private debt than in the past, higher returns to holders of financial assets, and in some cases larger financial sectors relative to the rest of the economy (World Bank and WTO, 2019). National financial regulation is made harder by the combination of a globalised financial system and new financial technologies.

Underpinning each of these trends is demographic change. Many developed societies are significantly ageing, and all are experiencing the pressures as well as the benefits of increased migration. Many developing countries are experiencing rapid population growth.

These challenges would be considerable in any circumstances, but they come after a period in which most OECD economies have performed substantially less well than in the past. For most countries, the recovery after the 2008-9 recession was among the slowest on record. Before the Covid-19 crisis economic growth had been restored, but it was generally fragile, still dependent on the emergency life-support of ultra-low interest rates and hugely expanded central bank balance sheets. Public and private debt levels as a proportion of national income were still high in many countries even before their recent surge. Productivity growth had stalled in some countries and was historically low in many others; innovation at the technological frontier was no longer being diffused to the rest of the economy (OECD, 2019b).

Inequalities have risen in most advanced countries over recent decades, particularly between the incomes of the top 1% of the population and the rest. Wealth inequality has grown, in large part due to the appreciation in the value of assets, itself a cause of financial volatility (OECD, 2019c). In many countries, unemployment remained stubbornly high even before the Covid recession, particularly for young people (Alveredo, 2019). Most developed economies have seen an increase in under-employment and insecure and precarious work of different kinds (OECD, 2019d). In some countries living standards for many households were barely above those of a decade ago, or maintained only via rising household debt (OECD, 2019e). In many the gap between richer regions and those on the periphery has widened (OECD, 2018).

Not all OECD countries have experienced all of these problems, but many have experienced the political consequences of a decade of economic underperformance and accompanying global pressures, alongside

other more directly political causes. Popular discontent with politicians and the political system has been rising over a long period in many countries. Trust in institutions, in experts and 'elites' has declined (OECD, 2017). Societies which once experienced high levels of social cohesion are now widely felt to be more fragmented, prone to cultural as well as economic divisions. In many countries large numbers of people report a sense that society has become less fair, with a widening gap between the richest and the majority, and that in a more globalised world, national societies have somehow 'lost control' of their own destinies (World Bank, 2018).

In these circumstances it is not surprising that, even before the Covid-19 crisis, many people were questioning whether current and conventional economic policies were sufficient to address the challenges and problems their countries face. With low interest rates and low growth rates seemingly entrenched - the phenomenon sometimes described as 'secular stagnation' - it had become clear that reliance on monetary policy alone leaves policymakers with particularly few options to deal with recession. As a knowledge-based economy becomes more digitalised, with 'intangible' investment increasingly important and a growing divide between firms at the cutting edge of innovation and those falling behind, new approaches will be needed to raise productivity across the economy as a whole and ensure this reduces inequalities rather than exacerbates them (OECD, 2019f; Unger, 2019; Haskel and Westlake, 2017). Normal labour market policies have not been able to sustain demand for lower-skilled jobs in the face of automation and globalisation or counter the growing divide between those in secure jobs and those in precarious ones. Redistributive welfare policies have seen their effectiveness reduced and are not sufficient to counter rising inequalities. Environmental policy has failed to prevent catastrophic risk. Competition policy has not kept pace with the growth of near-monopoly companies with operations across national borders. New approaches will be required if systemic risk is to be eliminated from the financial system.

Of course, national economic policies have differed, but there has been a widespread consensus on what makes for a successful economy. For example, that increasing global trade is a goal in itself, with countries doing better the more integrated they are into international trade and capital flows. Most countries have sought to make their financial and labour markets more 'efficient', deregulating and liberalising them where possible to widen the opportunities for financial activity and reduce restrictions on businesses. Central bank independence to conduct monetary policy has been accompanied by constraints on public borrowing. Corporation taxes have been reduced almost everywhere, and in many cases marginal personal income tax rates too. Economic growth has continued to be the dominant goal of economic policy, from which it is assumed other objectives will flow. Material consumption has been taken as a proxy for progress and development. Equity and environmental considerations have largely been dealt with 'after the event' rather than as integral to economic policy.

Before the financial crisis, this economic model (often described as the 'Washington Consensus') was strongly influenced by a particular form of economic analysis. Based on an orthodox version of 'neoclassical' economic theory, this assumed that liberalisation of markets would generally improve their efficiency in allocating resources and would therefore tend to optimise overall economic welfare. Although markets sometimes failed, governments were also seen as prone to failure. They usually had less information than market actors and could be captured by vested interests. Policy rooted in this kind of analysis tended to be sceptical of government intervention, with deregulation of various kinds widely favoured.

Over the last decade policy makers have modified some aspects of this analytical framework. It has been acknowledged that liberalised markets are not always efficient and market failures can be significant (Ostry et al., 2016). Policy makers have recognised the need for greater government intervention, in fields such as labour market, regional and environmental policy, as well as in monetary and financial policy.

These shifts have been important but have not gone far enough. A variety of economic theories, evidence and techniques have been developed which offer richer ways of understanding how economies work, and

how they can be made to work better. Analytical methods and models based on the new powers of data collection and computing, for example, have opened up insights not available to previous generations. Taken together, a 21st century economics has begun to come into view which looks more able to help policymakers find solutions to the economic problems they now confront.

It is possible to see how many of these critiques and explorations can be brought together to create a 'new economic narrative', broadly consisting of three elements (OECD, 2018):

- A new conception of economic and social progress - a deeper understanding of the relationship between growth, human wellbeing, a reduction in inequalities and environmental sustainability, which can inform economic policymaking and politics.
- New frameworks of economic theory and analysis - a richer basis of understanding and evidence on how economies work, and new tools and techniques to help policymakers devise policy.
- New approaches to economic policy - a wider set of policy and institutional reforms, based on the new frameworks and analysis, to achieve the new social and economic goals.

## The goals of economic policy

For over seventy years, economic growth has been the dominant goal of economic policy, and the principal measure of an economy's success. And with good reason: for much of this period, rising national income signified rising household incomes, and with them average living standards. Economic growth raised employment levels, reduced poverty rates, and provided the tax receipts to finance higher government spending on public services. In most OECD countries, up to the 1980s, economic growth was accompanied by falling inequality and - as higher GDP allowed more resources to go into air and water pollution control - better local environmental quality. So, while governments always had a wider set of economic objectives than rising GDP, economic growth was a pretty good metric for overall economic performance.

Today, economic growth continues to generate the benefits of higher national income, but the dominant patterns of growth in OECD countries over recent decades have also generated significant harms.

First, GDP growth is now associated with rising inequalities. In almost all OECD countries, the last forty years have seen a declining share of national income going to wages and salaries (labour), with a rising share going to the owners of capital (UNCTAD, 2012). With capital ownership increasingly concentrated among those on the highest incomes, the result has been a growth of both income and wealth inequality, particularly between the top 1% and 10% and the rest of the population (Dao et al., 2017). In such circumstances GDP growth no longer translates into rising living standards for those on median and lower incomes. In some countries high rates of poverty remain a persistent blight (World Inequality Database; Alvaredo et al., 2018).

Second, GDP growth is no longer correlated with improvements in wellbeing. People's sense of a fulfilled and flourishing life comes also from a wide variety of other factors in addition to income: from the security and satisfaction they experience in work; their physical and mental health, social networks and personal and family relationships; and from social goods such as the levels of crime and trust in society, and the quality of public services such as health and education 'Stiglitz et al., 2009, 2018). None of these are automatically improved simply by higher GDP and can often be harmed by the ways it is generated.

Third, severe environmental degradation has forced a recognition that today's patterns of economic growth are undermining our capacity to maintain current standards of living. An economic system based on fossil fuels, present forms of intensive and meat-based agriculture and the unlimited exploitation of global natural resources is not sustainable over the long term. Climate change, air and marine pollution and ecological breakdown are already damaging the lives and livelihoods of millions of people; they risk catastrophic

damage to our economies and societies within the next few decades unless currently dominant forms of production and consumption are radically changed (UNEP, 2019).

These developments do not mean that economic growth should be abandoned as a goal of economic policy. Rather, they force attention to the *form* of economic growth a country experiences and aims to achieve. It is not enough for GDP to be rising if the underlying patterns of growth are generating significant harms at the same time. Politicians and policymakers need to go 'beyond growth'. They need to ensure that, alongside rising GDP - and as a result of it - economic policy is achieving a wider set of objectives and measures of economic and social progress. Four objectives for economic policy-making should be paramount:

- Environmental sustainability - understood as a path of rapidly declining greenhouse gas emissions and environmental degradation, consistent with avoiding catastrophic damage and achieving a stable and healthy level of ecosystem services.
- Rising wellbeing - understood as an improving level of life satisfaction for individuals, and a rising sense of improvement in the quality of life and condition of society as a whole.
- Falling inequality - understood as a reduction in the gap between the incomes and wealth of the richest and poorest groups in society, a reduction in rates of poverty, and a relative improvement in the wellbeing, incomes and opportunities of those experiencing systematic disadvantage, including women, members of ethnic minorities, disabled people, and those in disadvantaged geographic communities.
- System resilience - understood as the economy's ability to withstand financial, environmental or other shocks without catastrophic and system-wide effects.

Countries which seek to achieve these four goals, rather than giving overwhelming priority to growth, will experience a more balanced path of economic and social development, with better outcomes for both current and future generations, meeting the needs of both people and planet.

It used to be thought that inequality was the inevitable price of growth, but in fact reducing economic inequalities can benefit growth (OECD, 2015; Berg and Ostry, 2011). Inequalities of income and opportunity prevent some people from achieving their full economic potential. Low educational attainment and skills, discrimination in the labour market, and the difficulties of working in the absence of adequate child and social care, all tend to constrain the productive resources of the economy. Addressing slow productivity growth in lagging firms and regions will drive growth and reduce inequality (OECD, 2018). At the same time, people on low incomes tend to spend a higher proportion of their income than the wealthy, who are more likely to save. So improving the earnings of poorer people have a much larger impact on consumption and aggregate demand, and therefore growth, than raising the income and wealth of the relatively well-off (Dabla-Norris, et al., 2015).

Inequality also tends to make economies more unstable, as the higher savings of the rich are channelled into financial and real estate assets prone to volatility. More unequal economies tend statistically to have shorter periods of growth (Berg A. et al., 2018). And politically, rising inequality has tended to result in policies skewed towards the wealthy, including (for example) pressures to reduce tax rates. These in turn tend to reduce spending on public goods such as education, health and childcare which can improve the economy's productive potential (Boushey, 2019; Case and Deaton, 2020).

The empirical evidence does not show that unequal societies are poorer than more equal ones. There are rich countries with high levels of inequality, and others which are more egalitarian. But the evidence does show that more unequal economies do less well than they would if they were more equal (Berg et al., 2018). In this sense it can be said that fairness and prosperity go hand in hand.

Reducing inequality also has an impact on social and individual wellbeing. Studies across developed countries show strong correlations between inequality and a variety of social harms, including higher rates of mental and physical ill-health, obesity and crime; and lower levels of social trust, educational attainment

and social mobility (Wilkinson and Pickett, 2009, 2018). This is true not just for those on low incomes, but across the population as a whole. Surveys of wellbeing consistently show that more equal societies are also those where life satisfaction and happiness are highest (Helliwell et al., 2017, 2019).

The trade-offs between economic growth and environmental sustainability are deeper. By changing what is produced in the economy and how, it is possible to reduce environmental damage significantly even while output increases (World Bank, 2012). Rapidly cutting greenhouse gas emissions, for example, will require significant investments in energy efficiency, renewable energy and sustainable transport technologies. These investments can act as a form of short-term economic stimulus, generating both jobs and incomes (Bowen and Kuralbayeva, 2015). In the longer term, technological and social innovation will need to drive very different patterns of production and consumption from those we see today, with much lower levels of energy and material use, and much higher levels of waste re-use and recycling. We do not know what impact this will have on long-term growth rates in developed countries. But there is little reason to doubt that a highly productive, environmentally sustainable economy of this kind can generate a high standard of living, and one more fairly shared (Jackson, 2016). Indeed, it is evident that the alternative - an environmentally unsustainable economy - will cause very serious damage to wellbeing and resilience in the medium and long term.

Going ‘beyond growth’ means neither abandoning growth as an objective nor relying upon it: it means changing the composition and structure of economic activity to achieve the multiple goals of a more rounded vision of economic and social progress. Policy making always involves difficult choices, particularly in the distribution of resources between groups and generations. But we are not compelled to make the same choices as those we made in the past.

The terms ‘inclusive growth’ and ‘green growth’ have been used to describe national economic pathways aimed at meeting wider objectives of the kinds suggested here. But these terms can be used with a range of meanings and have sometimes been accompanied by minimal policy changes in practice. The dynamics generating today’s economic crises are deeply embedded in the structure of our economies. So, giving serious priority to improving wellbeing, reducing inequalities, and achieving sustainability and resilience will demand more than a minor adjustment to current economic policies. The goals set out here need to be built in to the design of policy.

There are three crucial dimensions to this process in practice. The first is the adoption of a wider set of primary economic indicators to guide policy-making. GDP is not a good measure of overall economic performance. It does not take account of the distribution of income and wealth; it captures only flows of income not the stocks of capital that generate them; it undervalues unpriced and intangible services; it ignores unpaid work; it fails to measure environmental degradation; it is not a good proxy for wellbeing (Stiglitz et al., 2009; Coyle, 2014). Over the last decade, the OECD has pioneered the development of economic indicators which better capture the multiple dimensions of economic and social progress, and a number of countries have begun to adopt them. This involves use of a ‘dashboard’ of key indicators, including measurements of economic security, subjective wellbeing, environmental quality and public goods (OECD BLI, 2019). A particularly important new field is the development of ‘distributional national accounts’, which show not just the aggregate growth in GDP, but how it is distributed across income and population groups (Alvaredo et al., 2018).

But adopting a set of indicators is not sufficient. For new indicators to be effective they must be communicated: politicians and policy makers (particularly in finance and economic ministries) must make clear in their public pronouncements that this is how they want economic performance to be judged, and media debate needs to reflect this. Going ‘beyond growth’ needs to be an explicit political aim, reflected in a new public narrative and discourse on the nature of economic and social progress (Government of New Zealand, 2019).

Last, and most critically, the new economic indicators need to be attached to policies designed to improve them. It is no use adopting a new measure of performance without having the mechanisms to influence it.

This requires both an understanding of the causal factors which determine the level of the indicator; and the design of policies which can have an impact on it. This is why policy makers need a deeper framework of understanding of how modern economies work, and the kinds of policies which can make them work more successfully. Multidimensional indicators require a more sophisticated menu of policies.

Most economic policy is made by national governments, but in a globalised economy of complex supply chains and trading relationships, production, and consumption patterns in one country have powerful impacts on others, and many economic outcomes cannot be determined solely through national action. There is a vital need to achieve new international agreements and co-ordination mechanisms in areas such as environmental degradation, labour standards and tax policy which can ensure that economic goals in one country are not met at the expense of others, and national policy is enhanced by international co-operation (Hay et al., 2019).

## New frameworks of economic analysis

Over a period of about thirty years up to the financial crisis of 2008, the dominant model of economic growth in developed countries rested to a considerable extent on a form of neoclassical economic theory. This made relatively simple assumptions about how economic actors behave, and the implications of this for the functioning of the economy as a whole. In turn these led to a variety of standard prescriptions for economic policy which were widely adopted worldwide.

Within academic economics, this simple version of neoclassical theory was largely superseded by more complex approaches, but it remains the standard framework for the teaching of economics at school and early undergraduate level and continues to dominate public discourse and commentary about economic policy (Bowles and Carlin, 2020; Basu et al., 2018). And as an analytical framework, it had a disproportionate influence on economic policy making in many countries for a long period.

At the heart of this theory was an assumption of ‘rational’ economic behaviour. Individuals maximised their utility, based on preferences formed outside of the economic process. Businesses sought to maximise their profits. The ‘optimal’ level of output and consumption (and wages and profits) would then be achieved in markets that were as competitive as possible. Where they were not, it should be the objective of policy to make them so. In fields as varied as labour market policy, financial markets and international trade (and in some countries in the provision of public services too) the dominant policy view was that markets should be liberalised if possible, thereby improving their efficiency and achieving the highest overall gain in output and welfare.

Orthodox neoclassical theory acknowledged the existence of ‘market failure’, where competitive markets do not produce optimal outcomes due to the existence of externalities (such as environmental degradation) or public goods (such as science or defence). Market failure justified a range of government interventions, from environmental taxes to the public provision of services such as education, policing and research and development. But the neoclassical framework also noted that governments can fail: States may be captured by the interests of their officials or politicians, or simply lack the knowledge or capacity to improve market behaviour. As a result, economic prescription based on simple neoclassical analysis tended to be sceptical about the role of government in trying to steer the economy towards ends other than those determined by existing markets and well-defined externalities.

At the level of the whole economy, most macroeconomic models before 2008 were constructed using the tools of neoclassical economics (Oxford Review, 2018). Such models typically assumed that households and businesses behave in homogeneous ways, so could be modelled as ‘representative agents’. Though individual markets might involve frictions of various kinds, the long-run tendency of the economy was towards equilibrium, generally assumed to be at full employment. Instabilities were regarded as exogenous, coming from outside the system, rather than from within. In macroeconomic policy, the

neoclassical framework encouraged a view that high levels of government debt 'crowd out' private investment, so fiscal deficits should be limited, and monetary policy (adjustments to interest rates) should play the primary role in controlling inflation and managing overall demand (Goodfriend and King, 1997).

Since the financial crisis, the orthodox analysis underpinning economic policy has changed. Economists have had to acknowledge that the orthodox analytical framework has done a poor job of anticipating or explaining key developments and have begun searching for more helpful approaches (Skidelsky, 2016). It has been widely accepted, for example, that the crisis undermined the 'efficient markets hypothesis' which had informed financial deregulation (Wolf, 2014). It became clear that the behaviour of the financial sector needs more sophisticated analysis (BIS, 2014; Dagher, 2018). Indeed, in a variety of areas, from the understanding of fragmented labour markets to the analysis of productivity differences between different kinds of firms, policy makers have had to acknowledge that actually existing markets are not efficient, but beset by 'imperfections' and 'frictions' for example information asymmetries between market actors in different kinds of economic transaction which require different kinds of policy solutions (Lofgren et al., 2002). Macroeconomic models have been modified to include different kinds of financial institutions and behaviour, and rigidities and shocks of various kinds (Oxford Review, 2018).

Many economic policy institutions have acknowledged the limitations and failures of the more simplistic free market prescriptions of the pre-crisis period. It has been generally accepted, for example, that financial regulation needs to go beyond individual firms to the systemic risks which the financial sector as a whole can generate. As a consequence, various forms of 'macroprudential regulation' are now being considered and implemented (BIS, 2018). Similarly, it is accepted that free trade and deeper integration into global markets can have adverse consequences on particular groups of workers, sectors and geographical communities, and that counter-balancing policies are needed (Rodrik, 2017). In employment policy, minimum wages and active labour market policies to assist the unemployed into work have been supported for some time, while other kinds of government intervention, such as to redress gender inequalities in work opportunities and pay, are also advocated (OECD, 2018).

These developments are welcome but insufficient. Economics has been changing in more profound ways over recent decades. Economists working in both mainstream and non-orthodox traditions have developed new theories and analytical frameworks which can better explain the way in which modern economies work, and why they often don't. Many of these frameworks, some of them reformulations of older theories, have good claims to provide a better fit with the evidence, and in turn greater explanatory power, than those which continue to dominate mainstream policy making and public discourse. We list a few of the main developments below (Fischer et al., 2018; Mearman et al., 2019).

*Economic behaviour:* Few economists now think that the idea of rational 'homo economicus' is a useful way of explaining how people behave in real economic life, despite its widespread continuing use. Behavioural economics, informed by experimental evidence in economic psychology, offers a more sophisticated way of understanding, and is increasingly being adopted in mainstream economic analysis.[1] People do not constantly calculate and optimise their welfare: they use various forms of 'bounded rationality'. To save the time and effort of calculation, many economic decisions are made using 'heuristics' and 'rules of thumb'. At the same time, human reasoning is subject to many forms of bias. For example, people tend to operate within particular 'frames' of thought, rather than seeking a full range of information sources, and tend to draw general (and often mistaken) inferences from small samples of experience. 'Herd behaviour' (when people follow others' example, as happens, for example, in financial markets) can be common.

Economic psychologists and sociologists emphasise the role of social influences on the formation of economic tastes and preferences.[2] People do not act solely in their own self-interest: they have strong attachments and moral views which lead to various forms of caring, co-operative and altruistic behaviour, as well as conformity to social norms. Such behaviours suggest a 'social' human being as an important economic agent (McGregor and Pouw, 2017). Economic action in this sense is powerfully 'embedded' in

societal structures, institutions and relationships. Tastes and preferences are not exogenous to the economic system - they can be actively shaped by forces such as advertising, new technologies and new kinds of social networks and institutions. The common narratives about how the economy works and how people behave in it also influence behaviour (Shiller, 2019).

*Markets, institutions and power:* The neoclassical idea of the competitive market was intended to be a formalisation of what in the real world is obviously a wide range of different kinds of market arrangements. Over recent decades, institutional and political economists have pointed out that markets are brought into being by institutions and the social rules they embody: By law, custom, social norms, the structure and ownership of businesses, by public policy.[3] All of these can change the ways in which different kinds of market operate, and the outcomes they generate. The idea of 'market competition' is simply too narrow a frame to understand this. For example, the different systems of corporate governance and financing in different countries lead businesses to behave in different ways; the relationship between corporations and governments is a vital element in understanding how markets work in practice; and the development of digital information has fundamentally altered the nature of economic production. Comparative political economists have sought to understand how markets are co-ordinated through different institutional arrangements in different countries, giving rise to distinctive 'varieties' of modern capitalism.

Understanding markets as the outcome of the inter-relationships of institutions raises the issue of the role of power in the economy. The way in which today's labour markets work, for example, is made more explicable by analysing the relative power of employers, individual workers and groups of workers (Bivens and Shierholz, 2018; Weil, 2019). The growing concentration of many product markets in the hands of a small number of large corporations requires not just traditional analysis of monopoly and oligopoly, but of the impact of corporate lobbying on regulatory policy making. To understand the effect of rising inequality on economic outcomes requires an examination of the influence of the very wealthy on public policies such as taxation and public spending (Boushey, 2019). Overall, attention must be paid to the interaction of the economy and economic policy with politics and systems of democracy.

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*Evolution and complexity:* The standard neoclassical idea of macroeconomics has an essentially timeless frame of reference: the economy is analysed with little reference to its own history or to the processes of change. This makes it difficult to comprehend why and how economies develop over time. Evolutionary economists have sought to fill this gap.[4] They have shown how economies change in ways which mirror those of biological evolution, where differences in corporate behaviour and technological innovation generate advantages in markets and therefore get reproduced. They have analysed how change is 'path dependent', constrained by previous conditions and inertial forces. Many evolutionary economists and economic historians have focused on trying to understand innovation - the process of 'creative destruction' - as the key driving force of economic growth over time (Freeman, 2008). They have explained innovation as an institutional process influenced not just by the processes of technological 'invention' within firms, but the wider system of 'innovation networks' and financial markets, and the often powerful role of public funding at various points in the innovation process (Mazzucato, 2013).

The dynamics of innovation are hard to reconcile with the neoclassical view of the economy as an essentially equilibrating system: in reality it is always in turbulent flux. The school of complexity economics

has sought to combine this insight with those of behavioural and institutional economics to understand the economy as a complex adaptive system.[5] Drawing on theory developed to analyse complex systems in biology and engineering, complexity economics seeks to understand the ways in which the multiple and nonlinear relationships between heterogeneous actors in a modern economy generate aggregate outcomes which are not simply the sum or average of their constituent parts. Complex systems result in new, 'emergent' outcomes which cannot be predicted through a mechanistic approach based simply on their micro-foundations. Understanding this has particular value to elucidate complex systems such as finance and global value chains. Complexity economists have developed new kinds of 'agent-based' models which abandon the assumptions of rationality, representative agents, optimising behaviour and equilibrium of the standard neoclassical model. Utilising big data and modern computing power, such models are able to represent the economy in more complex ways, offering the potential of better explanation and prediction (Hamill and Gilbert, 2016).

*Finance and macroeconomics:* The failure of most macroeconomists to predict the financial crash of 2008, and the continued weakness of many developed economies despite the very low interest rates of the last decade, have led to a fundamental reassessment of neoclassically-based theory. A crucial dimension has been the role of the financial sector. Prior to the crash financial regulation was largely based on the neoclassical 'efficient markets hypothesis', which assumed that, with near-perfect information, liberalised financial markets would generate an optimal allocation of resources (Wolf, 2014). The evident failure of this theory has renewed interest in 'post-Keynesian' analysis which explains how financial markets shift between stability and fragility, and their tendency to create asset bubbles and subsequent crises (Minsky, 1986, 1992).

Keynesian and post-Keynesian economists have challenged the neoclassical orthodoxy around fiscal and monetary policy, emphasising the importance of effective aggregate demand in determining productivity and output growth, and the central role played by uncertainty in economic behaviour.[6] They have focused on the role of fiscal policy in stimulating growth (in part through its effect on business expectations), and the limitations (and inequitable impacts) of monetary policy. Such insights are now partially accepted in 'mainstream' economic analysis, for example, that a more active fiscal policy is both necessary and desirable in conditions when interest rates are very low and monetary policy has largely run out of options (Summers, 2016). Contrary to neoclassical orthodoxy, it has been shown how high levels of public borrowing and debt can be sustained so long as the growth rate of the economy (which can itself be stimulated by public investment) exceeds the rate of interest paid (Blanchard, 2019). Public investment can 'crowd in', rather than 'crowd out', private finance (Griffith-Jones and Cozzi, 2016).

A key field has been the development of new kinds of macroeconomic models. The unrealistic assumptions and poor predictive performance of standard 'dynamic stochastic general equilibrium' (DSGE) models used by many central banks and finance ministries has led to a questioning of their neoclassical 'microfoundations', such as rational expectations and representative agents (Stiglitz, 2018; Wren-Lewis, 2018). The new models incorporate financial assets of various kinds; can better account for the impact of stocks as well as flows; and allow for more realistic behavioural and institutional assumptions, including the critical role of information asymmetries and uncertainty; and the possibility of endogenous shocks and structural breaks in economic evolution, such as financial crises (Hendry and Muellbauer, 2018; Muellbauer, 2018).

*The natural environment:* Neoclassical economics understands environmental degradation as a form of market failure, where environmental goods are unpriced. It therefore seeks to find a monetary value for environmental resources or the damage caused to them, and to use environmental taxes or other incentive mechanisms (such as tradable permit systems) to 'internalise' the external cost and so correct the market failure (Tietenberg and Lewis, 2018). But this approach cannot fully explain or address the prevalence of environmental degradation. Ecological economists have offered a more fundamental explanation.[7] They have shown how the economy is in reality a subset of the earth's biophysical systems: it depends on the natural environment to provide it with resources, assimilate its wastes, and to provide various life support

services such as nutrient recycling and climatic regulation. These processes are governed by the laws of thermodynamics, which means that all resources are turned back into wastes, in a more 'entropic', or disordered (and therefore often polluting) state. Natural systems do not behave in linear ways but exhibit a range of thresholds and 'tipping points' which, when exceeded, risk catastrophic change, sometimes to local environments, sometimes (as with climate change) to the global one.

For these reasons, ecological economics seeks to bring the economy back within the earth's 'sustainability limits' or 'planetary boundaries', where environmental systems can naturally regenerate (Steffen et al., 2015). This will involve, not the marginal changes assumed by the notion of market failure, but transformation in the environmental structures of modern economies. A range of policy instruments will be required to stimulate this, including, but going well beyond, environmental taxes. This will have powerful implications for macroeconomic policy: the notion of economic growth itself will need re-evaluating.

*Inequality:* As inequality has increased, a growing number of economists have sought to map its extent, and understand its causes and effects.[8] In doing so they have challenged some of the fundamental tenets of the standard neoclassical approach. For example, increasing liberalisation of international trade does not have the widespread economic benefits formerly assumed, particularly for already open economies. Although greater trade may raise GDP, it frequently results in a highly uneven distribution of the benefits, with significant net economic costs being borne by particular industrial sectors and the geographic communities dependent on them (Rodrik, 2017). Experience in a variety of countries suggests that a non-liberalised, more government-directed approach to trade and industrial policy may have a much stronger impact on growth and its distribution (Chang, 2010).

As already noted, one of the key trends of the last forty years in many developed countries has been the declining proportion of national income which has gone to wages and salaries and the rising share going to the owners of land and capital. This has been explained in terms of the rising returns to capital relative to the growth rate of the economy as a whole, and of the increasing ability of higher income groups to capture the unearned 'rents' or surpluses from economic activity.[9] The relative power of employers and workers in the labour markets for different kinds of work has then magnified the difference in earnings between workers in different occupations. Rising inequality has negative impacts on the wider economy, including on productivity and economic growth and on many indicators of individual and social wellbeing (Stiglitz, 2012).

*Gender:* One of the persistent dimensions of inequality has been by gender. Women in all countries are systematically under-represented in high-status and high-earnings occupations, and over-represented in low-status, low-income ones (SIGI, 2019). Research in labour market economics has sought to understand the interaction of gender, family and labour supply (Blau et al., 2014; Goldin, 2014). Feminist economists have gone further, seeking to locate such gender stratification in the deeper structures in society which entrench the relative roles and power of men and women.[10] Comparable analyses have examined how ethnic minorities also experience systematic discrimination and under-representation in higher-status and higher-income occupations; the basis of this in the colonial and slavery histories of western economies; and the ways in which inequalities of gender, race and class intersect.[11] Analysis of economic and public policy outcomes without understanding their gender and racial dimensions is simply incomplete.

A critical feature of feminist economics has been an expansion of the boundaries of the economy and of economic analysis. It has emphasised the critical role which the unpaid work of raising children, very largely done by women, plays in maintaining the processes and structures of society, and the way this is systematically ignored in mainstream economic accounting and analysis. This is also true of other forms of unpaid work, such as caring for elderly and disabled people and voluntary and community work of various kinds. Only by understanding the economic value produced by these activities, it is argued, can the functioning of the economy, and its embeddedness in social structures and relations, be properly understood.[12]

*Ethics and the role of the state:* Inequality forces a questioning of the ethical basis of economic analysis. Proponents of the standard neoclassical framework widely assume it to be ethically neutral, since it seeks to maximise welfare given the existing tastes and preferences of consumers; it does not judge these (Wight, 2015). But in practice people's tastes and preferences change as they move along the income scale, therefore a different distribution would generate a different pattern of economic activity. This is even before we consider the moral claims of future generations (Nolt, 2017). Regarding the maximisation of welfare under current conditions as ethically 'neutral' is in practice to accept the current distribution of income (including between generations). This is why economic philosophers and political economists have argued for a more honest understanding of the inescapably ethical character of economic analysis. In turn this would lead to a more sophisticated public debate about the justice of different economic arrangements and policies.[13]

It also suggests a re-examination of the role of the state in economic policy. The neoclassical framework presupposes that well-functioning markets optimise overall welfare, and government policy is justified to correct market failures. But if public policy is to aim at different ethical outcomes, the state will have to play a larger role in guiding the overall patterns of economic activity to achieve them. Through public service and welfare provision it can also support a fairer and more productive form of economic development. 'Correcting market failures' will not be sufficient; markets can also be 'shaped' in pursuit of publicly determined goals.

These developments have generated new understandings of how modern economies work, and the advent of new data sources has enabled economics to become a much more empirical social science. It is notable that some of the key insights have arisen both within mainstream economic traditions - by relaxing simplistic assumptions and introducing 'frictions' or new explanatory variables of various kinds - and in more explicitly 'heterodox' ones (Zucman et al., 2019). The result is that economic analysis and policy making are now able to draw upon a much richer and more empirically based menu of academic economics and political economy than has generally been used or featured in public discourse over the last thirty years or so.

No single synthetic theory has emerged from these different approaches to economic thought. But this is not because they offer fundamentally competing analyses. Indeed, in many cases there are strong synergies between them, and powerful ways in which they can be combined. Many economists working in the complexity field have been explicit in making these links and incorporating insights from a wide range of economic analyses to understand in a more sophisticated way how economic agents behave and the outcomes which emerge from their interactions (Wilson and Kirman, 2016). Political economy likewise encompasses a range of interdisciplinary approaches, drawing on critical insights from history, sociology, anthropology and other fields.

Over the last decade much economic policy-making and advice has moved away from the simple 'orthodox' approach which was dominant before the financial crisis. But the persistence of serious economic problems, and the rise of new challenges, suggests that this movement has not gone far enough. Similarly, the new frameworks of economic thought are in some cases blurring the lines between the mainstream and the heterodox, but again, not enough. These two shifts need to be harnessed to one another. The new modes of economic analysis can provide a much broader approach to economic policy making than the simple neoclassical framework. They can help explain why conventional policies have not been working well. And in turn they can help point the way to alternatives that might more successfully do so.

## New approaches to economic policy

As the multiple problems and challenges facing developed economies have emerged over the last decade, many new approaches to economic policy have been developed in response. These approaches reflect two key insights. The first is that today's deep challenges will not be addressed simply by incremental

changes to existing policies. Environmental unsustainability, low levels of investment and slow productivity growth, rising inequality, the power of monopoly corporations, growing financialisation, and accelerating automation all arise from structural features of modern economies. So, they will require a more profound shift in the kinds of policy which governments use to address them.

For much of the last forty years, the dominant approach to economic policy making in most OECD countries has been to focus on the 'supply side' of the economy. Macroeconomic policy aimed to control of inflation. Some adverse impacts of growth have been ameliorated 'after the fact' by redistributing income through the tax and benefit system, and social and environmental policy. Meanwhile the central engine of the economy - the patterns of investment and forms of production that generate its shape, direction and scale - have been largely left to be determined by private sector businesses and finance.

Though both supply side and ameliorative policies are still important, they are no longer sufficient. We need to pay attention to the way the engine itself works. For it is in the patterns of investment and forms of production themselves that the major problems and challenges arise. Environmental sustainability, improved wellbeing, a reduction in inequality, and greater resilience need to be built into the structures of the economy from the outset, not simply hoped for as a by-product, or added after the event.

It is vital that policy is made in an integrated way. This starts from the adoption of economic performance and wellbeing indicators which capture the full breadth of economic and social objectives. These indicators must then be attached to policies which can change how they perform - not just individually, but together. Multiple objectives can only be achieved if economic and social policy making moves out of its traditional silos and seeks the synergies as well as the trade-offs between different policy areas (Tett, 2015). For example, reform of the financial system to reduce systemic risk must also distribute wealth more broadly. Macroeconomic policy must be bounded by environmental sustainability limits. Overall public spending must be audited for its impact on each of the multiple dimensions of wellbeing. Policy must take account of international as well as domestic impacts. Institutional innovation in government will therefore be required.

*Sustainability and decarbonisation policy* poses perhaps the most acute and urgent challenge in these respects. In the past, environmental policy aimed at improving the impacts of specific products and production activities through regulatory measures such as energy efficiency and pollution standards and protection of natural areas. But these have not been enough to reduce environmental degradation to sustainable levels. So policy makers must now consider how long-term decarbonisation and sustainability targets can be given greater legal and economic force, and used to drive investment and production into more sustainable and resilient forms (Jacobs, 2018). This will involve detailed examination not just of the technological options which can achieve radically lower environmental impact in different sectors, but of the patterns of consumption and modes of living which will be associated with them. Some activities - the subsidy of fossil fuels, for example - will need to cease, while 'just transition' strategies will be required to ensure an equitable restructuring of carbon-intensive sectors and enable workers to retrain for new jobs (ITUC, 2018; ILO, 2018). To make choices of these kinds, governments will need to engage in much deeper forms of sectoral planning, social partnership and public consultation than in the recent past.

*Innovation and industrial policy* will have a crucial role. Over the last few years a number of governments and public institutions have taken up the idea of 'mission-oriented' innovation and industrial policy (Mazzucato, 2017, 2018). This starts from the insight that economic development has a direction as well as a rate. So public policy can help drive innovation into meeting the major environmental and social challenges our societies face. Using a combination of policy targets, public procurement, innovation spending and 'patient' public investment, a more active industrial policy can help steer the economy, not just to support stronger industrial performance, but social and environmental goals as well. In most countries a strongly devolved regional policy will be necessary to ensure more equitable geographical outcomes.

There is a strong case for a more active industrial policy to be supported by a more active *macroeconomic policy.* With real interest rates still very low and quantitative easing still in place, fiscal policy will be needed to ensure sufficient aggregate demand to create new jobs, particularly in the face of a global downturn (Boone, 2019). Although public debt levels remain high in many countries, public borrowing for investment which supports economic growth can be sustainable, paying for itself over time (Blanchard, 2019). It is notable that many public investments which support growth and job creation will also contribute to improved individual wellbeing, and social cohesion and solidarity.

Improving the resilience of the economy through stronger *financial regulation* remains a priority. Though the period since the financial crash has seen stricter regulation of individual financial institutions, many analysts warn that the financial system as a whole remains fragile (Buiter, 2018; Tucker, 2019). While policy makers have been developing new forms of macro-prudential regulation aimed at preventing excessive credit growth, it is not clear that these are yet strong enough to prevent another crisis, with the growth of the largely unregulated shadow banking system a particular concern (Aikman et al., 2018; Lysandrou. and Nesvetailova, 2015). There are strong grounds for exploring stricter regulation of the types of assets which financial institutions can hold, penalising (through regulation or taxation) high carbon, speculative and 'non-productive' financial activity, and incentivising long-term investment in productive sectors of the economy .[152] In some countries this might include reforms to the 'shareholder value' model of *corporate governance* and executive pay, which has encouraged an excessive focus on short-term returns and a decline in long-term investment (Lazonick and O'Sullivan, 2000; Lawrence, 2017).

More widely, there is increasing interest in the role which *competition policy* might play in regulating the growth of companies with powerful monopoly positions, particularly in key digital markets. The orthodox approach of judging competition and market power largely through their impact on consumer prices has come under increasing challenge (Kahn, 2016; Lynn, 2017). With expanding influence on many aspects of life, the structure and regulation of digital platform companies is a particular focus of policy concern. This will clearly have to be done on an international as well as national basis. There is also increasing scrutiny of the ways in which multinational corporations govern their global supply chains, particularly in relation to labour and environmental standards. Raising such standards through new forms of international trade agreements offers a potentially powerful approach. Co-ordinating corporate taxation regimes on an international basis to ensure that multinational corporations pay fair levels of taxation in the countries in which they operate will also be important.

Building dynamics to reduce inequality into the structures and institutions of the economy poses a challenge. Redistributive measures through the fiscal and welfare systems remain vital, but it also requires 'predistributive' measures that address inequality's complex drivers (Boushey, 2019; Lustig, 2018). One of these lies in the ownership of wealth, which in many countries has become more concentrated over the last decade (Alvaredo et al., 2018). A variety of approaches to spreading wealth more widely are now under discussion in many places, including mechanisms to broaden the ownership of companies, reforms to land ownership and housing markets and the design of 'citizen's wealth funds'. It is also argued that wealth, and income from wealth, need to be taxed more (IPPR, 2018; Saez and Zucman, 2019). Reducing inequality will require particular attention to labour market policies. The falling share of national income going into wages and salaries (relative to capital) over recent decades has reflected a decline in the effective bargaining power of workers, particularly in lower-skilled jobs. Reversing this would require a range of measures: raising minimum wages; improving the access of trade unions to workers, particularly in smaller firms and under-unionised sectors; improving the regulation of working conditions and contracts, particularly in the so-called 'gig economy' of precarious work; employee profit-sharing schemes; improving the provision of childcare; and increasing the role of collective bargaining, particularly at a sectoral level.

Collective bargaining will be particularly important to steer and manage the processes of *automation,* ensuring that the benefits of higher productivity do not accrue simply to the owners of capital (Korinek, 2019). As automation and decarbonisation redistribute employment opportunities, there is increasing interest in the role of government 'job guarantees' to smooth the transition (Tcherneva, 2018). 'Flexicurity'

welfare policies which combine flexibility for employers with income security for workers may also be important (Wilthagen and Tros, 2004). There is growing interest in the idea of a 'universal basic income' for the same reason (Standing, 2017; Vanderborght, 2017). Others propose a system of 'universal basic services', including education, healthcare, housing and transport (Social Prosperity Network, 2017; Gough, 2019). Systematic measures will be needed to end discrimination against women, ethnic minorities and other minority groups in many countries, and to increase investment in childcare and early years provision. Investment in lifelong education and skills training will become increasingly vital. Perhaps more radically, there is increasing interest in the potential of reducing working hours to capture the gains of higher productivity in improved wellbeing, rather than simply higher consumption (Coote and Franklin, 2013).

The aim of these policy approaches is to help shift the structure of economies so that their internal dynamics work towards environmental sustainability, improved wellbeing, declining inequality and greater resilience. Rather than bolting on policies which have to act *against* the dominant dynamics of the economic system, the aim should be to change the way the engine of the economy works, so that these goals are its primary outcomes.

This must extend to the international sphere. It is not possible for individual countries to achieve economic and social progress in isolation. Global, multilateral rules are needed to prevent financial crises, tackle tax evasion and money laundering, address climate change and environmental degradation, regulate labour standards in international supply chains, and shift the distribution of global resources towards the poorest countries and people. A new global governance regime is required (Hay et al., 2019).

We are under no illusions as to how easy or quick policy changes of these kinds will be. They will require significant institutional reform. Many vested interests will stand in the way - the resistance of those with incumbent economic power is of course a major reason why more equitable and sustainable policies have not been followed previously. We recognise that this is as much a political as an economic policy making challenge. In some countries it may require innovations in democratic practice and the ways in which policy is made, for example to open it up to wider consultation and participation.[14]

It may also require a new role for the state. A number of practitioners and commentators have explored how modern governments can offer more than safety nets for their citizens, providing them with assets and skills that do not simply remove barriers to opportunities, but furnish people with the capacity to seize them.[15] States must become more entrepreneurial, seeking to shape markets and steer the process of economic change, not simply correct market failures. An empowering and entrepreneurial state would allow the development of a new kind of social contract - a new relationship between the state, business, civil society and citizens (Snower, 2019). These processes will take a different form in every country - despite the processes of globalisation, every country retains its own history, cultures and institutions. But everywhere it will need political imagination and courage.

## Conclusion: Towards a paradigm shift

A decade ago the financial crisis rocked not just the world's economic system, but the confidence that policy makers knew how to manage it. Since then, important changes have been made. Economic analysis has become more sophisticated, and new approaches have been adopted in policy making and advice - many of them led by the OECD. But the depth of the issues we now face makes clear that these processes have not yet gone far enough. Though modified and improved, policy makers are essentially still operating with the pre-crisis economic framework and its accompanying forms of policy. We believe that more radical rethinking is required.

In this chapter we have set out how this can be done, with a new set of goals and measures of economic and social progress; new frameworks of economic analysis; and new kinds of policies. These are not new in the sense of 'original': on the contrary, a critical part of our argument is that what we are doing is bringing

together well-established ideas which have many authors and important intellectual histories. But we do claim that it offers an alternative to the approach to economic policy making which has been dominant in OECD countries over the last forty or so years. If the new goals we propose are to be achieved, a new model of economic and social development is needed.

The critical idea - the common thread - that runs through our argument is that economics and economic policy need to understand the sociality of human life. People are not the individual utility maximisers of orthodox economic myth: they have multi-dimensional preferences and ethics formed in social and cultural settings. There is a reflexive interaction between individual economic decisions and societal forces, working itself out in social institutions and through political processes. This means that our conception of economic progress needs to extend beyond individual, material prosperity to include indicators of social wellbeing, cohesion and empowerment, and the environmental boundaries of human activity. Our frameworks of economic analysis need to acknowledge the social, historical, political and environmental context of economic behaviour, and the feedback loops between individual decisions and societal dynamics which characterise economic systems. Our approach to policy must go beyond the traditional instruments of economic policy to encompass reform of institutions, social policy and political narratives.

We do not claim to have presented a fully-fledged and coherent model of economic and social development which can simply be taken off the shelf and implemented. Much more work needs to be done. Yet it is evident too, that many of these ideas have already begun to enter mainstream economic and political debate, even if their full implications have not yet been acknowledged. The task now is to move from debate to practice.

It is daunting for economic policy makers to contemplate a fundamental shift in the way they make policy. But this kind of change has happened twice before in the last century. In the 1940s, in the aftermath of the Wall Street Crash and the Great Depression, the economic orthodoxy of *laissez faire,* which had dominated analysis and policy making in the preceding period, was replaced. Keynesian economic theory provided a better way of understanding how economies could be revived, and the economic policies of full employment and the welfare state won broad support across the political spectrum. But the 'post-war consensus' itself broke down amid the economic crises of the 1970s, and it too was replaced. The free market or 'neoliberal' model developed by economists such as Milton Friedman and Friedrich Hayek appeared to offer a better economic analysis, and a more dynamic policy prescription. Adopted originally (and most fully) by the US and UK under the governments of Ronald Reagan and Margaret Thatcher, the market-oriented model in various forms came to be applied widely across the OECD in the subsequent decades.

Social scientists describe these moments of economic change as 'paradigm shifts' - periods when old orthodoxies are unable either to explain or to provide policy solutions to conditions of crisis, and new approaches take their place (Laybourn-Langton and Jacobs, 2018). More than a decade after the financial crash, with the global economy and many individual OECD countries facing multiple crises, our argument is that the time is ripe for another such paradigm shift. The frameworks and prescriptions which have dominated policy making in recent decades are no longer able to generate the solutions to the problems and challenges we face today. We need a less incremental, more profound form of change.

In a world of complexity and radical uncertainty, only the foolish would argue that the solutions are simple. But this does not mean that it is beyond us to find them. No single prescription will fit all circumstances. Each country will wish to find its own way. But we are struck by the wealth of insight and understanding which now exists across the field of academic economics and economic policy making, from which solutions can be drawn. We applaud the OECD for its vital work in this field, and strongly recommend it continues to engage its member states and the wider global economic and political community to discuss and shape these new approaches further, and to support their implementation. The prize could not be greater.

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## Notes

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# 6 Build Back Brainier: Base Policies on Brain Science

This chapter presents a conceptual asset, Brain Capital, to inform novel policies. The concept builds on previous work, the Brain Capital Grand Strategy, that considers Brain Capital in all policies and offers a comprehensive investment plan and the development of an index or a dashboard. The premise, enablers, and barriers towards a Brain Capital Building Policy Agenda are outlined. Engagement with communities is proposed, and approaches for educating policymakers are described. Brain Capital building policies should be considered in sectors such as human development, migration, gender issues, social justice, multi-cultural affairs, economics, protections, and international relations. Novel approaches for public investment including brain bonds and social impact investing are considered.

## Introduction

Five of the top ten causes of disability in the Western world are brain disorders resulting in mental suffering (Economist, 2018; Whiteford et al., 2013; AARP, 2021). Additionally, 75-95 % of people with mental disorders in low- and middle-income countries are unable to access mental health services. (UnitedGMH, 2021; Vigo et al., 2019; Liu et al., 2020; Rehm and Shield, 2019). These types of brain-based issues are not actively considered in our modern economy and have seen very little policy development and investment (Eyre, Ayadi, et al., 2021; Ellsworth et al., 2021). In contrast, they are often major drivers of governmental spending to ameliorate their societal impacts (e.g. the costs of dementia care or substance use disorders). Moreover, they are critical to unlocking latent workforce capacity and skills, such as creativity (Glaveanu, 2020). Many current approaches are siloed within individual fields. Technologists are building new solutions without clinical inputs; clinical stakeholder groups have overlapping and sometimes competing agendas (e.g. psychology, psychiatry, neurology); economists have not considered how brain health issues can reduce productivity; and new care solutions are not effectively translated between high-, middle- and low-income settings. Integrated and harmonised public policy solutions are needed to ensure that otherwise unconnected stakeholder groups are moving in the same direction. A Brain Capital Building Policy Agenda aims to address and remedy these issues.

Brain Capital prioritises brain health and brain skills in the economy (Smith, Ali, et al., 2021; Smith et al., 2021; Eyre, Ayadi, et al., 2021). It is a reflection of a country's wealth; it affects a person's quality of life and the way they are able to contribute to their society. The 21st century "brain economy" is predicated on the increasing demand for advanced cognitive skills (Eyre, Hynes, and al., 2021). It is an economy where innovation is a tangible deliverable of employee productivity (Smith and al, 2021). However, this is also an economy where brain-based issues (e.g. spread of misinformation, psychiatric and cognitive disorders) are increasingly impacting on productivity and wellbeing and the stigma of these disorders persist in far too many communities. This brain economy is currently impeded by the widespread impacts of Covid-19 on our central nervous system (CNS) (i.e. chronic stress and the known neuropsychiatric and cognitive issues associated with long haul Covid-19), which creates mood changes and brain fog (Mendez et al., 2021; Rogers et al., 2021). Such an impediment of a brain economy will likely be magnitudes higher with accelerating likelihood of "systemic shocks" e.g. viral, climate, and financial.

In the brain economy, despite the challenges outlined, neuroscience discoveries and insights are accelerating and opening new opportunities for understanding and remedies. Brain health as a life-long, multidimensional, dynamic state consisting of cognitive, emotional and motor domains underpinned by physiological processes can be objectively measured and subjectively experienced(Eyre, Berk, Cummings, et al., 2021; WHO, 2021; Chapman, 2013). It is influenced by eco-biopsychosocial determinants. Brain health is also defined by minimised risk and disability due to psychiatric and cognitive disorders. Brain skills incorporate not only logical but also emotional, social, cultural and spiritual intelligences. They are the underpinnings of resilience and adaptability, which are critical in our societies where economic and societal shocks are expected to increase in the future (be they financial, pandemic-induced or climate-related) (NAEC, 2019, 2020; Klasa et al., 2021). Other key brain skills include literacy, numeracy, and different forms of intelligence.

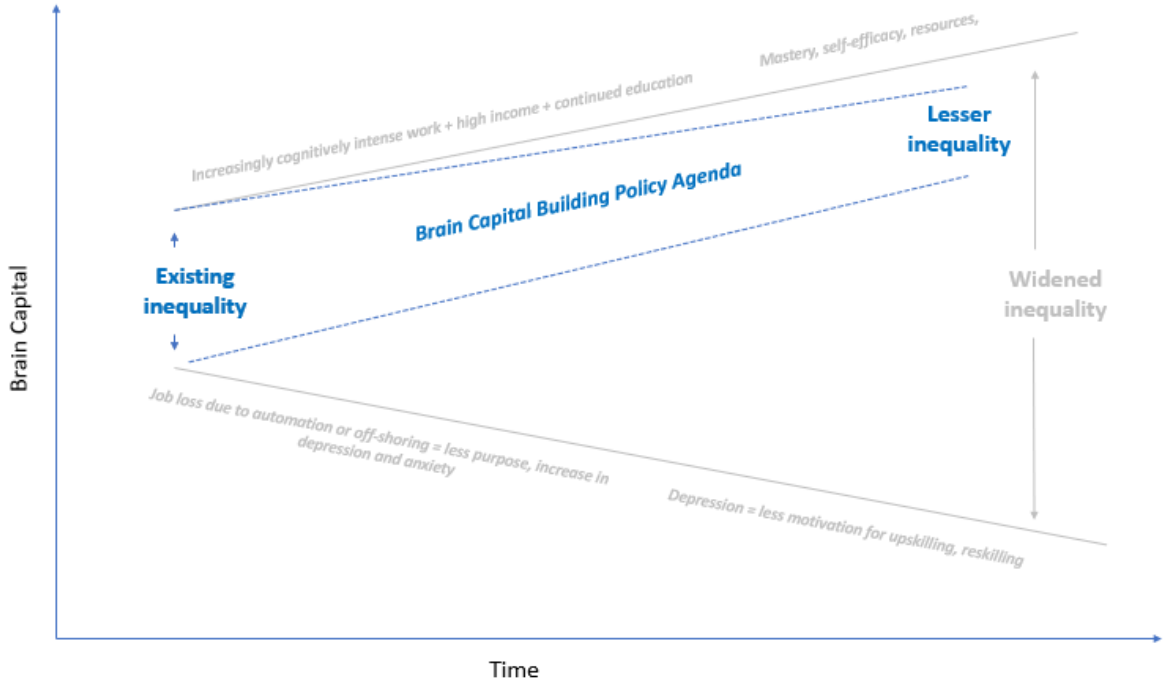
If we build Brain Capital, then other social and economic factors will potentially improve. The relationship between social factors and brain changes is bidirectional and an ongoing and active conversation amongst public health scholars, health care professionals, and scientists (The, 2021). Brain Capital is intertwined with overall health, longevity, and economics. Recent research has highlighted the importance of social determinants of health such as social isolation and loneliness versus social connectedness and compassion (Allen et al., 2014; UN, 2021). As articulated by the United States (US) Surgeon General, Dr. Vivek Murthy, and others, loneliness and social isolation impact physical and mental health as well as brain function as much as, if not more than, traditionally recognised risk conditions including smoking, obesity, substance use, hypertension, and sedentary behaviour (Murthy, 2020; Bzdok and Dunbar, 2020; Torrente

et al., 2021). Social connection is crucial to human development, health, and survival. There are perhaps no other factors that can have such a large impact on both the length and quality of life, from the birth to end of life (Holt-Lunstad, Robles, and Sbarra, 2017). Loneliness increases the risk of dementia and dementia increases loneliness, highlighting a pernicious relationship between brain health and social factors (Jeste, Lee, and Cacioppo, 2020; Blazer, 2020). The economic impact of loneliness was illustrated by United Kingdom (UK) Prime Minister Theresa May's decision in, 2018 to appoint a new "Minister for Loneliness" in order to assess and reduce business losses resulting from loneliness among workers (Gov.UK, 2021). Japan also appointed a similar minister in, 2021.

Our cognitive capacities are not a given and can be shaped in the course of our lifetime, in particular during childhood when brain plasticity is at its peak. During infancy, vulnerability and poverty compromise several aspects of neurocognitive development and language, two important predictors of later success in school and the labor market. Therefore, we are buoyed by US President Biden's planned human infrastructure agenda, which will boost childhood brain-based skills (Behrmann, 2021). This is aligned with our proposed Brain Capital Building Policy Agenda. US-based investments are proposed in childhood poverty reduction, universal pre-kindergarten, and a national paid leave program. If funded and executed well, these large-scale programs will facilitate early childhood brain development (Noble et al., 2021). Several governments have already invested heavily in research to explore the promise of such programmes, like the Neurons to Neighborhoods project and Baby's First Years (Council, 2012; Noble et al., 2021), so we hope policy influencers around the world take note of these approaches (Smith, Hynes, et al., 2021).

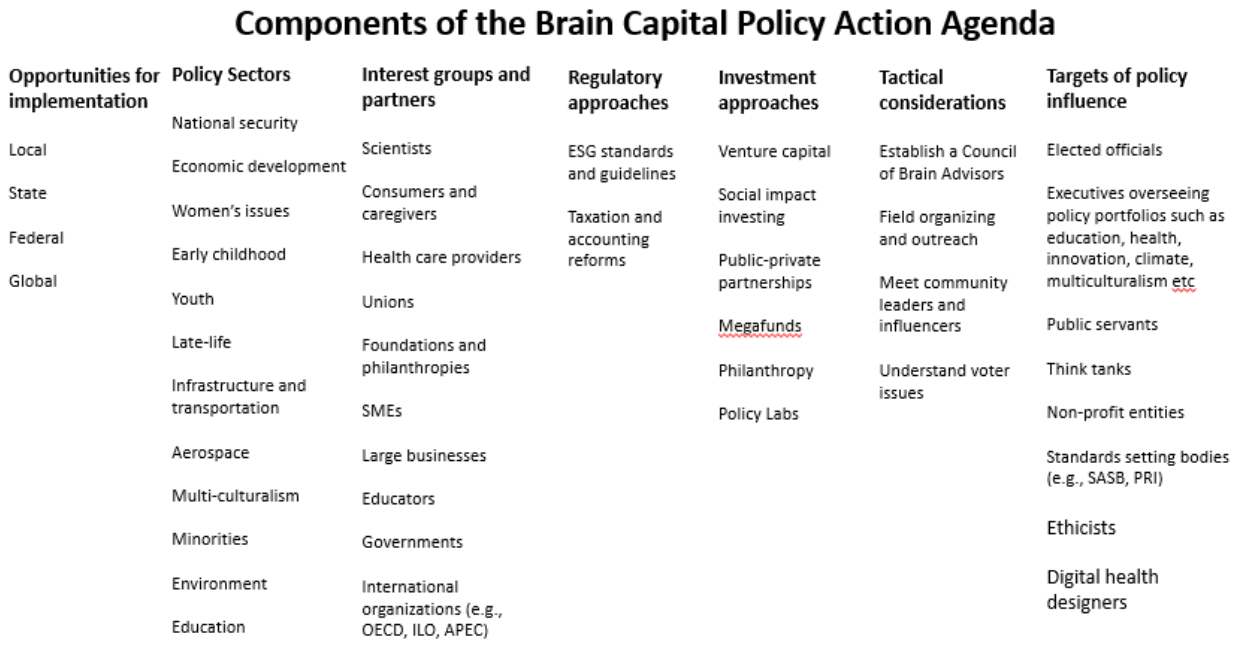
We suggest there is a current "Brain Capital Gap" occurring at different levels: within populations and between populations and society. Current inequalities will be exacerbated with the status quo. That is, individuals with lower Brain Capital are at higher risk of job loss, which creates a negative spiral of loss of purpose, economic hardship, depression, and anxiety. Taken together, these make upskilling and reskilling more difficult. In Figure 6.1, we outline the ultimate goal of the Brain Capital Building Policy Agenda, to reduce the current Brain Capital Gap by raising up all individuals and societies over time.

## Figure 6.1. Reducing the Brain Capital Gap



In figure 6.2, we outline the key components of a Brain Capital Building Policy Agenda, including policy sectors which can be targeted as well as investment approaches. Scientists are a key interest group and partner – it is important to engage neuroscientists and scientists from various brain-related fields (e.g. neuroimmunology, neuroplasticity, neuroepidemiology, etc). Health care providers, of course, are manifold and include psychiatrists, neurologists, psychologists, social workers, primary care providers, etc. It is key to engage the main professional organisations associated with scientists and health care providers.

### Figure 6.2. Components of a Brain Capital Building Policy Agenda.




## Facilitators of a Brain Capital building policy agenda

Brain Capital building approaches must be intensely multidisciplinary, and hence need to pull in diverse stakeholders, including those from economics, patient advocacy, early childhood and ageing interest groups, investors, educators, health care providers, arts, media, ethicists, and social services providers (Smith, Ali, et al., 2021; Eyre, Berk, Lavretsky, et al., 2021a; Eyre, Berk, Lavretsky, et al., 2021b). When one stakeholder group advances Brain Capital, it encourages and reinforces interest in other groups, therefore all stakeholders are allies of each other. Such dynamic interactions will be crucial to advance policy that is often fragmented, rigid, static, and ineffective to an adaptive, integral and dynamic approach that may guarantee efficacy.

Neuroscience discoveries are accelerating (Eyre, Berk, Cummings, et al., 2021), helped by new technologies to study the brain, from imaging to modelling and simulation. Stigma surrounding brain-based disorders is declining in many areas, meaning more open conversations are being held in communities about their impact and need for support. Globally, the SARS-CoV-2 pandemic highlighted the stressors and consequences of conjoint mental health crises, including concerns related to self-harm, suicide, and overall attestations of despair amidst a crisis – all of which contribute to diminished individual and household resilience to disrupted health, finances, and security (Ontiveros et al., 2021).

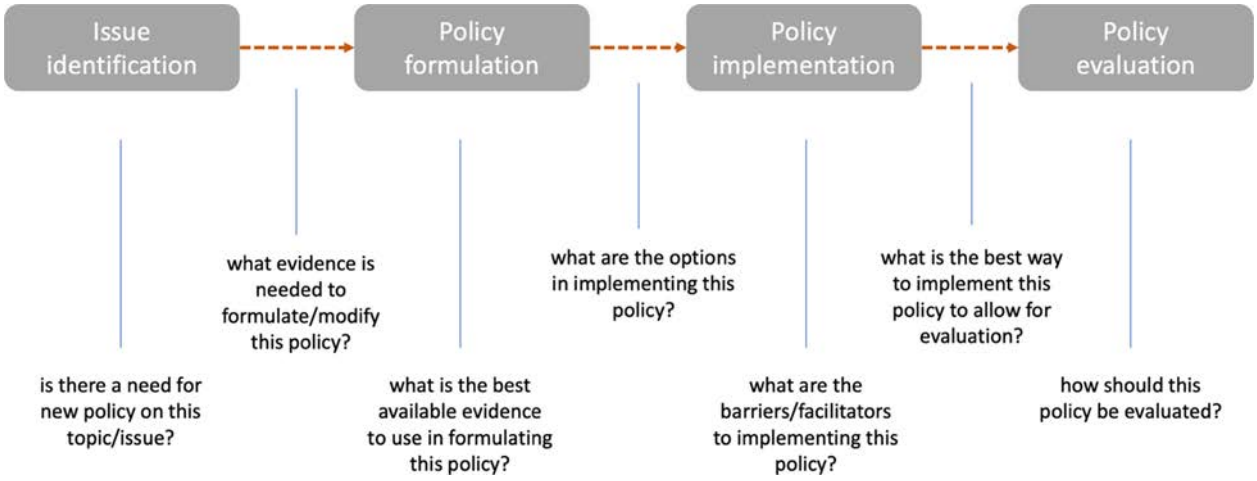
Levels of venture capital investment in brain health technology companies are rising (Shah and Berry, 2020). There is an increasing recognition that skills gaps are causing inequality, and these inequalities

create a negative spiral of despair, disenfranchisement, and depression (UN, 2020; Brookings, 2021; Case and Deaton, 2020). The pandemic has created the space for systemic changes to the way we approach and organise our societies, including the necessity of building individual and community resilience to shocks and stressors, as well as a focus on well-being and flourishing (Palma-Oliveira, Trump, and Linkov, 2021). Indeed, the Covid-19 pandemic has become an inflection point for substantive policy change (Bavel et al., 2020). An increased recognition and understanding of the principles of neuroscience and how these apply to individuals and society can and should be at the forefront of a world re-imagined after Covid-19.

### *A Brain Capital building Policy Lab*

While robust evidence is an important ingredient in the development of good policy, it is by no means the only one. Engaging with policymakers and the policymaking process requires collaborative working models, navigating through the experiences, values and perspectives of policymakers and other stakeholders, as well as communicating evidence in an accessible manner. As a response to these requirements, in recent years there has been proliferation of activities that engage producers of evidence (specifically, academics), policymakers, practitioners, and the general public in policy formulation, implementation and evaluation. One engagement approach for facilitating research evidence uptake into policy and practice is an activity called a 'Policy Lab'. Analysis by The Policy Institute of King's College London suggested the following values of policy labs: providing a forum for open, honest conversations around a policy topic; creating new networks, collaborations and partnerships between academics and policymakers; synthesising available evidence on a policy topic in a robust and accessible format; and providing timely access to evidence relevant to a policy issue (Hinrichs-Krapels et al., 2020). Figure 6.3 provides sample Policy Lab questions which should be considered in the context of the Brain Capital Building Policy Agenda.

**Figure 6.3. Sample Policy Lab questions**

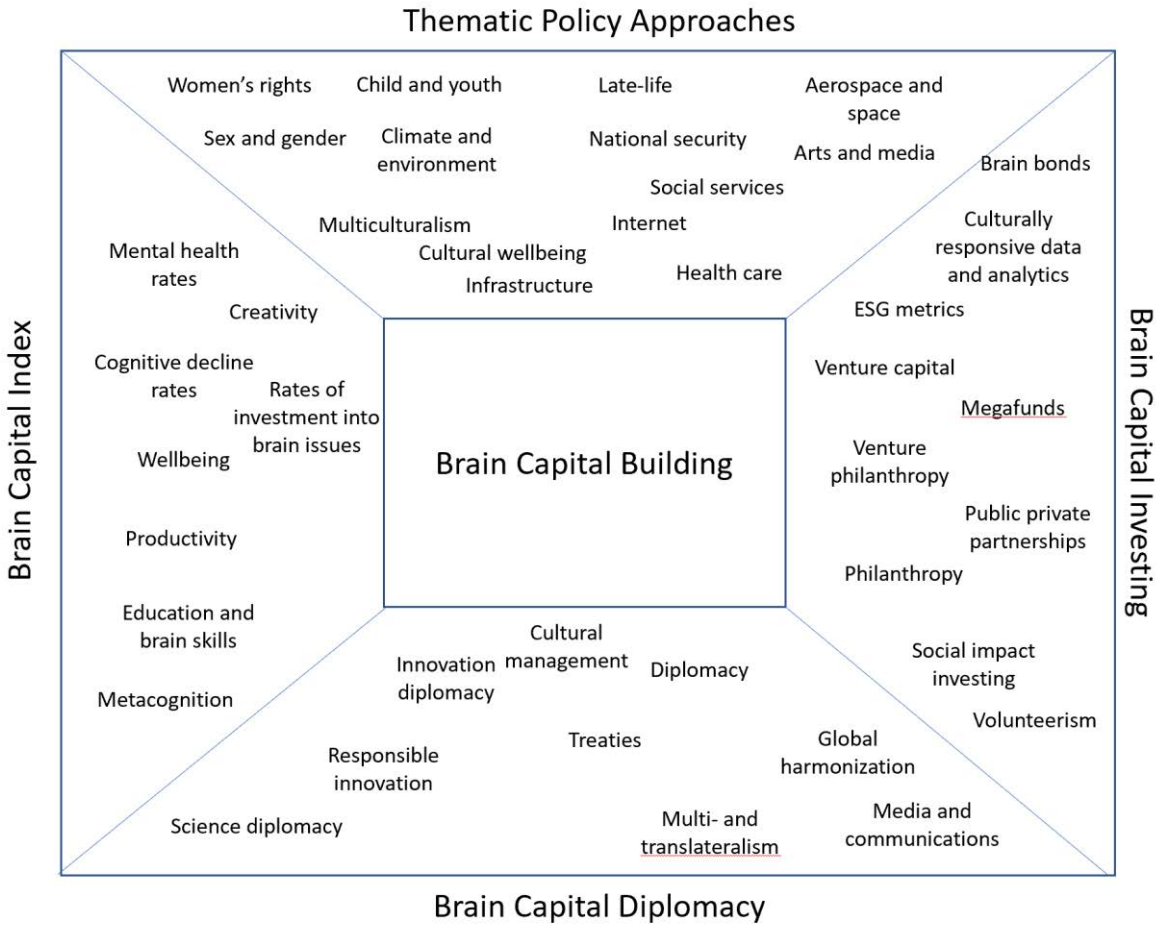



Source: Hinrichs-Krapels et al., 2020.

The OECD's New Approaches to Economic Challenges Unit (NAEC) created the Neuroscience-inspired Policy Initiative (OECD, 2021). This Initiative has many features of a Policy Lab. The Initiative seeks to reconceptualise and revitalise the world's economy and the way it operates, establishing the groundwork to identify relevant metrics while building a transdisciplinary network of global stakeholders (Council, 2014; Smith et al., 2020; Smith et al., 2021). The Initiative draws on experts from a broad array of fields such as neuroscience, medicine, gender analysis, economics, philanthropy, arts, media, industry and enterprise. The Initiative also seeks to sharpen and advance the concept of Brain Capital through research projects,

surveys, data collection, economic modelling, seminars, and policy analyses and recommendations. Dedicated working groups have been established on the four key elements listed in Figure 6.4, Brain Capital investing, Brain Capital diplomacy, Brain Capital thematic policy approaches and the Brain Capital index or dashboard.

### Figure 6.4. Key Elements of the Neuroscience-inspired Policy Initiative




## Brain Capital building policy sectors and recommendations

Brain Capital building should be considered in all policies to ensure that resources are optimised by leveraging science in service to effective, efficient and equitable solution finding for improved health, social good and economic growth. Perhaps the most robust Brain Capital building policy focuses on equitable access to high quality early childhood education, as well as social policies that reduce the likelihood of childhood and adult trauma, both physical and psychological (CDC, 2021).

In the case of poverty, for example, empirical evidence suggests that being poor is not only related to a lack of material resources but also to chronic scarcity and instability that impose great demands on a person's time and attention — such as having access to food and shelter. These findings illustrate that poverty is not associated with particular motives, skills, character or behavioural inclinations. Rather, they show that anyone living in a psychological environment of chronic scarcity would begin to display the same biases in planning and problem solving. As a result, behavioural science can help on a wide array of issues

intended to reduce poverty, including streamlining administrative procedures to reduce their burden on time, attention and the cognition needed to access social welfare programmes; providing widespread access to financial institutions to improve household savings; and reframing and empowering people living in poverty to counteract stereotypes and discrimination. Another protective policy is to achieve vaccine-based herd immunity to prevent or attenuate neuro-Covid presenting with substantial behavioural and cognitive symptoms and disabilities (GCBH, 2021). Table 1 outlines the most impactful examples of how Brain Capital can be built in various policy areas. There are other more speculative policy areas which could be influenced to build Brain Capital (such as transportation and the internet).

Brain Capital has implications for almost every policy domain. We note a helpful predicate from the 2008 UK Government Office for Science Foresight Report on Mental Capital and Wellbeing that generated the first neuroscience-inspired policy recommendations (Beddington et al., 2008). For example, investments in early childhood education facilitate brain development and offer the potential for significant enhancements of population-level health outcomes (Heckmann, 2021). A better educated citizenry may be more likely to reduce modifiable risk factors for dementia in late life (Larson, Yaffe, and Langa, 2013; Livingston et al., 2020) and less susceptibility to 'fake news' (Ternes et al., 2020; Miller, 2020). Additionally, as economies transition to the Fourth Industrial Revolution, economic growth and resilience will depend upon innovation that unlocks the latent capacity of workforce creativity in meaningful ways (Amabile and Pratt, 2016; Lister et al., 2021).

An aspiring Brain Capital leader or advocate can use these policy areas to raise awareness and/or build a political platform. These of course will be tailored to the geographic location and political subdivision (local, regional, or national) where the campaign is embedded. Policies need to be determined and prioritised based on local context or industry sector focus.

### Table 6.1. Brain Capital Building Policy Areas, Approaches, and Examples

| Policy area | Policy approaches and examples |
|---|---|
| **Early childhood** | The size of a child's brain reaches 90% of an adult's by the age of five. Early childhood is a time of rapid change – particularly for the development of the brain. These early years are critical for lifelong learning and well-being. We note the Minderoo Foundation's Thrive by Five program (https://thrivebyfive.org.au/), which will engage with government, research institutes and other stakeholders to advocate for effective policy and investment in early learning. This programme has initial activities in Australia, with global ambitions. Creating an optimal environment for healthy brain development starts prior to conception with adherence to healthy physical and mental preparation for parenthood. Therefore, focusing on young people prior to becoming parents by educating them about the importance of a healthy brain in giving their future children the best shot in life should be a cornerstone for optimal early childhood brain development. Given the importance of the caregiver to early relational health, better prevention, identification, and treatment of postpartum depression is key to boosting early childhood brain health and development. Not doing so is costly both economically and individually. A study found that the state of Texas is losing $2.2 billion by not treating mothers' mental health from pregnancy through their child's first five years of life (Villalpando, 2021). Postpartum depression has also been found to have both maternal and infant consequences, including negatively affecting physical health, sleep, motor, cognitive, language, emotional, social, and behavioural development in the infant (Slomian et al., 2019). Exemplary models for early childhood brain health include the Thriving Queensland Kids Partnership (https://www.aracy.org.au/the-nest-in-action/thriving-queensland-kids-partnership-tqkp). |
| **Women's health** | There is a clear sex and gender gap in outcomes for brain health disorders across the lifespan, with strikingly negative outcomes for women. This calls for a more systematic way of approaching this issue of inequality. The Brain Health Gap highlights and frames inequalities in all areas across the translational spectrum from bench-to-bedside and from boardroom-to-policy and economics (Smith, 2021). The WHAM Report (Women's Health Access Matters) shows that high-income countries cannot afford inaction (WHAM, 2021). The report studies the impact of accelerating sex- and gender-based health research on women, their families, and the economy across diseases, like Alzheimer's disease and related dementias, that impact women differently and differentially. The Women's Brain Project (WBP) is an international, non-profit organisation studying sex and gender determinants to brain and mental health. Founded in, 2016, the WBP is a group of scientists from disciplines including medicine, neuroscience, psychology, pharmacology, and communication who work together with caregivers, patients and their relatives, policymakers, and other stakeholders. The WBP identifies |

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| | how sex and gender factors impact diseases, diagnostics, drug and novel technologies development, to achieve precision medicine for sustainable and inclusive healthcare. www.womensbrainproject.com. |
| **Social science** | Emotion and social processes are hot topics in neuroscience and psychology, but the "visceral" nature of politics remains weakly assessed. Visceral politics (Tsakiris, Vehar, and Tucciarelli, 2021; Zmigrod and Tsakiris, 2021) highlight the non-rational nature of politics, as well as how the physiological engagement with the social world impacts on our decisions and political behaviour. Body experience, emotions and socio-cultural context are all impacting on neurophysiological process. Academic-governmental initiatives such as the Centre for the Politics of Feelings in UK (UL, 2021) are creating novel interdisciplinary understanding of how brain, emotions and feelings can be active causes but also targets of political behaviour in diverse socio-political contexts. |
| **Education** | Develop ways to increase equitable educational engagement and attainment to improve brain health. Innovative strategies are especially needed to rethink ageing and promote learning and engagement across the lifespan, beginning in early childhood. Education is key to flourishing and longevity (OECD, 2017). In the Age of Accelerations, with converging accelerations in technology, globalisation and climate, lifelong learning is no longer desirable, it is essential (Friedman, 2017). The 'OECD Skills Outlook, 2021: Learning for Life' (2021) noted that lifelong learning starts in childhood and youth, continuing throughout adulthood and old age. It encompasses formal learning in settings such as schools and training centres, informal and non-formal learning derived from colleagues and workplace trainers, and unintentional learning stemming from spontaneous social interactions. |
| **Psychological and cognitive resilience** | Resilience is an important quality during challenging times of pandemic and climate change that allows human beings to adapt to an uncertain and unpredictable future (Masten, 2016). Resilience can be developed across the lifespan and lead to the ability to self-regulate and adapt in the face of acute trauma and chronic stress. Building cognitive resilience can help build cognitive reserve and promote healthy cognitive ageing, but also off-set negative effects of stress and Covid-19 related cognitive issues (Killgore et al., 2020; Linkov et al., 2021). |
| **Despair** | Despair in society is a barrier to reviving labour markets and productivity, jeopardising well-being, health, longevity, families, and communities, and even national security. The Covid-19 pandemic exacerbated an already growing problem of despair. In the US, this despair in part results from the decline of working class, white Americans. It contributes to decreasing geographic mobility and has political spillovers, such as the increase in far-right radicalisation. Other population groups are also suffering, for different reasons. Over past few years, for instance, suicides increased among minority youth and overdoses increased among Black urban males (starting from a lower level than white Americans but now exceeding it). Policy responses have been fragmented, with much focus on interdiction or ex-post treatment rather than on the root causes of despair. There are local efforts to boost the well-being of vulnerable population cohorts, but there is no federal level entity to provide vulnerable populations with financial or logistical support, nor is there a system that can disseminate relevant information to other communities seeking solutions. While federal agencies - such as the Centers for Disease Control (CDC) - track mortality trends, no system tracks the underlying causes of these deaths. In contrast, many countries, such as the UK and New Zealand, track trends in well-being and ill-being as part of their routine national statistics collection and have key leadership positions focused exclusively on these issues. A Brookings Institution task force report (Brookings, 2021) highlights the increasing levels of despair in the US and the need for a new federal interagency task force to address the nation's crisis of despair as a critical first step to sustainable economic recovery. |
| **Ageing** | Key challenges that older adults face, including the decline of cognitive and physical health, social isolation, and psychiatric disorders, must be better understood and overcome to unlock and capitalise on the value of an increasingly aged society (Bishop, Lu, and Yankner, 2010). The challenges associated with caregiving is a brain-based issue directly impacting older adults. A major downstream benefit of reducing dementia and other brain-based disorder impacts would be to caregivers, in particular women, whose brain function is impacted by stress, depression, and the high economic costs (e.g. income loss and reduced employment) associated with caregiving. Brain Capital encompasses individual, societal, and global-level strategies for the promotion and protection of brain health in late-life. |
| **Mind-body practices for stress reduction** | Mind-body practices such as yoga and meditation, as well as tai chi or qi gong are increasingly utilised for self-regulation and for promoting psychological resilience in stress-based disorders (Laird et al., 2018). They are also found to have direct neuroplastic effects on the brain and may be used in the prevention of cognitive decline in older adults (Laird et al., 2018). They can serve as easy to learn and affordable tools to promote stress reduction and brain health across the lifespan. |
| **Environment** | There is a pressing need to fund research into the risks, impacts, and priority actions related to climate change and brain health. By increasing our understanding of the dynamics between the brain and environmental changes, innovative solutions and strategies can be developed. Air pollution and noise have been linked to cardiovascular conditions and cognitive decline in older adults, along with being associated with accelerated |

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| | brain ageing and neurodegeneration. Likewise, the presence of pollutants such as heavy metals can yield generational health challenges and even permanent disruption in cognitive function (Palma-Oliveira et al., 2018). Reduction in pollution is a risk reduction strategy for dementia and key to protecting and building late-life Brain Capital. |
| **Productivity** | The labour market appears to be healing slower from Covid-19 pandemic-induced shocks than the wider economy (Greene, 2021). Explanations include behaviour changes related to concerns of contracting Covid-19, enhanced caregiving needs, changing personal preferences about the nature of work, or a desire to take an earlier retirement. Another explanation is that brain health has suffered during the pandemic. By boosting brain health, it may not only be possible to heal the labour market at a faster pace, but also unlock higher productivity growth and help people retool for jobs in an economy that has been reshaped by the pandemic. One Mind at Work (onemindatwork.org) and The Global Business Collaboration for Better Workplace Mental Health (https://unitedgmh.org/unitedgmh-and-workplace-global-business-collaboration) are providing extensive resources, return on investment calculators, education, and networking to major global employers to help them navigate the new, post-pandemic economic environment. |
| **LGBT+ (Lesbian, Gay, Bisexual and Transgender)** | Members of the LGBT+ community report higher levels of mental health issues, different levels of access to mental health services with equity of access varying widely between different regions across the lifespan (Russell and Fish, 2016; Roe et al., 2020). LGBT+ people also tend to experience higher rates of substance use disorders, which needs to be addressed in relation to brain health. Research with LGBT+ youth show that earlier mental health support and boosting protective factors can improve the brain health of LGBT+ youth and adults. |
| **Physical activity** | It appears that regular physical activity provides benefits to the brain. Studies show that people who are physically active and not sedentary are less likely to experience a decline in their mental function and have a lower risk of developing Alsheimer's disease. Indeed, physical activity is one of the known modifiable risk factors for dementia. Regular exercise and avoiding a sedentary lifestyle may also help combat other risk factors for dementia, such as depression and obesity. |
| **First Nations people** | Addressing the factors recognised as contributing to mental health challenges faced by First Nations people. Taking a lifespan approach recognises that mental health disadvantages start before birth, including intergenerational trauma (IGT), often from residential or native "schools" and other legacies of colonisation. This coincides with barriers to accessing health services for pregnant women, which is compounded in remote and rural communities. A community mental health approach can help address the historical background factors that have led to increased mental health problems among First Nations people. Understanding the life expectancy, physical and brain health gaps between First Nations people and the rest of society should consider an explanatory framework which emphasises the role of toxic stress, trauma and allostatic load (multisystem dysregulation due to the wear and tear of the body and the brain) across the lifespan (Ketheesan et al., 2020). In Australia, Yiliyapinya Indigenous Corporation (https://www.yiliyapinya.org.au/) is responding to this decrease in brain health by working together with First Nation communities, schools, government organisations such as child protection, youth justice, and law enforcement, to improve brain health across the lifespan in a culturally responsive and contextualised way using tailored neuroplasticity impact programmes within multiple systems. |
| **National security** | Susceptibility to populist and extremist political messages can be studied using neuroscience-based approaches (Decety, Pape and Workman, 2018). People's political opinions emerge based on incoming information, and the learning of new information changes fundamental beliefs and political associations. Populism and extremist ideologies reach people in the form of oversimplified information and/or extreme solutions to crises, often while ignoring contextual nuance. Human responsiveness to these oversimplified political messages, such as propaganda and populist rhetoric, could be responsible for polarisation and radicalisation, which opens up the possibility of increasing political control by populist leaders. Therefore, brain science should investigate the causes and mechanisms of this phenomenon. |
| **Criminal justice reform** | Policymakers who focus on criminal justice struggle to develop and implement policies to balance justice, punishment, and rehabilitation (Bower et al., 2018). However, many of the issues that criminal justice policy is asked to manage involve the interactions of people and the modification of behaviour. Neuroscience researchers are actively mapping circuits and the changes involved in substance use, violence, and mental illness. They are developing neurological devices to help those living with mental illness or substance use disorders when traditional pharmaceutical therapeutic methods do not work. |
| **Chemical pollution and brain health** | Chemical pollution takes many forms with far-reaching direct and indirect impacts on human brain health (Grandjean and Landrigan, 2014). Examples include climate change (green-house gas pollution) and hyperthermia-induced CNS dysfunction such as delirium, seizures, coma, as well as increased incidence of depression (Ruszkiewicz et al., 2019). Concerningly, many of the damaging effects of chemical exposure are seen in children. Exposure to heavy metals has significant impacts with lead being linked to Attention Deficit |

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| | Hyperactivity Disorder (ADHD) (Froehlich et al., 2009) and lead and methylmercury to loss of IQ points (Boyle et al., 2021; Gaylord et al., 2020). Other chemical exposures include those associated with the use of plastics including flame retardants (e.g. polybrominated brominated diphenyl ethers and per- and poly fluorinated alkyl substances) which are linked to loss of IQ points and ADHD (Lam et al., 2017; Forns et al., 2020) as well as plasticisers (phthalates) which are linked to loss of IQ points as well as impaired cognitive development and fine motor control (Lee et al., 2018). The economic impacts of chemical exposure are substantial and skewed towards the disadvantaged. For example, childhood exposure to lead in low and middle income countries was estimated to cost 1.2% of world GDP in, 2011 (Attina and Trasande, 2013). Even when exposure to chemicals, for example the organophosphate pesticide Chlorpyrifos, is incontrovertibly linked to loss of IQ points in children, regulatory bans have not been implemented. The cost of this specific policy failure is estimated to be in the billions of dollars in the US (Trasande, 2017). Targeted reduction strategies such as reducing children's lead levels have resulted in intelligence gain as well as cost savings at a societal-level (Remy et al., 2019). |
| **Arts and Media** | Arts and media spur innovation across the economy, as well as contributing to numerous channels for positive social impact. They influence local economic development and entrepreneurial activity (NASAA, 2021) and have proven to be effective tools for improved population health (WHO, 2019). Even so, Covid-19 has induced potentially devastating job losses in the field (Florida and Seman, 2020) which may hinder the capacity of the creative workforce to continue its positive impact. On the other hand, consumption continues to grow. Gaming media alone is predicted to rise to nearly $200bn in 2021 (Upstart, 2019). As Gen Z, who embrace interactive media, is set to become 27% of the workforce by 2025 (Koop, 2021) the potential for disruption, either positive or negative, to existing systems is significant (Deloitte, 2021). Targeted investments in transdisciplinary approaches for developing the creative workforce in targeted ways related to the science of creativity, cognitive flexibility, as well as other critical skill-sets could yield significant gains that will better prepare economies for the future of work. |

## Quantification of Brain Capital

To be truly successful, Brain Capital will need to be quantified and tracked. Hence the development of an index or other forms of measuring brain capital capacity and comparative evaluation of managing alternatives is key, as we have previously outlined (Smith, et al., 2021). This way policy agenda setting can be more precise, and the impact of policy changes can be more accurately measured. More comprehensive tools that capture broader categories of metrics (e.g. multi criteria decision analysis), can be better suited to developing policy alternatives (Linkov et al., 2020). Standardised approaches to the quantification of Brain Capital will be needed to minimise subjectivity in comparisons of performance in different sociocultural and economic contexts. Through standardisation, fostering objective interpretation is facilitated and policy implementation will ultimately be well-informed and likely fairer.

## Regulatory and legislative approaches

Financial investments in environment, social and governance (ESG) issues have grown tremendously over recent years. Regulatory and legislative approaches to policy may help promote Brain Capital building within this domain.

The Sustainability Accounting Standards board recently included mental health and wellbeing in its proposed updated human capital standards (SASB, 2020). International Organization for Standardization ISO standard 45003 gives guidance on managing psychological health and safety risks within an occupational health and safety management system (ISO, 2021). The Business Roundtable recently noted the generation of a healthy environment is a key purpose of a corporation (BR, 2021) . The signatories of the Principles of Responsible Investing recently listed mental health as one of the top four social issue priorities in the future (PRI, 2020). This is promising given the $40.5 trillion currently allocated to Environment, Sustainability and Governance (ESG) investing around the world (Baker, 2020). The restructuring of taxation and accounting arrangements may support Brain Capital. For example, financial incentives to invest in Brain Capital may be achieved by re-designating business expenditures on

employee payroll, health, re-skilling, re-training, innovation, and human productive capacity to insurable capital investments. Treating expenditures on the employment, development, health, and productive capacity of people as capital investment may stimulate productivity. An exemplar of these approaches can be seen in the Human Capital Accounting Framework from the World Economic Forum and Willis Towers Watson (WEF, 2020).

Other opportunities for the building of Brain Capital could come from certified B Corporations. These are businesses certified as meeting certain standards of social and environmental performance, transparency, and accountability while balancing profit and purpose. Further, these entities seek to support a change in global culture that reconceives what defines business success and cultivates a more inclusive and sustainable economy. This model could be used to support Brain Capital priorities (www.bcorporation.net).

Classic regulatory tools (e.g. regulation and taxation) have demonstrated limited abilities to change behaviours related to brain heath (e.g. eating habits, physical activity, information processing or technology use). The use of nudging may have an impact on Brain Capital by promoting behaviour change and may be a useful complement to classical policy regulations (Ledderer et al., 2020; Pennycook et al., 2020).

### *Regulating neurotoxic chemicals to protect Brain Capital*

Governments can incentivise innovation in safe chemistry to create chemicals and products which protect Brain Capital rather than harm it. There are currently few chemicals restricted globally and little market incentive to switch to safe chemicals. By using a combination of positive and negative incentives, governments can push industry to phase out substances which are linked with reduced IQ, impaired cognitive development and neurological disorders. Restricting the use or prohibiting outright the use of chemicals which harm brain health forces consideration of the utility of that chemical and whether its functions are important (e.g. the colour, flexibility, or UV resistant properties it provides a product). If the functionality is important, manufacturers can seek alternatives. Alternatively, companies may be required to include data specific to brain health impacts of their products, and hence are incentivised to proactively move away from neurotoxic compounds/elements. With Brain Capital centralised as a pillar of chemical regulation, the search for alternatives will be shaped by needing brain-safe chemistry, lest the new alternative also be restricted from the market. Using non-legal levers, governments can also shape chemistry regulation. Criteria to assess safety claims (e.g. that a product is ‘green’ or ‘free from harmful chemicals’) are needed, along with establishing research and development hubs on safe chemistry, and guiding safe and sustainable design of products.

## Public investment opportunities

Brain Capital should be considered as an investable asset. This means novel approaches can be considered for investing in it, and Brain Capital benefits need to be factored into the cost-benefit equation of diverse policies from education to social services. These investment mechanisms can be supported and refined by effective and thoughtful policy making (Vigo et al., 2019). Table 6.2 outlines examples of public policies through which Brain Capital can be invested in.

### Table 6.2. Brain Capital Building Public Investment Opportunities

| Investment mechanism | Description and examples |
|---|---|
| **Brain bonds** | Social bonds are offered by municipal and sovereign issuers to fund research as well as clinical care (Initiative, 2018). They typically focus on economic impact in a region or an area of interest. The Healthy Brains Global Initiative is an example of an initiative seeking to develop innovative financing mechanisms through a collaboration of global leaders in neuroscience, policy, and finance who are developing an overarching set of financing mechanisms to fuel an |

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| | increase in brain science breakthroughs (HGBI, 2020). The HBGI has a particular focus on cutting $3 trillion in costs that are borne by low, middle, and high-income countries. The feasibility of a healthy brain bond is of significant global importance, then procuring a large amount of resources from bond capital is essential. The HBGI focuses on scaling up fundamental clinical services in low- and middle-income countries and breakthrough neuroscience research, conducted through networks of researchers around the globe. |
| **Public-private partnerships** | The Davos Alzheimer's Collaborative (DAC) is a public-private partnership with a commitment to a collective global response to the challenges Alzheimer's disease presents to millions of families worldwide. The DAC aims to raise $700 million for a six-year plan to accelerate and diversify innovation in Alzheimer's research. The three main components of DAC include a global cohort developed to identify new targets for potential treatments; a global clinical trial support platform to reduce the cost and time to test new treatments in trials and bring them to market; and promote health care systems to be better prepared to new treatments to patients. The DAC project seeks to enable novel biomarker development, connect global researchers using the data platform of the AD Data Initiative, and to keep the lived experience of Alzheimer's at the centre of its efforts. |
| **Social impact investing** | Funding strategies that take an outcomes-based approach lets public-sector entities pay only for what works, to the extent that it works; simultaneously, they can create pathways for the most impactful providers and interventions to flourish if they are able to achieve important public policy priorities. This approach to funding could be of particular value for addressing the social determinants of health and behavioural health. For example, Capital Impact Partners focuses on financing and scaling age-friendly communities in the United States, including expanding the scope and integration of the medical, social, and practical needs of older adults as they evolve. Increasingly, organisations such as Capital Impact Partners are establishing a new norm for investing impact metrics. Environmental, social and governance (ESG) factors are being weighed not only as indicators of corporate competitiveness, but also to minimise long-term risks to investors' portfolios (https://www.capitalimpact.org/). |
| **Early-stage technology investing** | There are record levels of venture capital investment into the brain health technology space, along with a number of companies now considered *unicorns* (valued at over $1 billion) (Shah and Berry, 2020). A Venture Capital firm, Primetime Partners, launched with a focus on early-stage investments in experiences, products and services for older adults. The firm's interests include care management, longevity health services, financial security for retirees, and enriching consumer experiences. Additionally, Primetime Partners invests in older adults who found new companies, building on their earlier career experiences. Other thematic funds include Telosity for youth (https://www.telosity.co/) as well as the Women's Venture Fund (https://womensventurefund.org/). Governments can engage in the venture capital sector. For example, the MRCF is the largest life science investment fund in Australia and New Zealand (www.mrcf.com.au). It is a unique collaboration between major Australian superannuation funds, the Australian and New Zealand governments, Australian state governments and over 50 leading medical research institutes and research hospitals. |
| **Philanthropy** | Philanthropy may have objectives for specific diseases, institutions, or populations that will benefit from research. It can be driven by research efficacy and research outputs (e.g. patents, economic impact, and patient outcomes, not monetary returns.) One notable model is the Alzheimer's Drug Discovery Foundation, which uses a venture philanthropy model to fund breakthrough research in academia and the biotech industry with promise to prevent and treat Alzheimer's disease (Alzdiscovery, 2020). |
| **Megafund** | A public-private partnership that takes a portfolio-based approach to drug and device development in which multiple projects are undertaken simultaneously for the purposes of developing Brain Health therapeutics. Although a greater upfront investment is required by this approach, the probability of at least one success should be higher, accelerating the search for cures to brain-based disorders and increasing the probability of successes within the next decade. |

## Engaging with the Brain Capital community

After covering the potential policy and investment approaches for Brain Capital building, it is important to consider the Brain Capital community. As outlined in Figure 1, this community is broad and may function at local, state, national and/or global levels. The community may include many stakeholder groups such as patient and caregiver groups, healthcare workers, scientists, thinktanks, non-profits, unions, SMEs, corporations and other elements of civil society. In table 6.3 we outline approaches for engaging with the Brain Capital community.

## Table 6.3. Approaches for Engaging with the Brain Capital community

| Component | Description | Refinement for Brain Capital Policy Agenda |
|---|---|---|
| **Voter issues** | Capture voter issues from early on with petition drives, canvassing and online surveys. | Be sure to monitor and correctly frame emerging Brain Capital-related issues, e.g. concerns over science denialism, Covid-mental health issues, misinformation propagation, political divisiveness. |
| **Strategic communications** | Be sure to correctly frame problems and then solutions. Consider these questions:<br>• What is the issue?<br>• What is the solution?<br>• How does this solution solve the problem?<br>• Who benefits from the solution and how?<br>• How much will it cost? | There are of course myriad 'problems' relevant to brain-based issues which need to be addressed. These may differ depending on the region and country. Key issues include:<br>• Rising rates of depression, anxiety and suicide<br>• Lack of effective treatments for most brain disorders<br>• Rising inequality resulting from brain skills gaps<br>• Disparities in outcomes based on sex and gender |
| **Field organising and outreach** | Connect your field outreach work or 'ground game' to your voter database, email and media operations for maximum efficiency. | Consider all relevant and aligned interest groups, spanning neuroscience, mental health, dementia, new economics, patient advocacy, caregiving, etc. Bring in and organise the key stakeholders outside of those areas who are less familiar with 'brain issues' such as unions, business and industry associations (trade associations), etc. |
| **Meet community leaders and influencers** | Connect and explore collaboration with opinion leaders. | Consider those at local, state, federal and global level. Consider Brain Capital interested celebrities, public figures, local union sections, active and retired individuals, philanthropists, business figures, humanitarians. Online communities tend to form around shared interests or identities. Specific people tend to attract large followings of people interested in physical and/or mental health, education, or specific skill development. Ask these influencers about the specific language, buzzwords, interests and platforms where their audiences are active and open to learning new information. |
| **Messaging** | Each issue area needs a stance. Connect your message to your organisation's brand. Be distinctive, the same message can be delivered differently. | A Brain Capital-based campaign will be unique. Always be 'on message' in public appearances, media, and social media. Be careful of a biological reductionist approach – brain issues of course are linked to mind, body, spiritual, place and planetary dynamics. |

We note that female empowerment may be the most simple, cross-cutting theme to boost Brain Capital at scale (Smith, 2021). We have previously noted the "Brain Health Gap" to frame inequalities in all areas across the translational spectrum from bench-to-bedside and from boardroom-to-policy and economics (Smith, 2021). Therefore, female empowerment has profound benefits for Brain Capital across the lifespan and needs to be multifactorial. For example, reducing social media-related distress for teenage girls, to supportive maternity policies, to supportive caregiver policies, and improved sex and gender tailoring of clinical neuroscience research, clinical care and innovation. Female empowerment can engage a large proportion of the population.

## Engaging partners aligned with the agenda

The envisaged impact on the policy agenda amounts to a paradigm shift in the way the challenge of the brain is perceived and addressed. In order to build the basis for such a significant recalibration, a comprehensive effort is required, involving multiple levels of government. Coalition building with various stakeholders is key to policy advancement. Engagement may vary in type and depth – from mutual advocacy, sharing resources, convenings, through to public-private partnerships and more formal activities. Pledges in agreement with a proposed policy agenda are a simple first step for building partners and a coalition. Activities should be pursued in parallel at the local, state/regional, national and international levels, given the significant feedback loops that need to be created. Anchoring the Brain Capital Policy Agenda within strong engagement of communities lies at the heart of its future success.

This process can and should be assisted by the provision of targeted expertise, customised to address the specific situation and requirements of each community. We recommend that entities considering a Brain Capital policy agenda establish the Brain Capital Network of Expertise to support and enhance parallel actions. The Network would provide a platform for the exchange of best practices and for seeking support in policy engagement. At the state (or regional) and national level, advisory groupings could be formed, such as 'Council of Brain Capital Advisors', akin to the US Council of Economic Advisors (www.whitehouse.gov/cea/). This approach may be useful particularly for executive-level elected positions (presidents, governors, mayors, etc.). An advisory council with expertise in brain issues would advise the brain agenda and help with the refinement of policies that advance this agenda.

The Brain Capital policy agenda would need to be taken up and crafted at the political level. Therefore, the emergence of potential political champions of this agenda would need to be encouraged and supported by means of active advocacy and provision of expertise. Links between political groups committed to the Brain Capital agenda would need to be built to facilitate the exchange of experience. Political parties should receive comprehensive information about the significant policy implications that the Brain Capital agenda would bring.

The key constituency for the paradigm shift towards centrality of the Brain Capital agenda is already in place. These are the thousands of people actively involved in improving education, promoting efforts at prevention of brain disorders or simply caring about cognitive development. It is this constituency that needs to receive guidance how to orient their actions to create collective value added. This is where the Brain Capital movement will be necessary, firmly based on evidence and action-oriented. Activities undertaken at different levels will be mutually-reinforcing and should usher in the Brain Capital Policy Agenda becoming one of the points of orientation for countries and communities globally before the end of the decade.

Studying human conduct can be an additional tool in the policymaking process and it has become a cost-effective way to change behaviour in ways that can be both subtle and beneficial for wider society.

## Conclusion: Overcoming barriers to a Brain Capital building Policy Agenda

When progressing this Policy Agenda, it is critical to anticipate potential barriers. Below we outline several key barriers and approaches to overcoming them.

*Inertia*: Perhaps the greatest barrier is that unless Brain Capital gets onto the policy agenda and support is built, any attempt to move this forward may face headwinds in gaining traction. Therefore, broad based coalitions, evidence-based proposals, and proactive public communications programs are key to advancing this agenda.

*Institutional barriers*: The institutions which include the political architecture of a nation can be a barrier to policy change and the implementation of innovative policies. In the US, for example, federalism (individual

states vs. federal government) and the separation of powers between different branches of government disperse power and has been an impediment to major change in social policies (Huberfeld, Gordon, and Jones, 2020). This may be less of a barrier in countries with unitary governments such as New Zealand or the United Kingdom. Nonetheless, institutional structures remain a potential barrier in every country. Entrenched bureaucracies and administrative hurdles may pose additional institutional barriers to a Brain Capital Building Policy Agenda in many countries.

*A sense this is already being done:* In some ways, Western economies are moving in this direction. As a result of globalisation and labouring/manufacturing jobs being outsourced overseas, university attendance is increasing, people are choosing courses that are more innovation-focused, etc. Many people will believe we are already moving that way – to an economy that is more focused on cognitive ability. It is therefore key to outline the failures of the current policy approaches and how this proposed Brain Capital Building Policy Agenda is unique and additive.

*Lack of large-scale evidence to prove 'value' over and above existing policies and efforts*: Some may feel policies that appear to be building Brain Capital already exist, and may not accept that our proposed Policy Agenda will add additional value. Large-scale, randomised controlled studies may be useful to demonstrate impact (as has been achieved by the field of public health-behavioural economics (Ledderer et al., 2020)).

*Complexity of neuroscience:* It is important to work extensively on strategic communications to make these potentially complex topics relatable to a broad, non-specialised audience.

*Brain Capital Index scoring is challenging:* We must recognise that indices in general, and specifically of morbidity and mortality, may provide a limited reflection of the actual situation and may not necessarily reflect policy efforts. For example, Deaths of Despair in the US are increasing and recently spread from being a primarily working class, white American phenomenon to reaching increasing numbers of African Americans and Hispanics, and rates of teenage anxiety and suicide are increasing in many countries (Racine et al., 2021; Brookings, 2021; Luby and Kertz, 2019). If such indices (and the issues they track) worsen over time, they may not be politically viable.

As our "brains are indispensable drivers of human progress - why not invest more in them?" (Smith et al., 2021) And why not develop a novel policy agenda around building our brains? To adapt as a society to the challenges of the "Brain Capital Age", we need to direct attention to optimising human decision making; to ensure it is scientific, consistent, collective, and long-term focused; and we need political leadership to make this happen. Increased Brain Capital means better lives for citizens. We look forward to seeing these types of Brain Capital policies actioned at local, state, federal and international levels. Imagine a long-term policy agenda in which the whole society is expected to be involved, including civil society organisations, private sector stakeholders, and agencies from different levels of local, national, and international governments. Much work is needed to prioritise and advance the top policy approaches for each region of the world.

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# 7 Conclusion: System Threats Should Not Mean Systemic Collapse

This chapter summarises the main conclusions of preceding chapters on the characteristics of the systemic threats facing society and how to deal with them. It notes a shift in thinking among decision makers towards some of the positions argued for by this publication's authors, notably the need to build resilience into important systems; to pay attention to the human aspects of crises, notably the psychological aspects; and the advantages of a systems approach in identifying and prioritising areas of intervention. The chapter looks in particular at health, employment, global value chains, inequality, and the environment.

## Introduction

As mentioned in the Chapter 1, the view that the economy is a complex system goes back at least to Adam Smith (Kirman, 2017). Smith's compatriot and contemporary Adam Ferguson examined socio-political complexity, notably the phenomena of emergence and unintended consequences, concluding that "nations stumble upon establishments, which are indeed the result of human action, but not the execution of any human design" (Smith, 2009). Unintended consequences result of course from today's economic decision-making too. The US Congressional Research Service notes that: "As infectious cases began rising sharply in late February 2020, governments took unprecedented steps in March 2020 to lock down social activities to contain the spread of the pandemic, inadvertently creating a global economic recession" (CRS, 2021).

In fact, the idea of interconnectedness of the different systems that affect our lives dominated thinking about society and nature until economics began treating the environment as an "externality". Even the idea that epidemics have to be understood systemically is nothing new. In his series of lectures on *The Philosophy of Nature* in 1830, Hegel shows that to understand an epidemic, you have to understand the interactions between the internal functioning of the human body and the whole of nature outside it, including climate, geography, and history (Bourgeois, 2004).

You also have to understand human psychology, as Steven Taylor warned a few months before Covid-19 struck (Taylor, 2019). Taylor described the mental health and behavioural implications of "severe disruptions of routines, separation from family and friends, shortages of food and medicine, wage loss, social isolation due to quarantine or other social distancing programs, and school closure". Taylor appears to be eerily prescient about everything from panic buying to conspiracy theories, but he simply notes what happened in previous pandemics such as the Spanish Flu in 1918. The Brain Capital Agenda described in Chapter 6 is a response both to the immediate impacts of the pandemic on mental health and a longer-term programme for preparing people to cope with the stresses and take advantage of the opportunities of life post-Covid.

Psychology is also important because the way people describe events to themselves determines how they respond, not just to the immediate crisis, but to future ones. Robert Shiller develops this aspect in relation to economic crises (Shiller, 2019). The Great Depression was due in part to people expecting thing to get worse and acting accordingly – withdrawing money from banks, saving instead of spending, not hiring new employees, for example. Shiller makes another important point – memory of past crises influence present ones. Runs on banks and failures are part of the powerful narrative of the Great Depression, and as the 2007-2008 financial crisis unfolded, both citizens and governments drew parallels with events in the 1930s, and this had an impact on their reactions, prompting massive quantitative easing for instance.

It is only to be expected then that stories that have captured the most attention recently should be reflected in how one considers the future. The latest DTCC Systemic Risk Barometer asked financial market actors what they saw as the most important systemic risks to the sector (DTCC, 2021). Cyberattacks and pandemics are the main concerns. Reinsurers shared the concerns about cyberattacks in the latest survey of how they saw the future, but they think risks related to climate change are more important (Artemis, 2021). There was a similar ranking from people surveyed for the World Economic Forum's *Global Risks Report 2022,* who see environmental risks as the five most critical long-term threats to the world as well as the most potentially damaging (WEF, 2022).

It is important to remember that while the past shapes the present and the future, it is not an infallible guide. The surveys mentioned above, and futures thinking more generally, reflect an argument supported by a complex systems approach: you should not simply extrapolate from previous conditions to plan for the future. A report by Citi explicitly calls for a systems approach, on the basis that "as our world becomes more globalied and interconnected, we have inadvertently built systems which have not just the ability to

transmit those risks across geographies and turn them from local into global phenomena, but which also have the ability to cause further global crises to materialize" (Citi, 2021).

Chatham House brings this approach to climate change, highlighting another phenomenon discussed above – the way a shock to one system can spread to other systems (Quiggin et al., 2021): "Cascading climate impacts can be expected to cause higher mortality rates, drive political instability and greater national insecurity, and fuel regional and international conflict". The main reason the report gives is interconnections between shifting weather patterns, resulting in changes to ecosystems and the rise of pests and diseases, which combined with heatwaves and drought, "will likely drive unprecedented crop failure, food insecurity and migration. In turn, all will likely result in increased infectious diseases, and a negative feedback loop compounding each impact."

We tend to think of feedback as instantaneous, but the multiple time scales operating in complex systems mean that we have to consider the longer term too when trying to forge a resilient response to the Covid pandemic. And given that the systems we are dealing with are adaptive as well as complex, we have to think of how different systems respond to changes in each other. In the following sections, we will look at a selection of domains that have been impacted strongly by the crisis and that will have a major influence on how resilient the next normal is.

## Health

The OECD stresses the systemic interactions of health with other issues when it says that the pandemic showed how vulnerabilities in health systems can have profound implications not only for health, but also for "economic progress, trust in governments, and social cohesion" (OECD, 2021a). Better health and health systems produce positive feedback loops with the economic system and the education system. For example, health returns to education increase the total returns to education by at least 15%, and perhaps by as much as 55% (Cutler and Lleras-Muney, 2006). A US study found that 20% of health outcomes are linked to medical care; the remaining 80% stem from interactions with the socioeconomic and environmental systems, and behavioural and lifestyle factors (Hood et al., 2016). Addressing inequality in its various forms, and tackling problems such as homelessness, hunger, exposure to intimate partner violence, adverse childhood experiences, racism and so on would therefore improve health outcomes.

At a different scale, the latest *Lancet* survey on health and climate change warns that the cost of inaction on climate and health will vastly outweigh the costs of acting now (Romanello et al., 2021). The report calculates that rapid decarbonisation could prevent most of the 3.3 million deaths from air pollution that occur each year, the 842 000 deaths associated with excessive red meat consumption, and result in better physical and mental health from higher exposure to nature and more physical activity. The *Lancet* estimates that the monetised value of global heat-related mortality increased by 6·7%, from 0·27% of gross world product in 2018 to 0·28% in 2019; Europe continued to be the worst affected region, facing costs equivalent to the combined average incomes of 6·1 million of its citizens.

To be prepared for the next health shock, such as one linked to antimicrobial resistance, we need a coherent approach. Public funding contributed to every one of the 210 new drugs approved by the Food and Drug Administration from 2010-2016. Collectively, this research involved over 200 000 years of grant funding, totalling more than USD 100 billion (Cleary et al., 2018). Yet the pharmaceutical companies who benefit from massive public subsidies and guaranteed sales still want to keep the IPR on vaccines and the profits that go with it.

There are clearly market failures in drug development. The Rand Corporation estimates that antimicrobial resistance could result in a cumulative loss to the world economy that ranges between USD 2.1 trillion and USD 124.5 trillion depending on the scenario, due to impacts on labour supply and productivity alone (Taylor et al., 2014). This problem has arisen because despite the costs, there is not enough profit in

developing new, low cost drugs to tackle it. Covid shows similar failings. As mentioned in the introduction, funding for research into coronavirus vaccines was cut before the pandemic because there was no guaranteed market for the products (Hoetz, 2020). We have to change the business model, and consider vaccines and other vital medicines as a global public good.

## Employment

The pandemic was the great accelerator of a number of trends already shaping labour markets and the workplace. A typical summary of pre-pandemic views on the future of work was published by NASA in 2019: "We live in a time of volatility, complexity, and transition, and it is here to stay. Between technological advancements, demands for re-defined careers and for work–personal life balance, the next decade will see a transformation in the way we work, learn and explore. Sweeping global forces are already reshaping the workplace, the workforce, and work itself." (Skytland, 2019). That same year, a Gartner survey found that 55% of organisational redesigns were focused on streamlining roles, supply chains and workflows to increase efficiency. Writing two years later, Gartner noted that: "while this approach captured efficiencies, it also created fragilities, as systems have no flexibility to respond to disruptions. Resilient organizations were better able to respond — correct course quickly with change." (Baker, 2021).

Digitalisation in its various forms was the main technological foundation of efforts to boost resilience and keep firms operating. The dramatic rise in telework was the most obvious consequence. In Europe, for example, the proportion of workers engaged in telework increased from 11% before the pandemic to 48% during it, with about 40% of paid workhours during the COVID-19 pandemic taking place by telework (WHO/ILO, 2021). While the ability to telework may have contributed to company and employee resilience during the pandemic, in the longer term, a number of questions have to be addressed. According to the OECD (2020a) telework can improve firm performance by raising worker satisfaction and thus worker efficiency, for example through better work-life balance, less commuting or fewer distractions, leading to more focused work or less absenteeism. It is, however, also possible that worker satisfaction decreases due to solitude, hidden overtime, a loss of work-life balance, or an inappropriate working environment at home.

The ability to telework highlighted and reinforced other pre-Covid trends, discussed in NAEC seminars: the rise in what Guy Standing terms the "precariat" (Standing, 2017); and what David Weill calls the "fissured workplace" (Weill, 2018). Standing defines the precariat along three dimensions. First, those in it are being pressured to a life of unstable, insecure labour, in which casualisation is being extended. Second, the precariat relies mostly on money wages, which have been falling in real terms while becoming more volatile and unpredictable; and they are also losing non-wage enterprise benefits (paid leave, medical leave, occupational pensions, etc), which give labour-based security. Third, members of the precariat are losing all forms of rights – civil, cultural, social, economic, and political. Standing argues that universal basic income should be part of any policy response to these issues.

Weill reaches similar conclusions from his analysis of the situation in the US, where large corporations have shifted to outsourcing work to small companies that compete fiercely with one another. He recognises that fissuring - splitting off functions that were once managed internally - has been a phenomenally successful business strategy, allowing companies to become more streamlined and drive down costs. However, he also says that from the perspective of workers, this has meant declining wages, eroding benefits, inadequate health and safety conditions, and ever-widening income inequality.

Gartner (Baker, 2021) expects companies to react to the coronavirus crisis in a similar manner to the 2008 financial crisis, with a focus on expanding their geographic diversification and investment in secondary markets to mitigate and manage risk in times of disruption. However, "this rise in complexity of size and organizational management will create challenges" in addition to the those posed by rising inequality. The WEF suggests in five areas to concentrate on in the post-pandemic recovery: reskilling and upskilling;

supporting the jobs of tomorrow; prioritising redeployment and re-employment; re-evaluating essential work and improving the quality of jobs; and resetting education, skills and jobs systems (Zahidi, 2020). The OECD looks in more detail at how such an approach could improve work and employment in the longer term, arguing that active labour market policies should play a key role in underpinning the economic recovery through helping jobseekers find jobs, making available training for those most in need, and providing comprehensive support to those who struggle most (OECD, 2021). Active labour market policies can also help speed up the reallocation of labour from declining sectors and firms to expanding ones, including through support provided to employers and entrepreneurs.

## Global value chains

A digger trying to free the gigantic *Ever Given* container ship that was blocking the Suez Canal became the emblematic image of the supply chain crisis during the pandemic. Speaking of the incident to Foreign Policy, maritime analyst Cormac McGarry said: “we are pouring highly concentrated volumes of our critical supply chains into vulnerable positions, so we are losing the spread of risk. It leaves businesses more exposed to singular, isolated events” (Braw, 2021). The blockage happened because high winds blew the ship off course. This is a known risk, but waiting even a few hours for the wind to drop before entering the canal jeopardises the tight schedules of global just-in-time supply chains. Ships carrying 10 000 containers or more may only have hours to unload their cargo in a given port and pick up a supply of empty containers for ports they will visit later. “It’s an efficient model, saving on storage and inventory, but a fragile one” as Bloomberg remarks (Chellel et al., 2021).

Delays to the *Ever Given*’s 17 600 containers therefore quickly rippled through global supply chains, adding to and aggravating other problems created by the pandemic. Images of container ships waiting offshore to enter lockdowns meant it took longer to process goods once they reached the ports, and once they were unloaded, reduced road and rail capacity due to lack of personnel meant they could not be moved. This reduced the number of containers being returned to manufacturing hubs, holding up shipments, provoking further congestion and causing prices to rise. The Drewry World Container Index reached USD 9421.48 per 40-foot container on 12 August 2021, about 350% higher than a year previously (Curran, 2021). Punctuality suffered too. Before the pandemic, about 80% of container ships arrived on schedule. By June 2021, this had halved to around 40% (Sea Intelligence, 2021). In addition to the blockage of the Suez Canal in March 2021, the closure in May because of a Covid outbreak of Yantian, the world’s third-biggest container port, made matters worse.

The Yantian closure highlighted the fact that despite digitalisation, robotisation and other emerging technologies, people are still needed to make and transport goods. In July 2021, a surge in Covid cases caused Toyota to shut factories in Japan and Thailand, while in Vietnam health officials closed the largest trainer factory in the world (Allen, 2021). Adidas expected pandemic-related losses to total 500 Euros in 2021, while Nike said that the three-month shutdown meant that they lost 130 million units of production.

The increased concentration of supply chains reflects the increasing concentration of global economic power in the hands of large corporations, aided by changes in trade and competition policy in recent decades. While this has been beneficial to the firms themselves, it has left countries exposed to the risks of supply disruption and shortfalls, as we saw with the lack of even the basic equipment needed to deal with the pandemic. Hynes and Lynn (2021) argue for a system of regulation and subsidisation that promotes a rapid but not wrenching de-concentration and redistribution of keystone industrial capacities, such as for the manufacture of semiconductors, chemicals, and other capital-intensive goods and components. They cite the Reagan administration’s moves to diversify supply of computer components away from Japan, and believe that the goal should be to distribute key industrial capacity in ways that ensure that no one natural disaster or national actor can ever disrupt more than a minor portion of the total

supply of any particular vital good or component. They suggest that no more than 25% of the international capacity for any component or finished product be located within the borders of any one nation.

## Inequality

Growing inequality of income and wealth is a global phenomenon. Oxfam claims that the wealth of the world's 10 richest men has doubled since the pandemic began, while 99% of humanity are worse off because of the pandemic and over 160 million people have been pushed into poverty (Oxfam, 2022). The World Inequality Report 2022 states that "In 2021, after three decades of trade and financial globalization, global inequalities remain extremely pronounced: they are about as great today as they were at the peak of Western imperialism in the early 20th century. In addition, the Covid pandemic has exacerbated even more global inequalities. Our data shows that the top 1% took 38% of all additional wealth accumulated since the mid-1990s, with an acceleration since 2020." (Chancel et al., 2022).

Gender aggravates inequality, and once again the pandemic made a bad situation worse. Women are on the front line of the "war" against Covid-19, representing around 70% of the health care workforce. They are also the majority in many of the occupations that are the most exposed to pandemic health risks or job losses, such as retail. Figures from the US Bureau of Labor Statistics, for example, showed that at the end of 2020, every single one of the 140 000 jobs lost was a woman's job (Kurtz, 2021), while globally, female employment declined by 4.2% in 2020 compared to 2019, versus a 3% decline in male employment (ILO, 2021). Although there has been some recognition and praise for the role women play, the latest UN report on achieving the Sustainable Development Goals shows not only a lack of progress as regards gender but a regression (UN Women, 2021). The report says that women have not recovered lost jobs and income, so hunger is on the rise, and school closures threaten girls' educational gains. The UN Population Fund looked at the impacts of a six-month lockdown on women and girls over the next decade: 7 million additional unintended pregnancies; 31 million more cases of gender-based violence; 13 million child marriages and 2 million female genital mutilation cases that could have been avoided (UNFPA, 2020).

Ethnicity adds a further layer of difficulty. A European Union Minorities and Discrimination Survey found that Black people encountered racism in the police's attitude towards them, their chances of getting a job and the kinds of jobs they could get, access to housing, and how they were treated in educational institutions. Younger people tended to experience more discrimination and exclusion than older ones (EUAFR, 2018). In June 2020, UN High Commissioner for Human Rights Michelle Bachelet warned that: "The data tells us of a devastating impact from COVID-19 on people of African descent, as well as ethnic minorities in some countries, including Brazil, France, the United Kingdom and the United States… In many other places, we expect similar patterns are occurring, but we are unable to say for sure given that data by race and ethnicity is simply not being collected or reported" (UNHCR, 2020).

In its analysis of the impacts of the Covid pandemic, the US House Committee on the Budget states that: "Decades of stark income inequality have made the United States more vulnerable to economic shocks" (House Budget Committee, 2020). Inequality makes communities less resilient to shocks, and in its proposals for "building back better", the OECD insists that: "recovery policies need to be measured on more than just economic growth and total job creation. Emphasising other elements that improve well-being, such as income, job quality, housing and health is important" (OECD, 2020b). This approach builds on the philosophy of the OECD Centre for Opportunity and Equality (COPE), "a platform for promoting and conducting policy-oriented research on the trends, causes and consequences of inequalities in society and the economy, and a forum to discuss how policies can best address such inequalities" (OECD-COPE).

The OECD proposes a five-point plan to improve resilience by reducing inequalities (OECD, 2021c):

- Support the creation of sustainable, inclusive and high-quality jobs, especially in the green, education, health and wider care sectors.
- Support wide access to high-quality green and sustainable jobs to benefit firms' productivity, improve the mental health and well-being of workers and their families, and provide society with the skills and services needed for sustainable economic growth.
- Strengthening mental and physical health promotion and prevention to allow people to lead productive and fulfilled lives.
- Use a whole-of-government approach to raise the well-being of disadvantaged children and young people.
- Restore trust to reconnect people and the institutions that are meant to support them.

## Environment

The 2022 IEA Climate Resilience Policy Indicator warns that over 85% of the organisation's member and associate countries are already exposed to a medium or high level of climate hazard risks (IEA, 2022). The report advocates reinforcing the climate resilience of energy systems, which it says is "the ability to anticipate, absorb, accommodate and recover from the effects of a potentially hazardous event related to climate change", in line with definition of resilience used in Chapter 2 of this publication. The IEA's recommendations could apply to any system exposed to climate-related shocks, a resilient energy system being one that: "can adapt to and withstand the long-term changes in climate patterns and continue to operate under the immediate shocks from extreme weather events, and restore the system's function after an interruption resulting from climate hazards".

Many of the changes observed in the climate are unprecedented in thousands, if not hundreds of thousands of years according to the IPCC (2021), and some of the changes, such as sea level rise, are irreversible over hundreds to thousands of years. The report cites evidence that strong and sustained reductions in CO2 and other greenhouse gas emissions would limit climate change, although it could take 20-30 years to see global temperatures stabilise. Lockdowns and other economic consequences of the Covid pandemic have not noticeably slowed the pace of climate change, and atmospheric $CO_2$ concentrations continue to grow, after a one-off dip in 2020. Only a small percentage of most Covid recovery packages are designed to reduce the impact on the climate and wider environment; a far greater amount is being spent on investments and activity that does not consider environmental or climate objectives or will even make things worse (OECD, 2021d). The IMF estimates that global fossil fuel subsidies for example were USD 5.9 trillion in 2020, or about 6.8% of GDP, and are expected to rise to 7.4% of GDP in 2025 (Parry et al., 2021).

Bad policy choices and prioritising are hampering strategies specifically meant to deal with climate-related problems. For example, projections by the UN Environment Programme and GRID-Arendal (2022) suggest a global increase of extreme fires of up to 14% by 2030, 30% by the end of 2050 and 50% by the end of the century. However, more than half the expenditures related to wildfires are for response, while planning typically receives just 0.2% of the total budget for wildfires. As in the IEA Policy Indicator, the UNEP study promotes a resilience-based approach, suggesting as a starting point that countries rebalance investments by up to 1% for planning, 32% for prevention, 13% for preparedness, 34% for response, and up to 20% for recovery.

Historical evidence of societies that proved to be resilient to climate change provides grounds for hope. Degroot et al. (2021) studied the period of cooling around the sixth century (the Late Antique Little Ice Age, LALIA) and the Little Ice Age (LIA) lasting from the thirteenth to nineteenth centuries. They combined findings from archaeology, history, geography, and palaeoclimatology with a definition of resilience based on that of the IPCC, focusing on a system's capacity to absorb energy and to redirect or to convert it without

losing the fundamental features and shape of the system as a whole; and adaptation, being able to adjust to moderate harm or exploit beneficial opportunities. They conclude that climate-resilient communities in the past had five overlapping pathways that could still be explored today: exploiting new opportunities; developing resilient energy systems; utilising trade and resources; political and institutional adaptations; and migration and transformation.

The OECD outlines four mechanisms and three enablers in support of climate resilience (OECD, 2021d).

First, an effective governance arrangement to provide the foundation on which a government can co-ordinate action on climate resilience across sectors and levels of government. This arrangement has to be adaptive to benefit from diverse perspectives, data and information on climate-related hazards, exposure and vulnerability, and approaches to manage the climate risks. Second, since climate risks are in many cases sector-specific, national climate resilience objectives must be mainstreamed into sectoral development policies. Third, integration of climate risks into financial management determines how, when, to whom and by whom finance will be allocated, provided or mobilised for climate resilience. Fourth, monitoring, evaluation and learning can support an iterative and adaptive approach to climate resilience informed by good practices and lessons learnt; and can also inform countries' own accountability mechanisms on progress made on climate resilience.

The first of three enablers is data and information on weather, water, and climate, and the underlying infrastructure that supports and distributes them, to guide decision making by state- and non-state actors. Second, greater awareness, as well as institutional and individual capacities, drive climate action, and capacity constraints can be important barriers to implementation. Third, technologies are also essential for action on climate resilience, but their characteristics should match the needs and available resources of users and their socio-economic and environmental contexts.

## The advantages of a systems approach

With so many factors involved, it may seem at first sight that a systems approach is an impractical way to prepare for, react to and recover from a crisis. It seems reasonable to argue that by isolating a problem, policymakers can focus on tailoring their response to the specific issue in the most efficient manner. That is probably true in the rare cases where a problem really can be isolated. But as the wildfires example discussed in Chapter 5 show, often, the outcome of will not be as hoped for due to unintended consequences, unforeseen spill-overs, and unsatisfactory trade-offs.. At the same time, trying to adjust all the parameters of a problem simultaneously where the challenges are interconnected, multidimensional, and complex is impractical. There is another way, described in a joint report by NAEC and IIASA: "Systems thinking offers a solution to this dilemma. It allows us to identify the key drivers, interactions, and dynamics of the economic, social, and environmental nexus that policy seeks to shape, and select points of intervention in a selective, adaptive way" (Hynes et al., 2020).

Systems thinking also allows us to identify the most important system characteristics at play in a given situation. Some characteristics are given and are extremely hard or impossible to influence – radical uncertainty being the most obvious. But it is now becoming increasingly accepted that another system feature, resilience, can be strengthened and that by doing so, many of the costs of reacting to a crisis rather than preparing for it can be avoided. There is a shift in business thinking away from pushing for maximum efficiency. In an interview presenting the WEF report, James Corless, Head of Business Resilience Risk at Zurich, put it like this: "Just-in-time delivery has stripped the fat from supply chains but, in times of crisis, that fat can act as shock absorbers in the chain" (Zurich, 2022). This is the same argument Irina Sodin presented at the NAEC conference on Integrative Economics two years earlier – "Maybe just-in-time needs a dose of just-in-case" (Sodin, 2020).

## The need for resilience

In the same interview, Corless also says that: “The pandemic is a reminder that you need to start thinking about engineering greater resilience into your existing operation”, or what Chapter 1 of this publication calls “resilience by design”. The Citi report (Citi, 2021) estimates that to reduce the probability, frequency, and severity of systemic risks, annual investments totalling nearly USD 3 trillion could be needed. This is a massive sum, but as the report goes on to say, “it pales into insignificance when compared to the tens of trillions of dollars in potential costs of inaction, and makes a strong argument that we can’t afford not to act”. The Global Preparedness Monitoring Board’s *A World In Disorder* report gives a stark illustration of this (GPMB, 2020). The GPMB calculate that preparing for a pandemic would have cost the world USD 5 per person, compared to the USD 16 trillion the IMF estimates had spent on pandemic responses by the end of 2021 (IMF, 2021).

The main lessons to be drawn from the work summarised in this publication is that decision makers should assume that any system will fail sooner or later and that it is not possible to guess when and how. One should also assume that the failure of the system in question will have consequences for the other systems it is connected to and this may create feedback loops. The winter power outages in Texas mentioned in the first chapter hit the Samsung microchip foundry in the state, quickly causing bottlenecks in the supply chain to auto manufacturers among others (Dobberstein, 2021). Burying the power lines was considered an unjustified expense. Spending money is no guarantee either though. It is impossible to buy down every risk, so the aim should be to reinforce the ability of a system to absorb the impact of a wide array of systemic threats, recover from them, and adapt to the new situation.

We do not know what, where or when the next major shock to the world system will be. We do know that its seeds have probably been planted already in the fertile soil composed of increasing interdependence and interconnectedness, failure to deal adequately with the climate emergency, and growing inequality and the resentment it generates. One positive lesson from our analysis of systemic challenges is that the good can be diffused and amplified by the same mechanisms that can provoke cascading failures. Systems thinking gives us a powerful tool to understand and shape our world, while resilience provides both a philosophy and pragmatic guide to ensure that systemic threats do not lead to systemic collapse.

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## New Approaches to Economic Challenges

# A Systemic Recovery

New economic thinking and acting through a systemic approach could outline policy alternatives to tackle the global-scale systemic challenges of financial, economic, social and environmental emergencies, and help steer our recovery out of the current crisis. A systemic recovery requires an economic approach that balances several factors – markets and states, efficiency and resilience, growth and sustainability, national and global stability, short-term emergency measures and long-term structural change. To achieve this, we need to think beyond our policy silos, comprehend our interconnections, and build resilience into our systems.

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