EVERY AVENUE AVAILABLE

LESSONS FROM MONETARY HISTORY FOR TACKLING CLIMATE CHANGE

Rens van Tilburg and Aleksandar Simić

February 2021

“I WANT TO EXPLORE EVERY AVENUE AVAILABLE IN ORDER TO COMBAT CLIMATE CHANGE”

Christine Lagarde, president of the European Central Bank, July 2020

Utrecht, February 2021.

The Sustainable Finance Lab (SFL https://sustainablefinancelab.nl/en) is an academic think tank whose members are mostly professors from different universities in the Netherlands. The aim of the SFL is a stable and robust financial sector that contributes to an economy that serves humanity without depleting its environment. To this end the SFL develops ideas and provides a platform to discuss them, thus bridging science and practice.

This paper has been drafted by Rens van Tilburg, Director of the Sustainable Finance Lab at Utrecht University (r.vantilburg@uu.nl) and Aleksandar Simić, researcher of the SFL.

The authors wish to thank Roben Kloosterman for his excellent research support and Alexander Barkawi, Simon Dikau, Maarten Kavelaars, Jens van 't Klooster, Cormac Petit, Rick van der Ploeg, Dirk Schoenmaker and Roland Uittenbogaard for their comments. The views expressed in this publication are those of the authors and do not necessarily reflect those of all members of the Sustainable Finance Lab.

This paper was commissioned by the Council on Economic Policies and supported by the European Climate Foundation.

KEY TAKEAWAYS

Insufficient action to limit climate change

The costs of runaway climate change are much higher than those of limiting it. Despite this, we still do not see the political action and coordination — globally — that is required to curb climate change.

Climate change is a threat to price stability

Climate change will have monetary consequences and seems to be incompatible with price stability. The economic damage of climate change can be of the order of magnitude of the most disruptive and damaging wars. These were periods of high, or even hyperinflation in some countries.

Preventing climate change is within the central bank mandate

Such severe monetary consequences mean central bankers have a duty to act. To help prevent climate change, as this is a prerequisite for price stability in the medium to long term. Other reasons for monetary policymakers to act are the climate risks that a central bank wants its balance sheet protected from and the secondary objectives that most central banks have, among which environmental protection.

Central bankers are uniquely positioned to contribute to mitigating climate change

Monetary policymakers are uniquely positioned to support the necessary long-term climate mitigation efforts of governments. They have a long history of international

cooperation, have closely aligned mandates and have much longer tenures than their respective governments.

Central banks have performed similar tasks successfully in the past

Central bankers, historically, have been instrumental in co-financing economic development efforts of a similar scale and time span as the climate mitigation challenge. For example, in the USA during the New Deal and in many countries after World War II. Monetary support for such reconstruction and industrialization efforts have not led to excessively high inflation.

Central banks need to formulate a common long-term strategy

In response to the recent and current economic crisis central banks have adopted new forms of unconventional monetary policy. These should specifically support investments in the global energy transition. The energy transition however, will not be realized during one economic downturn. For that reason, in support of government policies, monetary policymakers should formulate a common long-term global strategy to avoid a runaway climate change that could place price stability out of reach. They need to explore every avenue available to reach the related objectives of stable prices and a stable global climate.

CONTENTS

p. 7 **Summary**

p. 10 **List of abbreviations**

p. 11 **1. Introduction**

p. 12 **2. The nature and origin of central banks**
12 The nature of central banks
13 The origin of central banks

p. 15 **3. Financiers of emergency responses**
15 Children of war 1668–1900
17 World Wars I and II
20 Wars seem incompatible with price stability
21 Central banks' response to natural disasters
23 Central banks' response to epidemics

p. 25 **4. Guardians of stability**
25 Stabilizing the currency: ending free banking
26 Stabilizing commercial banks: lender of last resort
29 Stabilizing the economy: rebuilding after World War II
32 Stabilizing the financial sector through money creation
34 Conclusion: extending their role to safeguard stability

p. 35 **5. The monetary response to climate change**
35 The challenge of climate change
37 Central bankers and climate change: the current situation
38 Climate change and the tactics of monetary policy
41 The historical perspective on climate change as a monetary question
45 Conclusion: central bankers, globally, need to make a common developmental effort

p. 47 **6. Historical lessons for a monetary response to climate change**

p. 49 **Literature**

SUMMARY

The monetary response to climate change: a historical perspective

Climate change impacts the global economy and will do so increasingly in the years ahead. Central bankers agree that both physical risks of climate change and energy transition risks are material to the stability of financial institutions and the wider financial system. That said, climate change has not, so far, been taken into account in setting the monetary policies of Western central banks. That may change this year at the European Central Bank (ECB) as its current monetary Strategy Review has established a working stream on climate. ECB president Lagarde stated that she wants "to explore every avenue available in order to combat climate change".

This paper contributes to that exploration by discussing the historical role of monetary policy in society. We do this to establish which lessons can be learnt in determining an appropriate response to the challenges of climate change. We discuss how, throughout history, thinking has developed about what central banks are and what they should do: what aims they have had and which instruments they have used to pursue these aims. We look in particular at periods of turmoil and crisis: wars, epidemics, natural disasters, as well as financial and economic crises. We discuss how the challenges of climate change compare, and which monetary policy responses may be warranted.

The twin objectives of central banks

Although the term 'central bank' was coined only in the 19th century, and the oldest central banks still in operation were only created in the late 17th century, (semi-)public institutions have been performing roles we now associate with central banking from the moment larger civilizations came into existence. Two objectives can be identified that such institutions have been expected to realize:

1. Ensuring there is enough currency to serve society's needs;
2. Protecting the stability of the currency and, increasingly, the wider financial and economic system.

Providing the currency

Most central banks were founded primarily for the first reason, as 'banks of issue': to provide the sovereign with financial means beyond borrowing and taxation. Often this was for the purpose of war, as when the Bank of England helped finance war against France in the late 17th century. Central banks have also helped to overcome natural disasters, as the Bank of Japan did after the 2011 Great East Japan Earthquake and tsunami. Most recently we have seen how central banks in many countries helped in funding support measures during the lockdowns due to Covid-19.

Stabilizing the currency

Central banks' second objective is guarding the stability of the currency. Price stability, however, requires financial and economic stability. This has led central banks to expand their activities beyond the mere monetary sphere, to enabling real world economic changes. Central banks are now the 'lender of last resort', the backstop of banks and, increasingly, other financial institutions. The Bank of England has assumed this role during the crises that plagued the financial system almost every decade from 1760 onwards.

After WWII the stabilizing role of central banks in most countries extended to the whole economy. They were given the tasks of economic development and maintaining full employment. These efforts have mostly yielded economies with strong growth, full employment and only moderate inflation.

In more recent times, central banks have used their money creating powers to stabilize the global financial system through a series of 'quantitative easing' programs. Fierce discussions have arisen over the legality of these measures — especially in relation to the ECB. The European Court of Justice, however, concluded that the ECB's purchasing program "does not go manifestly beyond what is necessary to achieve the objectives it pursues" (Court of Justice of the European Union, 2015).

The monetary challenge of climate change

The economic costs of climate warming beyond two degrees can be tens of percentage points of national income. The two world wars are among the few recorded historical events that had a similar global impact. Both were followed by periods of high and hyperinflation.

So, if safeguarding price stability is the primary objective, limiting climate change would be a necessary precondition.

The costs of runaway climate change are much higher than the costs of mitigating climate change (estimated at 1-3 percent of global GDP). While substantial, the costs of mitigation are manageable. Both the scale and time span of mitigation are comparable to the development and reconstruction co-financed by central banks, supported through monetary policies before and after World War II.

Despite international agreements on climate change, political action to limit climate change is insufficient. It requires international coordination between countries with widely differing financial means and climate vulnerabilities. Unlike in a war, there is no clear enemy in sight. Unlike in a natural disaster, the damage done is not (yet) clearly visible. When a 'Pearl Harbor moment' arrives and galvanizes the political will to act, it may be too late.

Monetary policymakers are particularly well positioned to play a more active role in limiting climate change, supporting government policies in this field. They have long and intensive histories of global cooperation. Central bank mandates are much more aligned than the mandates of their governments. And central bankers have much longer tenures than politicians. Importantly, central banks also have unique and powerful instruments to support economic and financial development. Instruments that historically have been used for the common good when needed.

Towards a common long-term strategy

Central banks are currently exploring and using new forms of monetary-fiscal coordination. These need to be focused more specifically on supporting the global energy transition to curb climate change. Energy transition will not be realized during one economic downturn — that takes longer. For that reason, and to support government efforts, monetary policymakers need to formulate a common long-term global strategy to mitigate climate change and avoid runaway climate change where price stability may no longer be within reach. Throughout history central banks have gone 'every avenue available' to help societies meet the challenges of their times. Now, central banks need to agree on a common course to safeguard the closely related objectives of stable prices and a stable global climate.

LIST OF ABBREVIATIONS

ABSPP	Asset-Backed Securities Purchase Programme
BACEN	Central Bank of Brazil *(Banco Central do Brasil)*
BIS	Bank for International Settlements
BoE	Bank of England
BoJ	Bank of Japan
CBPP	Covered Bond Purchase Programme
CSPP	Corporate Sector Purchase Programme
DNB	Dutch Central Bank *(De Nederlandsche Bank)*
ECB	European Central Bank
ECJ	European Court of Justice
GDP	Gross Domestic Product
GNP	Gross National Product
IDB	Industrial Development Bank
IPCC	Intergovernmental Panel on Climate Change
LoLR	Lender of Last Resort
MEFO	Metal Research Company *(Metallforschungsgesellschaft)*
MERS	Middle Eastern Respiratory Syndrome
NGFS	Network for Greening the Financial System
OMT	Outright Monetary Transactions
PBL	Netherlands Environmental Assessment Agency *(Planbureau voor de Leefomgeving)*
PEPP	Pandemic Emergency Purchase Programme
PSPP	Public Sector Purchase Programme
QE	Quantitative Easing
RFC	Reconstruction Finance Corporation
SARS	Severe Acute Respiratory Syndrome
SMP	Securities Markets Program
UNEP	United Nations Environment Programme
US(A)	United States (of America)
VOC	Dutch East India Company *(Vereenigde Oostindische Compagnie)*
WWI	World War One
WWII	World War Two

1. INTRODUCTION

Climate change and monetary policy

There will be no 'business as usual' scenario for the global economy in the coming decades. Either the average global temperature will exceed the threshold of one and a half to two degrees Celsius, or the economy will be fundamentally reorganized in order to prevent this from happening. Both scenarios will have profound consequences for the economy, and therefore, for financiers (IPCC, 2018a; Taskforce on Climate-related Financial Disclosures [TCFD], 2018). These scenarios provide opportunities as well as risks, with the overall costs to the economy being much higher in scenarios where climate change exceeds two degrees (Netherlands Environmental Assessment Agency [PBL], 2014; Stern, 2007).

Central bankers agree that both the physical risks of climate change and energy transition risks are material to the stability of financial institutions and the wider financial system (Network for Greening the Financial System [NGFS], 2019). However, despite initial explorations of the topic, climate change so far has not been taken into account in the monetary policies of Western central banks (Bolton et al. 2020; Cœuré, 2018; Krogstrup & Oman, 2019; NGFS 2020a).

What does history teach monetary policymakers about climate change?

In this paper we place the role of monetary policy in addressing climate change in an historical perspective: what lessons can be drawn from the history of central banking in order to determine an appropriate monetary response to the challenges of climate change? We discuss how throughout history, thinking has developed about what central banks are and what they should do, what aims they have had and how their instruments have evolved. For this, we look in particular at periods of turmoil and crisis. We then discuss how the challenges that climate change poses relate to these, and hence which monetary policy responses may be warranted.

Structure of the paper

We start in chapter two with a general discussion of the nature and origins of central banks. Chapter three looks at the primary role of the oldest central banks: ensuring there is enough money to serve society's needs, especially in times of fiscal emergency spending, such as war and natural disaster. After that, in chapter four, we discuss the other role of central banks: as stabilizers of the currency and the wider financial system and economy. Then, in chapter five, we discuss climate change and its economic and financial impact. We will compare these to the historical challenges discussed before. Finally, based on this discussion, we will draw lessons for an appropriate monetary policy response to climate change.

2. THE NATURE AND ORIGIN OF CENTRAL BANKS

Even though the term 'central bank' was coined only in the 19th century, and the oldest central banks still in operation today were created in the late 17th century. (Semi-)public institutions have been performing roles we now associate with central banking from the moment that larger civilizations came into existence.

The nature of central banks

Modern definitions of a central bank emphasize either their specific objectives, such as controlling the money supply and price stability, or refer to its specific instruments, in particular its privileged status such as having the monopoly on issuing (paper) money, setting reserve requirements for commercial banks and acting as the 'lender of last resort' to financial institutions (Bindseil, 2019; Epstein, 2009; Goodhart, 1991). However, neither all of these objectives of modern central banks nor their instruments were fully present when they were founded. The mandates of central banks, the goals they are expected to achieve and the instruments at their disposal, vary between monetary blocks even today, and are still constantly challenged and changed (Goodhart, 2011).

Broadly speaking, two overall objectives can be identified that all central banks currently, and historically, have been expected to realize:

1. Ensuring there is enough currency to serve society's needs, and
2. Protecting the stability of the currency and, increasingly, the stability of the wider financial and economic system.

These objectives are not mutually exclusive; rather, they depend upon each other. Without money there is nothing to stabilize, and without stability of the currency, there will be no demand for it. But there are also trade-offs. Creating more money than the economy can digest will, all else being equal, lead to price rises, and hence, loss of value of the currency. On the other hand, too little money hurts the economy, as valuable transactions cannot take place.

The origin of central banks

The oldest central banks still in operation emerged in the late 17th century. The Swedish Riksbank was founded in 1668 and the Bank of England (BoE) in 1694. However, these were not the first financial institutions granted special privileges by the government offering the public a medium of exchange, controlling the money supply and acting as an emergency lender to other financial institutions.

In what is called the cradle of civilization, the Fertile Crescent in the Middle East, where settled farming first began to emerge, clay tablets have been found dating from 3100 BC that are thought to have been used by traders for making payments (Tymoigne & Wray, 2006). These tablets derived their value from the promise that they would be exchanged for a specified amount of corn, grain or maize — staples stocked at the temple where the clay tablet had been issued (Tymoigne & Wray, 2006). Already here, in the role of the temple as the issuer of the medium of exchange, the importance of a trusted 'public' institution backing the means of payment becomes clear. A similar link is seen in the first coins such as the Lydia lion and the Aeginan turtle (see box).

Of lions and turtles

The Lydian Lion was first issued around 610 BC in what is now Turkey. The coins bear the roaring lion that was the symbol of the Lydian kings (Robinson, 1951). Within decades, on the Greek island of Aegina, the first European coin was minted. The seafaring people of Aegina chose the turtle as their coinage symbol, very likely because it was the symbol of Aphrodite, whose temple stood on the island (Poole et al., 1888, p lxv). Some scholars believe that the money was originally issued by the Temple of Aphrodite (Poole et al., 1888, p. lxvi).

Whereas systems of mutual credit have always existed in smaller communities (Graeber, 2014) for trading over larger distances with less well-known counter-parties, money issued by a public institution (or at least an institution with some sort of public backing) has usually been preferred. The advantage of publicly backed currencies over private currencies are that, whereas a company or individual can disappear or default, a country cannot.

The history of modern banking started in Italy. In 1157 the Bank of Venice was the first bank in Europe established with a guarantee from the State (Bindseil, 2019). It was set up to finance the Crusade of Pope Urban the Second. The bank ceased its operations during the French invasion of 1797 (Thomas, 1828). The Italian town of Florence set the modern norm for coins, with the Florentine florin that was struck from 1252 to 1533 (Spufford, 1989). Through the many branches across Europe of Florentine banks, the florin became the dominant trade coin of Western Europe for large-scale transactions, replacing silver bars (Spufford, 1989).

The next step in the development of central banking was taken in 1609 when the Amsterdam Exchange Bank (see box) was established and vouched for by the city of Amsterdam. It was able to regulate the value of the paper notes that it issued, which allowed it to perform what we now call 'open market operations'. In the 18th century it developed further facilities that we traditionally associate with modern central banking. For instance, in the financial crises in 1763 and 1773, it managed to coordinate the financial system and provide emergency financing for failing banks (Bindseil, 2019; Westerhuis & van Zanden, 2018).

The Amsterdam Exchange Bank

The Amsterdam Exchange Bank accepted all coins in circulation and in return provided paper receipts, enabling giro transactions to any entity with an account at the bank. The Dutch guilder was very stable due to the interventions of the Amsterdam Exchange Bank, with an average annual inflation of 0.37 percent over its 190 years in existence (Westerhuis & van Zanden, 2018). The ultimate demise of the bank came when France took power over Amsterdam and opened the books of the Bank from 1794 onwards. The French revealed that the Exchange bank was secretly lending to the government and the Dutch East India Company (VOC). In the 1780s, when the VOC suffered greatly as a result of the Fourth British–Dutch war, loans from the Exchange Bank made it possible to keep the company afloat. This revelation resulted in distrust by the merchant class who consequently withdrew their funds. The bank was subsequently liquidated by the city government in 1821 (Westerhuis & van Zanden, 2018).

The last (mis)step before the creation of the oldest still functioning central bank was the Stockholms Banco. After over issuance of banknotes of this bank (see box) the Riksdag, the Swedish Parliament, took matters into its own hands and created the Riksbank, which was not allowed to issue notes and obliged to lend only against safe collateral (Fregert, 2018; Goodhart, 1991).

Inspiration for the oldest central bank: The over-issuance of banknotes

Stockholms Banco, founded in 1657, took its design principle from the Amsterdam Exchange and Lending Bank. It was also the first European bank to have printed paper banknotes (Edvinsson, Jacobson, and Waldenström, 2018). The Stockholms Banco was a private institution that promised half of the bank's profits to the Crown. The main difference between it and the Amsterdam Bank was that the Stockholms Banco's subdivisions worked together legally (Fregert, 2018). Stockholms Banco collapsed after only eight years in 1666 due to over-issuance of notes (Fregert, 2018; Goodhart, 1991).

3. FINANCIERS OF EMERGENCY RESPONSES

Most central banks were founded as 'banks of issue', to provide the sovereign or government with financial means not achievable through borrowing or taxation. In this chapter, we discuss this role of central banks over the last several centuries, specifically with regard to their role in financing war efforts and in the aftermath of natural disasters.

Children of war 1668–1900

In general, there are three ways wars can be financed: by taxation, by borrowing (foreign or domestic), or by money creation (printing money) (Cappella, 2012). All of these options have their advantages and drawbacks. Taxation has a high political cost; it is unpopular among citizens. It is also slow, which is a setback in a war, when finances need to be raised quickly. Borrowing is usually quicker. Money creation is the fastest of the three. Also, it is politically more acceptable, as its costs are usually opaque to citizens. Money creation, however, may also be inflationary and, thus, economically costly (Rockoff, 2014). In general, the more support a war has from the public, the larger the willingness to accept tax rises and to buy war bonds (Zielinski, 2018).

Financing war efforts has historically been an important reason to set up an institution that could issue money. In that sense one could say that central banks are the 'children of war'. These were, therefore, initially called 'banks of issue' (Bordo & Siklos, 2018). In Europe several central banks were formed during or in the aftermath of the Napoleonic wars (1803-1815). The Bank of Japan (BoJ) was formed after the Meiji Restoration of 1868 (Edvinsson, Jacobson & Waldenström, 2018; Goodhart, 1991). Even central banks established with an explicit aim not to finance war efforts have succumbed under pressure to do so, such as the aforementioned Swedish Riksbank (see box).

Riksbank forced to finance war

In order not to repeat the mistakes of the Stockholms Banco, the Riksbank was taken under the protection of Parliament and given a high degree of independence. It was, however, not long before the Riskbank's charter was broken and it was forced to lend to King Karl XI, for his war efforts against Denmark (1674-1679) and again after that to his successor for the Great Nordic War (1701-1718) (Fregert, 2018). The following decades were marked by more strength of Parliament and a corresponding increase in independence of the Riksbank. However, when King Gustav III staged a *coup d'état* in 1772, the Bank was brought under his control and the government debt was written off (Fregert, 2018).

The history of the world's second oldest central bank is even more directly linked with the need for fiscal emergency spending. The Bank of England was founded in 1694 as a result of the deteriorating state of government coffers during the Nine Years War with France (1688–1697) (Elgie & Thompson, 1998; Goodhart, 2018). For the first decades, the BoE was given a relatively free reign selecting its own Governor and Directors (Elgie & Thompson, 1998). However, in the wake of the Napoleonic Wars in 1797 the Bank was forced to suspend the convertibility between gold and sterling because of excessive government borrowing to fund the war (Elgie & Thompson, 1998).

Monetary financing was also used by the American colonists in their war of independence of 1775-1783. Domestic borrowing from rich individuals, and some foreign assistance from England's foes, such as France, proved to be insufficient. Taxation was not possible as the Continental Congress had no authority to tax. The only remaining source of finance was printing money, the so-called Continentals (Rockoff, 2014). Continentals were not simple fiat currency, but zero-coupon bonds. It is estimated that "77% of the expenditures of the Continental Congress were financed by issuing continental dollars" in the period 1775-1779 (Rockoff, 2014). This led to high inflation and depreciation of the currency against gold. At its highest, inflation was just below 50 percent on a monthly basis (Baack, 2008).

Monetary financing does not always need to result in such high inflation. During the United States (US) Civil War (1861-1865) both North and South resorted to monetary financing of their war efforts. Due to the lack of a central bank, the Treasury in both regions issued new money itself (Zarlenga, 2002). Whereas in the South this led to runaway inflation, with prices increasing 28 times between January 1861 and January 1864 (Lerner, 1955), in the North where the 'greenback' was issued inflation spiked at 27 percent annually in 1864, but quickly subsided afterwards (Federal Reserve Bank of Minneapolis, 2019).

Also, in Asia, monetary financing of war efforts was the norm. In 1868, the Japanese government introduced the *dajoukan-satsu*, a new government note and the first paper money to be circulated nationwide (Shizume, 2018). Due to massive fiscal expenditure leading up to the civil war and shortage of fiscal revenues, the *dajoukan-satsu* was issued excessively, which resulted in price increases of 150 percent (Flath, 2005).

In many cases central bankers have tried to resist the monetary financing of government expenditures. However, even when succeeding, sovereigns found other ways of financing their expenditures, such as the establishment of a new financial institution — which could also take the place of the central bank. This was Sweden's experience in the late 18th century (see box).

Bypassing the Riksbank

King Gustav III started a war in 1788 with Russia. The General Council of the Riksbank reluctantly agreed initially to fund this, but later prohibited further lending (Fregert, 2018). This time, instead of forcing the Riksbank's hand, the ruler introduced a new institution, the *Riksgäldskontoret* (National Debt Office), and allowed it to issue a new currency, *Riksgäldssedlar* (Treasury notes) (Fregert, 2018). The new notes soon took precedence with the Riksbank notes becoming almost irrelevant. Only in 1803, when convertibility between these two currencies was established, was the Riksbank was able to reassert its dominance (Fregert, 2018).

Sweden was not unique in this aspect. Something similar happened in the Netherlands in 1815-31 when De Nederlandsche Bank (DNB) refused to fund King William I's modernization plans for the economy (Westerhuis & van Zanden, 2018). Here too, the King found other sources of finance, establishing the Dutch Trading Company (*Nederlandsche Handels Maatschappij*, now part of bank ABN Amro), to which he granted a profitable monopoly for trade with the colonies (Westerhuis & van Zanden, 2018).

World Wars I and II

With the development of tax systems and international financial markets, the options for financing wars grew. However, despite the increasing availability of these alternatives, the role of central banks as financiers of war has continued into the 20th century.

The first World War (WWI) was expected to be a short war. It was thought that it could be fought without raising taxes. All parties expected that after victory the opponents could be presented with the bill (de Haan, 2018). As it turned out, the war was much longer and much more destructive than anyone had imagined. Government spending rose from around ten percent of Gross Domestic Product (GDP) in 1914 to 50 percent in France and even 60 percent in Germany in 1917 and 1918 (Broadberry & Harrison, 2005). As a result, monetary financing was

applied in many European countries. The central bankers often resisted this, only to find their independence curtailed (see box).

Central bank independence as a casualty of World War I in the UK and France

As soon as the UK government realized that the war could not solely be financed through fiscal channels, the relative independence of the Bank of England was again suspended. The Bank saw the pressure as undue, but finally had to give in. In a last desperate attempt for independence, then Governor Lord Cunliffe tried to block the government's access to the gold that the Bank held in Canada, which led to his resignation (Elgie & Thompson, 1998).

The Banque de France initially extended emergency liquidity to the government and launched public campaigns to repatriate gold and silver. But this cooperative stance changed as the government delayed tax increases (Bignon & Flandreau, 2018). Most expenses were financed by money creation and, to a lesser extent, by long-term borrowing. This led to an increase of the money supply and price increases of almost 400 percent between 1914 and 1920 (Bignon & Flandreau, 2018; Bordo & Hautcoeur, 2003). After the war, in 1920, threatening not to renew advances made, the Banque secured an agreement with the government for the gradual reimbursement of the war debt. This promise was soon broken, as no political majority could be established to prioritize debt repayments over compensation of wounded soldiers and widows or the reconstruction of numerous areas in the north and east of the country. This led to a further increase in prices (Bignon & Flandreau, 2018; Bordo & Hautcoeur, 2003).

Many central banks did not regain their lost independence after WWI. As we will discuss more extensively in the next paragraph, many took on a development role, financing the rebuilding of the economy and, increasingly, the rearmament for World War II (WWII) (see box).

Monetary financing of rearmament by the Reichsbank and Bank of Japan

As German rearmament was forbidden after its role in WWI, the Nazi regime had to rebuild its military covertly. The Reichsbank was crucial for this role. In the first instance, a shell company, the *Metallforschungsgesellschaft* ('MEFO'), was created and officials from the Ministry of Finance and the Reichsbank placed on its board. (Leaman, 2001; Schacht, 1967). Then, four large German industrial companies (including Siemens and Krupp) contributed 250,000 Reichsmark each as a starting capital. All the companies performing production services for the government issued bills to MEFO, whose bills, in turn, were fully underwritten by the Reichsbank

(Schacht, 1967). These MEFO bills, thus, became an unofficial currency, and could be used for savings and as a means of transaction. MEFO bills were finally cancelled in 1938 when their total volume reached twelve billion Marks, and full employment and first signs of inflation were achieved (Schacht, 1967). Due to its refusal to further finance the government, the head of the Reichsbank Hjalmar Schacht was dismissed and by 1939 the bank was in full control of the Nazi party. This enabled it to increase the amount of money almost eight-fold (from eleven billion Reichsmark to 79 billion) until 1945.

When the war with China escalated in 1937 the Bank of Japan financed Japanese armament. BoJ increased its holdings of government securities of almost one billion yen and almost two billion yen in banknotes in 1936, to eight billion yen in government securities and 21 billion yen in banknotes in 1945. It further loaned 14 billion yen for the war effort through commercial banks (Shizume, 2018). In order to control inflation, the government and the BoJ used financial repression and direct price control (Shizume, 2018). Nonetheless, inflation after the war was very high, at above 80 percent (Ito, 2010).

WWII was to become the most expensive war in history. In many countries central banks played an explicit role in financing the war, as in Germany and Japan. In the USA, the role of the Fed was more limited. However, even there the central bank did play an important role in keeping interest rates low. By doing so, it stimulated demand for war bonds among the public (Freeman, 2006). Central banks, thus, not only financed the war through explicit monetary financing, but also by creating favorable conditions for government borrowing.

Fed keeping rates low and the Treasury financing the Reconstruction Finance Corporation

WWII was the most expensive war for the United States of America (USA). At its peak in 1945, over 35 percent of GDP was dedicated to the war effort (Zielinski, 2018). When the USA entered WWII, the Fed indicated that it was "prepared to use its powers to assure at all times an ample supply of funds for financing the war effort" (Federal Reserve, 1943). Soon after the Pearl Harbor attack, the Fed bought US$100 millions' worth of government bonds, while keeping interest rates low — well below the typical peace-time rate (Federal Reserve, 1943; Rockoff, 2014). They also reduced their discount rate substantially. Inflation was kept at bay through the price control of goods and wages. Rationing was introduced for obtaining scarce commodities and consumer durables (Federal Reserve, 1943). The Fed was authorized to "purchase government securities directly from the Treasury" and "war loan deposits were exempted from reserve requirements" (Federal Reserve, 1943; Richardson, 2013). Inflation reached 14.4 percent in 1947 (Federal Reserve Bank of Minneapolis, 2019).

The Reconstruction Finance Corporation (RFC) also played an important role before, during and after WWII. Founded by President Hoover in 1932 for bailing out the banking sector and later used by President Roosevelt to finance his New Deal, the RFC issued bonds that were bought by the US Treasury (Freeman, 2006). From 1941 through 1945, the RFC issued US$23 billion for war mobilization, the equivalent of US$795 billion in 2006 dollars (Freeman, 2006). This funding enabled development of not only military-related machinery, but also new industries and new scientific areas such as radar, nuclear energy and medical developments such as penicillin. Through the RFC electricity coverage in rural areas rose from ten percent in 1933 to 88 percent in 1955 (Freeman, 2006). The RFC continued to operate until 1957.

Wars seem incompatible with price stability

We have seen that wars often lead to high inflation and hyperinflation, irrespective of the monetary policy applied. War seems to be incompatible with the objective of price stability even when monetary financing is kept to a minimum, e.g. in the USA in WWI and WWII, inflation reached double digits for several years, peaking at 17.3 percent and 14.4 percent respectively (Federal Reserve Bank of Minneapolis, 2019). Monetary financing does not necessarily increase inflation for longer periods of time, as we have seen in the US Civil War when despite the large role of newly printed greenbacks, inflation peaked at 27 percent and was reduced quickly afterwards (Federal Reserve Bank of Minneapolis, 2019).

In WWI, France, the UK and Germany all resorted to monetary financing. In the first years of the war Germany had roughly the same economic performance as Britain in WWI (Gross, 2009). Also, in France prices increased rather strongly, rising four-fold between 1915 and 1920 (Bordo & Hautcoeur, 2003). Germany's financial demise started only after it had lost the war and was forced into large war reparations, denominated in foreign currency. Inflation peaked at almost 30 thousand percent in October 1923 (Hanke & Krus, 2012) (see box).

The complex of causes of the German hyperinflation of 1922

The German hyperinflation is often used as a showcase of the danger of money printing by the state. However, this account is misleading in several ways. Firstly, the Reichsbank was actually private and had a high level of independence — this being one of the requirements of the Allied forces after WWI (de Haan, 2018). Secondly, while it is true that the Reichsbank did continue discounting government bills in ever-larger quantities, it did the same with bills from other private banks. These were created in ever-larger quantities and allowed private speculators to short-sell the domestic currency and convert the gains to foreign currencies (Kumhof & Benes, 2012; Schacht, 1967). Inflation ended when the new Reichsbank President Schacht stopped convertibility of private money to the Reichs-

mark (Schacht, 1967), stopped on demand loan issuing by the Reichsbank, broke the convertibility between the new Rentenmark (another currency then in circulation) and foreign currencies, and reintroduced parity between the Rentenmark and the Reichsmark (Schacht, 1967).

Losing a war seems to increase inflationary pressures more strongly (Issing & Wieland, 2012), as evidenced by not only Germany after WWI but also by Hungary after WWII (see box).

Hungary's hyperinflation of 207 percent a day

When occupied by Nazi Germany, Hungary was largely an agricultural economy. The war destroyed a considerable amount of fertile soil. Furthermore, as German forces retreated, they took with them most remaining valuable assets and demanded yearly contribution payments (Siklos, 1991). The last resort to pay off the debt was creating new money (Siklos, 1991). This led to the highest hyperinflation, worldwide, ever recorded at 207 percent a day in July 1946 (Hanke and Krus, 2012).

While there was extensive monetary financing both in Germany post-WWI and Hungary post-WWII, it would be too simplistic to blame this specific policy for the hyperinflation. Resorting to monetary financing rather signals the hopeless situation in which countries find themselves. (Hyper)inflation always has many different causes. Money creation, wages, import prices and reduced productive capacity can all be important drivers (Ryan-Collins & van Lerven 2018; Vernengo, 2006).

Central banks' response to natural disasters

Like wars, natural disasters can lead to sudden and very large financial needs for governments. In this section we discuss the responses of central banks to natural disasters.

Natural disasters have detrimental macroeconomic effects. Most obviously, the disaster may cause physical destruction of housing and other physical infrastructure, thus reducing supply. On the demand side, reconstruction efforts increase it in disaster period, but may also *de*crease it by reducing consumption and investment (Batten, Sowerbutts & Tanaka, 2016). Central banks need to determine the appropriate policy response. Often this is temporary loosening of monetary policy (Batten, Sowerbutts & Tanaka, 2016; White, 1997).

Research by the European Central Bank (ECB) found a large degree of heterogeneity in the impact of disasters on inflation (Parker, 2016). Whereas disasters have little impact on inflation in advanced economies, the impact in emerging and developing economies can be large and persistent. The impact also varies by type of disaster and for different sub-indices of consumer prices (Parker, 2016).

Even though inflation effects are real and measurable, in most cases these effects are judged to be too small or are transient and do not merit a monetary response. When Hurricane Katrina caused damage amounting to US$125 billion (1 percent of USA GDP in 2005), the Federal Reserve went on increasing the interest rate as planned, arguing that the effects of the disaster were temporary (Batten, Sowerbutts & Tanaka, 2016, p. 24; Keen & Pakko, 2011).

Some central banks, however, have taken more active stances in the face of larger natural disasters (see box). The 2011 flooding in Thailand had a much larger impact proportionally than Hurricane Katrina. It generated total losses of US$43 billion, or 11.6 percent of GDP, leading the Bank of Thailand to cut policy rates (Batten, Sowerbutts & Tanaka, 2016).

Bank of Japan's active response to the 2011 Great East Japan Earthquake and tsunami

In 2011, the Great East Japan Earthquake and the ensuing tsunami, resulted in damage of more than US$200 billion or around 3.6 percent of GDP (Laframboise & Loko, 2012, p. 10). Monetary authorities reacted by injecting liquidity into the system, with a loan program for institutions influenced by the earthquake and by expanding its asset purchase program. The Financial Services Agency loosened rules for bank recapitalization in the affected area (Laframboise & Loko, 2012). A fiscal stimulus of 3.8 percent of GDP was effected by the government, mostly for infrastructure rebuilding and to sustain the labor market (Laframboise & Loko, 2012). The G7 showed "readiness to provide any needed cooperation", while major central banks intervened to maintain the value of the yen (Batten, Sowerbutts & Tanaka, 2016; Reuters, 2011).

The appropriate monetary policy response also depends on the extent to which costs are borne domestically or by foreign entities. See, for instance, the case of the Canterbury earthquakes in New Zealand.

Central bank and foreign insurance share the burden of the Canterbury earthquakes

In New Zealand, the Canterbury earthquakes comprised two separate earthquake events, in September 2010 and in February 2011 with a total damage of US$24 billion or 10 percent of GDP (Laframboise & Loko, 2012). The earthquakes led to a jump in public expenditure by 6 percent of GDP between 2010 and 2011. However, New Zealand households and firms had extensive property insurance with a high level of reinsurance (Bollard & Ranchhod, 2011). The majority of privately insured losses were thus borne by global insurers. Total reinsurance payments related to the two earthquakes have been estimated at 6 percent of GDP. Following the second earthquake, the central bank reduced the policy rate by 50 basis points to stimulate the economy (Laframboise & Loko, 2012). What made New Zealand a special case is that most banks are foreign owned, and their balance sheets are more diversified (White, 1997).

Central banks' response to epidemics

Central banks in times of epidemics

Large epidemics are comparatively rare events in developed economies. With modern medical systems, reliable access to medication, and high standards of hygiene, the number of victims who died in recent epidemics has been counted in hundreds or thousands rather than millions. For instance, SARS and MERS were responsible for around 8,000 and 2,500 cases, respectively (CDC, 2004; WHO, 2015, WHO, 2019)., The avian flu (H1N1) was an outlier, killing between 150,000 and 575,000 people, predominantly in less developed countries (Dawood et al., 2012).

The Spanish flu (1918-1919) is an obvious example of a pandemic, killing anywhere between 50 and a 100 million people (Jilani, 2020). However, any macroeconomic effects must be considered together with the ending of WWI (1914-1918). For instance, banks in the Federal Reserve System increased interest rates in the period 1918-1919 by 25 to 50 basis points (Velde, 2020, pp. 34-36). It is not clear to what extent that was a result of the pandemic or a result of reverting from the artificially low interest rate policy that supported the war effort and the ensuing fight against inflation.

More recently, South Korea increased liquidity in the face of the then raging MERS epidemic. With social distancing and quarantining in place, causing a ten percent annual fall in exports, the Bank of Korea reduced interest rates four times from 2.5 percent in August 2014 to 1.5 percent in June 2015 (BBC, 2015).

Central banks and Covid-19

The most direct monetary support in the Covid crisis was that given by the Bank of England. It extended the government overdraft (temporarily) from the maximum of £400 million to an undefined amount (Bank of England, 2020). Less radically, and in line with other large central banks, the Bank of England reduced interest rates, first, from 0.75 percent to 0.25 percent, and, later, to its lowest ever level of 0.1 percent.[1]

The ECB, for its part, also reduced interest rates on its refinancing operations as a response to the Covid crisis (European Central Bank, 2020c). Moreover, it introduced a new asset purchase program called the Pandemic Emergency Purchase Programme (PEPP).[2] PEPP was initially set at €750 billion, but was later further extended by another 600 billion (European Central Bank, 2020d). The deadline for purchases under this program has been extended until at least June 2021 (European Central Bank, 2020b).

In many ways the Federal Reserve acted similarly to the Bank of England and the ECB. It reduced its main interest rate from a range of 1.5 percent to 1.75 percent early in 2020 to a range between 0 percent and 0.25 percent in March (Federal Reserve, 2020a). However, unlike the ECB, Fed officials have indicated skepticism about entering the below-zero interest rate area (Federal Reserve, 2019). They have used forward guidance to indicate that they would keep these rates low (Federal Reserve, 2020b), in order to keep not only the short term, but also the long term interest rates low.

Next to assisting federal funding, the Fed also created several lending facilities to support state-, municipal- and city-level funding as well as funding to the private sector.[3] The Municipal Liquidity Facility is a case in point, providing loans with investment-grade credit ratings of up to US$500 billion to all sub-federal levels of government, against notes backed by tax revenues three years into the future.

Aside from the outright purchase of municipal bonds, the Fed has also acted to increase liquidity. High-rated municipal bonds are included as eligible securities for its Money Market Mutual Fund Liquidity Facility. And municipal bonds are included in the Commercial Paper Funding Facility — the facility backstopping the value of companies and municipalities through purchase of their commercial paper (Cheng et al., 2020).

1. www.bankofengland.co.uk/boeapps/database/Bank-Rate.asp

2. www.ecb.europa.eu/mopo/implement/pepp/html/index.en.html

3. www.federalreserve.gov/monetarypolicy/muni.htm

← Back to Contents

4. GUARDIANS OF STABILITY

Aside from their role as banks of issue, modern central banks are responsible for a stable currency. In most cases today it has become their primary responsibility. However, as we shall see, price or monetary stability also requires financial and economic stability. In times of crises this has often led central banks to extend their activities beyond monetary stability to the enabling of real world economic changes. In this chapter we discuss the evolution of this task of central banks: the crises that gave rise to the development of this role and the specific instruments which have been used.

Stabilizing the currency: ending free banking

Until far into the 19th century, in many countries (e.g. Germany, Sweden, Japan and the USA) in addition to the (central) bank of issue other private banks issued paper money. In the mid-19th century, there was strong growth in commercial banking, which led to the creation of more money and credit than the economy could absorb. The result was inflation and financial instability. As a consequence, more instruments were created for central banks to curb overall money creation. These ranged from a monopoly on the issuance of paper money to other instruments, such as setting reserve requirements — thus obliging private and commercial banks to hold part of their balance sheet as a reserve at the central bank.

In 1871 the German Empire faced monetary and banking chaos due to the multiplicity of coinage systems and note-issuing banks (Flink, 1930; Goodhart, 1991). In 1872 there were 33 private banks of issue. Several of them were "putting as many notes as possible into circulation" (de Haan, 2018). In response, the Reichstag transformed the Prussian Bank into a Reichsbank (de Haan, 2018; Goodhart, 1991) and gave it a central note-issuing role, although not a monopoly (de Haan, 2018).

A similar development took place in England. While the Bank of England's bank notes enjoyed a *de facto* monopoly in London, this was not the case in other parts of the country, most notably Scotland. The Bank had its powers reinforced by the Bank Charter Act of 1848 which gave it the *de jure* monopoly to issue bank notes in England and Wales (Goodhart, 2018).

In Japan, after the Satsuma Rebellion of 1877, in response to the banking boom and in the face of rampant inflation, the government relieved private national banks of their right to issue banknotes. That right was granted solely to the Bank of Japan (Shizume, 2018).

So, in response to instability, privileges were transferred from commercial banks to central banks, with the latter starting to take on a more pivotal role within their national financial systems.

Federalization as an answer to instability in the USA

In the USA, after three failed attempts at establishing a central bank[4], a thirty-year free banking period between 1837 and 1865 followed. Bankers were allowed to establish limited-liability corporations without obtaining government-issued charters (Eichengreen, 2018). However, the rules for these banks were unevenly applied across the states. For example, New York banks were required to hold (safe) government bonds, while other states allowed banks to back their notes with less stable claims, such as real estate and various personal notes. This led to different levels of success of free banking across the states. As a result of financial crises in 1893 and 1907 the Federal Reserve System was created in 1913 (Eichengreen, 2018). As with its predecessors, there was disagreement between the advocates of federal, centralized solutions and those who favored more local, state-based policies. The Federal Reserve System was therefore created with a fairly decentralized structure (Eichengreen, 2018). The Wall Street crash of 1929 and the ensuing Great Depression were not dealt with adequately. Only the New York Fed provided emergency liquidity. Further in-fighting contributed to the banking crisis of 1933. The Fed was then transformed into a more centralized institution with a stronger hold by the Board over the individual federal reserve banks (Eichengreen, 2018), with more independency of that Board by removing the Treasury secretary and Comptroller of the Currency, by lengthening the mandate of Board members and by empowering the Board to set interest rates, reserve requirements and discount rates (Eichengreen, 2018).

Stabilizing commercial banks: Lender of last resort

Even before central banks gained responsibility for limiting money creation, they increasingly took on the role of rescuing banks with liquidity problems. The first recorded prevention of a banking crisis probably took place in 16th century Venice. In 1587 Banco di Rialto was founded in order to stabilize the volatile private banking system. It performed this role by taking on their troubled assets and matching them in full with precious metal currency (Bindseil, 2019).

4. The Bank of North America (1781-1783), the First (1790-1810) and Second (1812-1836) Bank of the United State. For a more detailed discussion on the effects of free banking in other countries as well, see Goodhart (1991).

The first real lender of last resort (LoLR) role is found in the Hamburg Bank in 1763. Amid falling asset prices and a credit crunch the Neufville bank in Amsterdam threatened to drag a host of Hamburg merchants and bankers with it in its fall. The Hamburg city authorities, wanting to prevent the spread of the crisis to their city, decided that the Hamburger Bank could lend 500,000 Mark Banco to the Admiralty (a port authority partly run by merchants). Even though the interest was low and the collateral offered consisted mostly of perishable goods, the crisis was averted, and the Hamburger Bank stayed in good shape (Bindseil, 2019).

Several years later the Netherlands went through a similar endeavor. On behalf of the Bank of Amsterdam some 120 wealth owners created the three million florin 'Fund to maintain public credit' (Bindseil, 2019; Uittenbogaard, 2014). This Fund propped up the market not only in 1773, but also later in 1780, when the Fourth Anglo-Dutch war caused another crisis. In 1782 this Fund became a permanent fixture (Uittenbogaard, 2014).

The Bank of England assumed its role as LoLR during the crises that plagued the financial system almost every decade from 1760 onwards. In the USA, the first Secretary of the Treasury Alexander Hamilton took on that role in the financial panic of 1792 — Wall Street's first crash, when securities lost nearly a quarter of their value in two weeks. Hamilton coordinated a clearing-house arrangement among New York securities dealers and bankers that made lender-of-last-resort loans (Sylla, Wright & Cowen, 2009).

Only in the last third of the 19th century in the UK — through the intervention of the Bank of England — did Lender of Last Resort become a properly theorized and widely accepted role of central banks (Goodhart, 1991; Humphrey, 1989). A banker and journalist, Walter Bagehot (1873), set out the principles for this: that in times of financial crisis, central banks should lend freely to solvent depository institutions, yet only against sound collateral, and at interest rates high enough to dissuade those borrowers not genuinely in need. Bagehot credited the Bank of England with saving several commercial banks after the demise of the then systemically important Overend Gurney bank (see box). Overend Gurney itself was, however, not rescued, as it was insolvent, with large losses on loans to railway companies (Sowerbutts, Schneebalg & Hubert, 2016).

No rescue for the bankers' bank at Lombard Street

On May 11, 1866, large crowds gathered at the head office of the wholesale discount bank Overend Gurney at 65 Lombard Street in London. For forty years it had been the greatest discounting-house in the world, with a turnover double that of its largest competitors combined (Sowerbutts, Schneebalg & Hubert, 2016). During the financial crisis of 1825, Overend Gurney was able to provide cash to many other bankers, earning it the nickname of "the bankers' banker". Many firms which had previously dealt with the Bank of England now began depositing their surplus cash with Overend Gurney. However, the bank took on substantial investments

in railways and other long-term investments and in the railway crisis of 1866 it found itself with liabilities of around £4 million, and liquid assets of only £1 million (Sowerbutts, Schneebalg & Hubert, 2016). The BoE refused assistance. The financial crisis following the collapse saw the bank rate rise to ten percent for three months. More than 200 companies, including other banks, failed as a result (Sowerbutts, Schneebalg & Hubert, 2016).

A few months after the failure of Overend Gurney, then BoE Governor Holland stated: "we would not flinch from the duty which we conceived was imposed upon us of supporting the banking community and I am not aware that any legitimate application made for assistance to this house was refused." (Sowerbutts, Schneebalg & Hubert, 2016). In The Economist, Walter Bagehot concluded that the BoE thus acknowledged a 'duty' to support the banking community, and would act similarly under similar circumstances (Sowerbutts, Schneebalg & Hubert, 2016). This article met with sharp disagreement by many of the Bank's directors. Former BoE Governor Thomson Hankey described the idea that the BoE should act as lender of last resort as "the most mischievous doctrine ever broached in the monetary or Banking world" (Sowerbutts, Schneebalg & Hubert, 2016).

Nonetheless, a new standard had been set. Bordo (1990) notes that Britain's last panic happened in 1866. After that the BoE provided necessary liquidity when needed. According to Bordo, the LoLR role of the Bank of England prevented panics in 1878, 1890, and 1914. Most countries' central banks had developed an effective LoLR mechanism by the late 19th century (see box) — the USA at that time being the principal exception. Wood (2000) compared the reaction of central banks to different crises in England, France, and Italy. He found that when a lender of last resort existed, panics did not turn into crises.

The LoLR role internationally: France, Japan and the Netherlands

In 1889, the Banque de France arranged a lifeboat operation for the Comptoir D'Escompte, involving other commercial banks to provide the resources to keep the bank afloat (Hautcoeur, Riva & White, 2014). The Banque used very little of its own resources in the rescue, but provided guarantees for the participants in the event of losses (Hautcoeur, Riva & White, 2014).

The Bank of Japan also assumed the role of LoLR even though Matsukata Masayoshi, the founder of the BoJ, did not mention this role when the Bank opened in 1882 (Goodhart, 1991). The BoJ changed its stance after the banking panic of 1890 in Osaka and western Japan. The Bank actively extended its lending operations by adding company stocks to eligible collateral. Later, during the 1927 Showa Financial Crisis, the BoJ again functioned as the LoLR, swiftly extending its credit to combat bank runs (Shizume, 2018).

In the Netherlands, the first time that the DNB was required — under considerable pressure from the Minister of Finance Hendrikus Colijn — to play the role of LoLR was in the 1920s. DNB saved the bank Marx & Co with 27 million guilders, while the Rotterdamsche Bankvereeniging was given 60 million guilders as support in the form of a guarantee (van Riel, 2015; Westerhuis & van Zanden, 2018).

The financial instability after WWI gave rise to more international cooperation between central banks, leading in 1930 in Basel to the founding of the Bank for International Settlements (BIS). Initially, the BIS was created to deal with the reparation payments imposed on Germany by the Treaty of Versailles. The BIS administered international loans issued to finance reparations (the Dawes and Young Loans) and promoted central bank cooperation in general. In addition, the BIS provided or organized emergency financing to support the international monetary system when time was of the essence. For example, during the 1931-33 financial crisis, the BIS organized support credits for both the Austrian and German central banks (Borio & Toniolo, 2006).

Stabilizing the economy: rebuilding after WWII

The experience of badly handled crises after WWI, as well as some good experiences in public development initiatives — for example, the role of the Reconstruction Finance Corporation in the New Deal in the USA — changed the mandate of most central banks after WWII. Central banks were nationalized and assigned the role of economic development and maintaining full employment (Goodhart, 2011). This was deemed essential for the stability of the economy and society, and hence the financial system. Similar shifts in thinking occurred in the UK, Canada, and Continental Europe, with the notable exception of Germany and Switzerland (Epstein, 2007). The scope of central banks thus widened, effectively institutionalizing roles that some central banks and treasuries had already assumed before WWII.

The costs of reconstruction and industrialization are not easy to identify as funds came from different sources, both public and private. A rudimentary proxy is obtained comparing pre-war and post-war investment levels. Average non-residential fixed investments (investments in production capacity) in Europe after WWII were six percentage points of GNP higher than before the war (Eichengreen, 1995). This is not complete as investments in non-commercial real estate are excluded. However, it does include the application of new technologies developed during the war.

Canada's central bank lending to SMEs after WWII

Canada founded its central bank relatively late, in 1935. The bank was established specifically in order to alleviate the consequences of the Great Depression. It started with a loose monetary policy and a $4 million advance to the government (Ryan-Collins, 2015). Aside from direct advances, it purchased government securities and maintained a low bank rate. In the initial period the Bank funded over two thirds of government expenditure and increased currency in circulation by 70 percent (Ryan-Collins, 2015). It also played an active role in financing the war effort. None of this sudden explosion in financing proved to be inflationary, as industrial development also grew rapidly. The highest inflation rate in the period between 1935 and 1945 was six percent in 1941 (BIS, 2019).

A special role in the post-war development of Canada was played by the Industrial Development Bank (IDB). It was created in 1944 as a subsidiary of the central bank — fully funded by new money creation — to lend to small and medium enterprises (Ryan-Collins, 2015). During its life it made 65,000 loans with a total value of $3 billion. In the last decade of its existence, its loans amounted to a quarter of bank lending to the non-financial sector (Ryan-Collins, 2015).

Some central banks, like the Fed, were given a dual mandate, maintaining both price stability and full employment (Bordo & Siklos, 2018). In Europe, for instance, the Dutch Central Bank Act of 1948, gave the DNB goals of price stability and full employment and, more generally, the creation of conditions for economic growth (Westerhuis & van Zanden, 2018).

In Europe, credit controls were the instruments of choice for central banks. Credit controls modify the cost and availability of credit that markets would otherwise generate. These measures have been used for a variety of purposes, from financing government debt to allocating resources in the real economy (Epstein, 2007; Monnet, 2018).

In France, the Banque de France used variable asset-based reserve requirements for commercial banks in order to promote lending for various assets deemed nationally beneficial (Epstein, 2007). The Banque had insight into individual loans of commercial banks and could control sectoral targeting of these loans. It also reduced interest rates for privileged industries (Epstein, 2007).

The role of central banks in economic development was even more pronounced in the Global South. These countries experienced swift industrialization after WWII which was often supported, to a large extent, by their central banks (Epstein, 2009). They assumed the role of development banks by, among others, providing capital to or purchasing securities and equity of development institutions, such as industrial and agricultural development banks (Epstein, 2009). Central banks

Inflation in countries with vs. without monetary financing, 1956–1970

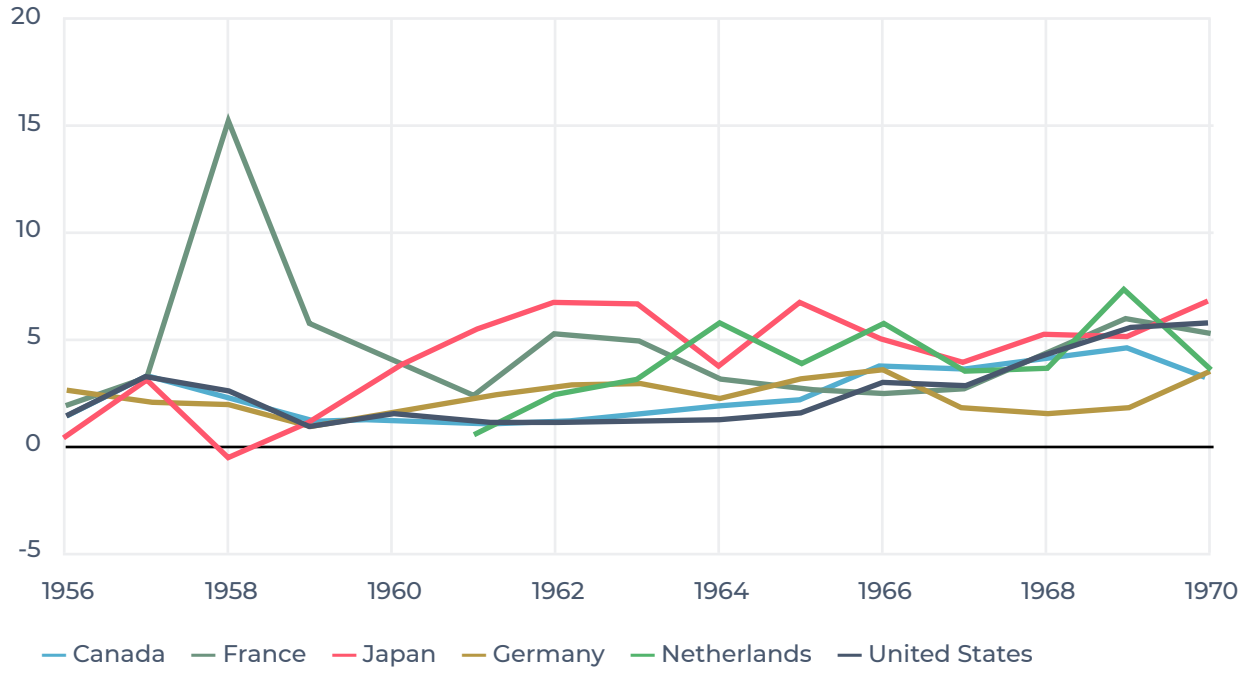

Figure 1 OECD data. Authors' calculations

have also established ceilings on activities having a low priority or set unfavorable reserve requirements for these activities (Epstein, 2009).

In Korea, the government directly targeted sectors it intended to fund, setting low interest rates and advancing loans directly to individual firms. The central bank was under the strong control of the Ministry of Finance and was given little political power. Its sole mandate was *de facto* credit control (Epstein, 2009).

Inflation was not markedly higher in countries with more active monetary stimulus, such as France, Canada, and Japan (in red in the graph).[5]

Inflation increases in the late 1970s hit almost all industrialized countries equally, irrespective of the monetary stimulus provided. Other factors may therefore better explain this inflation: the end of the Bretton Woods system, and especially the trade deficit of the USA that continued growing after the need for imports from the USA declined on completion of reconstruction (Vernengo, 2006) and the two oil price shocks (Bordo & Orphanides, 2013).

5. The spike in France in 1958 was not as a result of monetary policy, but rather a result of the 'Algiers putsch' or the 'Coup of 13 May' when Charles de Gaulle returned to power. In Korea, another country with an active monetary financing by the central bank, inflation was markedly higher, especially in the 1950s, shortly after the Korean War.

Stabilizing the financial sector through money creation

Too much money creation can lead to price instability. Hence, for most of their history, central banks have moderated money growth, injecting extra liquidity only in times of crisis. Identifying that moment of crisis is one of the hardest calls for central bankers to make. Failure to recognize this need has had devastating consequences, as the history of the 1930s showed. Milton Friedman and Anna Schwartz (1963) most famously argued that the effects of the Great Depression would have been avoidable, had the Fed executed massive open market operations to keep the yields down and backstop the banks (Broadbent, 2018). At the time, this policy was on the table within the Fed. Its New York branch was in favor but was opposed by the Board in Washington and by the reserve banks of the "interior" (Broadbent, 2018).

In 2002, then Fed Board member Ben Bernanke indicated that the Fed had learned its lesson: "I would like to say to Milton and Anna: Regarding the Great Depression. You're right, we did it. We're very sorry. But thanks to you, we won't do it again" (Bernanke, 2002). Only a few years later, then Chairman of the Fed Bernanke, proved he had indeed learned the lesson by leading an unprecedented effort of the Fed to support the financial system and the broader economy through successive rounds of 'quantitative easing' (QE), new money creation by the central bank used for bond purchase. This started in November 2008 with the purchase of US$600 billion worth of government-sponsored-enterprises' debt and mortgage-backed securities (QE1) (Bernanke, 2008). QE lasted in the USA until 2013. Across the Atlantic, the Bank of England started its first round of QE in 2009.

The USA and UK essentially followed the script of quantitative easing written by the Bank of Japan (BoJ). The BoJ was the first to hit the zero-lower bound with its interest rate in 1995. It went on to implement a quantitative easing policy (QE) in 2001–2006.

Coming in last, the ECB also implemented QE in 2015. The program was extended until 2018. Although it was mainly focused on government bonds — the Public Sector Purchase Programme (PSPP) — it included other parallel sub-programs, namely the Corporate Sector Purchase Programme (CSPP), the Asset-Backed Securities Purchase Programme (ABSPP), and the Third Covered Bond Purchase Programme (CBPP3).

In all of these countries, QE programs were controversial. Possibly the fiercest discussion raged in the Eurozone, where, in particular, the Northern Euro-countries questioned the legitimacy of these QE programs, arguing they could result in 'monetary financing', which is explicitly forbidden by the EU Treaty (see box).

Monetary finance: between prohibition and proportionality

On 10 May 2010, the ECB announced its "Securities Markets Program" (SMP), involving the purchase of sovereign bonds in secondary markets. Only four days earlier, after its regular meeting of May 6, then ECB president Jean-Claude Trichet had denied the possibility of purchasing sovereign bonds. The ECB's bond buying focused primarily on Spanish and Italian debt. Then Bundesbank president Axel Weber argued that "SMP risks blurring the different responsibilities between fiscal and monetary policy" (de Haan, 2018). As a result of this dispute Axel Weber resigned as president of the Bundesbank and member of the ECB Governing Council in April 2011, one year before the end of his term, and the German chief economist of the ECB, Jürgen Stark, resigned in September 2011.

The SMP ended when in August 2012 the ECB announced conditional Outright Monetary Transactions (OMT) for Eurozone member states in need of monetary assistance. Legality of the OMT was also challenged in Germany. A Bundesbank document filed in Germany's Federal Constitutional Court pointed out the risks of OMT for central bank independence by bringing monetary policy too close to the realm of fiscal policy (Evans-Pritchard, 2013). The European Court of Justice decided, however, that "This program for the purchase of government bonds on secondary markets does not exceed the powers of the ECB in relation to monetary policy and does not contravene the prohibition of monetary financing of Member States" (Court of Justice of the European Union [CJEU], 2015). Despite there being a risk of monetary financing — "that the ECB's intervention could, in practice, have an effect equivalent to that of a direct purchase of government bonds" — the ECJ ruled that the ECB response was proportional as it "does not go manifestly beyond what is necessary to achieve the objectives it pursues." (CJEU, 2015). In 2019, Bundesbank president Jens Weidmann acknowledged the legality of OMT and accepted that it was "current policy" of the ECB (Schieritz, 2019). However, when in September of that year the ECB decided to restart the ECB's bond buying program, the German ECB Board member Lautenschlager resigned over this decision.

During the monetary stimulus of 2008 and in subsequent years there were many warnings that QE would lead to runaway inflation (CNN, 2010; Economist, 2012). However, more than ten years later, and with monetary stimulus far higher than anticipated, inflation is still *below* target.[6]

6. For the Eurozone data see: https://sdw.ecb.europa.eu

Conclusion: extending their role to safeguard stability

We see an historical development in the role of central banks: from being, primarily, banks of issue to, increasingly, guardians of stability. Following the era of free banking, central banks were assigned the task of keeping overall money creation within limits. However, interestingly, to protect the stability of the wider financial and economic system, central banks have repeatedly resorted to creating money. These interventions spanned from injecting liquidity into the financial system to financing economic development before and after WWII and, most recently, keeping long term interest rates down through QE.

Among central bankers there is a broad consensus that their predecessors failed in the 1930s, leaving economies in deflationary spirals with rising unemployment and political upheavals that resulted in a world war with unprecedented human suffering and devastating effects on inflation almost everywhere.

← Back to Contents

5. THE MONETARY RESPONSE TO CLIMATE CHANGE

We have seen how, throughout history, monetary policy has supported governments taking on the challenges of their times — and what the effects have been on price stability. In this chapter we look at the lessons current monetary policymakers can draw from these experiences for what may be the largest challenge of our age: climate change.

To this end we discuss in what respects the challenges that climate change poses are comparable to those that central banks have faced before. We start by discussing the specific challenge of climate change. Then we discuss how climate is currently taken into account by central banks, in particular the ECB. To answer the question 'What monetary policy responses may be warranted in the face of climate change?' we use the same two lenses we used for the history of monetary policy: central banks as the provider of emergency funding and central banks as the guardian of price stability — including central banks' role in the development of new infrastructure or in reconstruction after a disaster.

The challenge of climate change

The changing climate

In 2017, human-induced global average warming reached approximately one degree Celsius over pre-industrial times. Global average temperature is projected to increase 0.2 degrees Celsius per decade, if emissions continue at the current rate (IPCC, 2018a; IPCC 2018b). According to the United Nations Environment Program (UNEP), the current commitments of the Paris Agreement signatories still lead us on a trajectory of global warming exceeding three degrees Celsius in 2100 (UNEP, 2018). This can set off tipping points, such as the melting of the ice on Greenland, resulting in sea levels rising by six meters and threatening megacities such as New York and Mumbai (Pigato, 2019). The regional impacts of climate change vary from increased risk of floods, decreased crop yield and coast erosion in Europe, to water shortages in East, Central, South and South East Asia and decreased precipitation and food shortages stemming from drought in Africa (Piguet & Laczko, 2014).

Economic costs of climate change

Climate change has both economic costs and benefits. However, on a global scale the costs are projected to be much higher than the benefits. The costs of physical changes in the climate result from decreased production capacity, negative impacts on workforces (heat stress and increased disease-burden), write-offs of existing assets, increased operating costs, increased capital costs, reduced revenues from lower sales/output, increased insurance premiums, and reduced availability of insurance on assets in "high-risk" locations (TCFD, 2018). Droughts, decreased crop yields, floods and extreme weather conditions can drive large migrations (World Bank, 2018).

The first study into the global macroeconomic effects of climate change is that of Stern (2007). He estimates that if no new mitigation is undertaken the overall costs and risks of climate change will be equivalent to losing at least 5 percent of global GDP. Wider estimates of damage yield costs of 20 percent of GDP or more. 'Socially contingent' impacts, such as migration and conflict, were not quantified in this study (Stern, 2007).

After Stern, many other studies tried to quantify the effect of climate change. An overview of the literature by the Dutch Environmental Assessment Agency (PBL) shows economic damage ranging from 10 percent to 47 percent of global GDP if the temperature increase reaches four degrees Celsius (PBL, 2014). In more recent studies the economic damage of such a scenario is estimated at between 4 percent of GDP (Nordhaus & Moffat, 2017) and 40 percent of GDP (Burke et al., 2015), with 16 percent of GDP as the best estimate (Howard & Sterner, 2017).

Like the physical consequences of climate change, the impact on the economy is not geographically uniform. The countries in the Global South will be more affected than in the North. Burke et al. (2015) estimate that by 2100 GDP per capita in South Asia, Southeast Asia and Sub-Sahara Africa will be 80 percent lower should global warming hit 3.7 degrees Celsius compared to a scenario without climate change. Weitzman (2009) even speaks of potentially infinite costs of unmitigated climate change, including, in the extreme, human extinction.

Such model exercises have limitations. Political risks in particular, the risk of countries or citizens turning on each other, is ignored while these risks can have the greatest impact in the short term. The US Department of Defense has called climate change a "threat multiplier" as it exacerbates existing tensions within and between nations (Department of Defense, 2014). This is a mechanism we may have seen recently in Syria, see the discussion on the relationship between climate change, the hot and dry summers in Syria, and the war that has erupted there (Karak, 2019).

Costs of mitigation and adaptation and current investments

Compared to the costs of runaway climate change, the costs of mitigation (preventing climate change) are much lower. Stern (2007) sets these costs, using available technologies, at one percent of GDP. In a broader literature study, the Dutch Environmental Assessment Agency finds estimates of the costs of mitigation of between one and three percent of worldwide GDP annually (PBL, 2014).

A report by the New Climate Economy estimates the global infrastructure investment need at US$90 trillion between 2015-2030. This includes renewing existing infrastructure in developed nations, but more importantly, new infrastructure that is needed in the developing world due to rapid urbanization, population growth, and other structural changes.

The report finds that the extra costs of making these infrastructure investments sustainable is modest. A shift to low-carbon investments would add about US$4 trillion, or about US$270 billion per year, to the total bill of US$90 trillion, which is less than a five percent increase in the cost of projected aggregate infrastructure investment requirements. The report stresses that infrastructure investment decisions currently being made will determine whether limiting climate change can be achieved, as these investments will 'lock in' a level of energy use for decades to come (Global Commission on the Economy and Climate., 2014).

Despite the relatively low costs of making the economy more sustainable and the urgency of making the investments, these efforts are not being made. The European Commission has estimated that the 'finance gap' of the energy transition for Europe alone is €180 billion a year (EC, 2019). Others estimate the funding gap globally to be between US$650 billion and US$900 billion, annually (Campiglio, 2016).

Also, investments for adapting to a changed climate lag behind what is needed. In 2010, the World Bank estimated that for the developing world, adaptation costs of climate change will be US$70 to US$100 billion a year (Margulis et al., 2010). UNEP (2016) estimates that the costs of climate change adaptation are two to three times higher than what is currently being raised for that purpose by governments and markets.

Central bankers and climate change: the current situation

Climate change and supervision

Both the costs of climate change and the costs of adaptation and mitigation will affect the financial sector. Climate change in that sense is a material risk to financial stability and hence requires the attention of supervisors (Schoenmaker, van Tilburg & Wijffels, 2015). That climate change poses a material risk to the stability of individual financial institutions and of the financial system as a whole is understood by most central bankers (ECB 2020a; NGFS 2020b).

Today most central banks have started work on climate risks. Since 2017 over 70 central bankers and supervisors joined the Network for Greening the Financial System (NGFS). NGFS-members acknowledge that "climate-related risks are a source of financial risk" and that dealing with climate change therefore falls squarely "within the mandates of central banks and supervisors to ensure the financial system is resilient to these risks" (NGFS, 2018).

Central banks in emerging economies were front-runners in taking the environment into account. Early examples are the central banks of Brazil (see box), Nigeria, Bangladesh, Lebanon and Indonesia (UNEP, 2015). This could be because, in these economies, environmental regulation is often not, or only weakly, implemented, as weak public institutions lack clout. These economies are often more dependent on agriculture and, hence, the state of the environment. Central banks and other financial regulators are often the most respected and advanced institutions in these countries, with a tradition of interventionist and developmental policies (Dikau & Ryan-Collins, 2017; UNEP, 2015; Volz, 2017).

Brazil: Greening Basel III in 2011

Brazil is rich in natural resources and its economy is very reliant on those resources. So much so, in fact, that the Superior Court of Justice decided that financial institutions such as banks could "face potentially unlimited liability for environmental damage caused by borrowers" (UNEP, 2015, p. 20). As a result, the central bank of Brazil (Banco Central do Brasil) mandated all commercial banks to take environmental risks into account as a part of Basel III regulation. It is the first central bank in the world to do so (UNEP, 2015).

Climate change and the tactics of monetary policy

As discussed above central banks acknowledge the relevance of climate change for their role as supervisors and as guardians of financial stability. They also acknowledge the impact of climate risks on monetary policy and on their own balance sheets.

First, there is a growing recognition that climate change, and its mitigation, influence relevant macro-economic variables, including inflation. Even in a more benign energy transition scenario, shifts in the energy mix and, hence, relative prices of energy sources could destabilize inflation expectations. For instance, a sustained rise in the relative price of carbon could impact wage negotiations, leading to a wage-price spiral. For this reason, central banks are increasingly studying the impact of climate change and integrating it into their macro-economic forecasts (Batten, Sowerbutts & Tanaka, 2016; Cœuré, 2018; McKibbin et al., 2017; NGFS 2020).

Secondly, there is a growing recognition that climate risks need to be taken into account for the central banks' own balance sheets, for instance through their large-scale asset purchase programs or collateral frameworks. It is part of central banks fiduciary duty to manage all risks, including climate risks (Krogstrup & Oman 2019; European Parliament, 2019).

Engaging in QE, central banks have been buyers of corporate bonds. Currently their portfolios are more carbon intensive than the economy as a whole (Matikainen, Campiglio & Zenghelis, 2017). As such, central banks are exposed to relatively large transition risks, risks like investments in oil fields losing their value as the switch to clean energy sources accelerates. To illustrate, if these transition risks were taken into account, five percent of the corporate bonds purchased by the ECB could face a credit rating downgrade to the extent that they would no longer be eligible for purchase (Monnin, 2018).

In its current Strategic Review, the ECB is studying how to factor climate into its decision-making. In that context, ECB president Christine Lagarde stated that the ECB wants "to explore every avenue available in order to combat climate change" (Khalaf & Arnold, 2020). To this end Lagarde mentioned, inter alia, that the ECB will re-examine its collateral, i.e. the assets pledged by banks as security for ECB-funding, to ascertain whether those have been valued correctly, taking climate risk into account (Salamé & Sotto, 2020). ECB board member Isabel Schnabel added to this the possibility of linking the eligibility of securities for ECB purchases and as collateral to the disclosure regime and climate risks of the issuing firms (Schnabel, 2020).

Mitigating climate change as a strategic driver of monetary policy

Climate change is thus increasingly taken into account in the implementation of monetary policy at the tactical level. However, climate change does not yet drive monetary policy actions. Can and should climate change also be a strategic driver of monetary policy?

Among others, this question is on the table at the current ECB Strategic Review. The ECB is "investigating if and how our monetary policy operations and portfolios could be adjusted to reflect the fact that climate change, if not addressed swiftly, may affect the economy in ways that pose potentially material risks to price stability in the medium to long term" (Schnabel, 2020). This may lead the ECB to exclude bonds that are used to finance projects that conflict with the decarbonization objectives of the EU (Schnabel, 2020). In addition, President Lagarde stated that the ECB will very likely use the fight against climate change as a parameter when calibrating its programs for purchasing assets (Salame & Sotto, 2020).

There are two reasons why supporting governments in their efforts to mitigate climate change is within the mandate of central banks, including the ECB.

First, like the energy transition, climate change has the potential to have long-lasting effects on aggregate supply and demand, and thereby on inflation. (Cœuré, 2018; Krogstrup & Oman, 2019; Lagarde, 2021; McKibbin et al., 2017; Schnabel, 2020). On the one hand, the physical damage of climate change can set off a negative supply shock, e.g. raising food prices after harvests have been damaged by extreme weather. Until now, these have mostly been seen as one-offs, with monetary policymakers expecting inflation levels to return to their pre-shock levels without any monetary policy reaction. However, increases in both the impact and the frequency of such shocks may force monetary authorities to raise interest rates to dampen inflation, thereby further hurting the economy (McKibbin et al., 2017; Cœuré, 2018). On the other hand, climate-related supply shocks may become adverse demand shocks. Rising sea levels, for example, could lead to abrupt re-pricing of real estate in exposed regions, causing large negative wealth effects that, if uninsured, may weigh on demand and prices, and have a deflationary effect (Cœuré, 2018).

Secondly, even without these destabilizing effects on prices, central banks ought to act to help prevent climate change or at least not go against the policies of the government.

Most central banks have secondary objectives in their mandates that include contributions to general economic welfare (Dikau & Volz, 2019). For instance, the ECB mandate states that, without prejudice to the objective of price stability, the ECB must support the general economic policies in the Union with a view to contributing to the achievement of the goals of the Union. These goals explicitly include environmental objectives (Treaty on the Functioning of the European Union, Article 127). In practice, however, central bankers have so far tended to neglect this objective as they feared it would bring them into political waters. As ECB's Cœuré (2018) stated "one could equally ask, for example, why the ECB should not promote industries that promise the strongest employment growth". Central bankers fear that making choices with regard to prioritization of such secondary objectives threatens their independence, which is based on a narrow mandate of inflation targeting (Tucker, 2018).

There is, however, an important distinction between employment and climate as a secondary objective due to the different nature of the trade off with price stability in the short- and long run. Historically the secondary objective has been economic growth or employment. Here there was a well-established trade-off between prices and employment/growth. This led to a consensus among central banks that long-term employment/growth is best served with a sole focus on price stability. In the case of climate change this relationship is different, as a changing climate may in the long run actually threaten price stability. Support for government policies to mitigate climate change thus contribute to price stability in the medium to long term.

Another line of reasoning starts with the observation that the central bank, through its impact on financial markets and banks, steers the direction of the economy. Due to market failures a market neutral approach may then be at odds with the general economic goals of the Union (Schnabel, 2020). As discussed above, this argument has been made with respect to the ECB's Corporate Sector Purchase Programme (Matikainen, Campiglio & Zenghelis, 2017). More recently the case has also been made that climate should be taken into account in refinancing operations for banks. In the Targeted Longer-Term Refinancing Operations (TLTROs), banks are "enticed to ramp up their unsustainable lending practices. By providing cheap funding without applying any environmental criteria, the ECB accelerates a set of market practices that may be unsustainable; fund carbon lock-in and keep funding rates too low for unsustainable business models" (van 't Klooster & van Tilburg, 2020).

The historical perspective on climate change as a monetary question

Increasingly, both climate change and the energy transition are recognized as being relevant for monetary policy. In this section we look at which monetary policy responses may be warranted in the face of climate change and the energy transition. How are the challenges of climate change comparable with other challenges faced by central banks in the past? What were the reactions of central banks then, and what results did they achieve?

We use the two lenses we applied when looking at the history of monetary policy: the central bank as financier of emergency funding and the central bank as guardian of stability — including central banks' role in development of new infrastructure or in reconstruction after disaster.

Climate change as a case of fiscal emergency spending

As discussed, runaway climate change will impact the economy through a general decline in labor productivity and an increased incidence of natural disasters. The severity of these impacts grows quickly once temperature increases exceed one and a half to two degrees.

We have seen, in times of large natural disasters, a clear role for monetary policymakers e.g. the 2011 Great East Japan Earthquake and the Canterbury Earthquakes in New Zealand. In both instances, international coordination between central banks, (re)insurance and foreign holdings of financial institutions meant that costs could be shared across borders. This may not always be possible in the future. Insurance for ever more frequent and predictable natural disasters will become increasingly expensive, if available at all. If the ability to spread risks diminishes at the same time as governments are faced with increasing costs and lower tax receipts, central banks may need to be more active in financing reconstruction.

In recent years, comparisons have been made between the experience of WWII and climate change (McKibben, 2016; Rockoff, 2016; Stiglitz, 2019). These comparisons take account of two dimensions:

1. The damage that climate change, an existential threat, can do, and
2. The economic effort needed to fight this challenge.

With regards to the first, the extent of the potential damage of climate change matches, or is even greater than, the most expensive wars ever fought. As the history of wars shows, it is almost impossible to preserve price stability in such circumstances. (Hyper)inflation often follows periods of war and geopolitical upheavals — irrespective of monetary policy choices.

Table of economic costs (% GDP) and peak inflation (%)

(annual, * = hyper = monthly)

	Economic costs	Peak inflation
First World War Germany	60	29500 (1922)*
First World War France	50	40 (1922)
Second World War Hungary	n/a	$4.2*10^{16}$ (1946)*
Second World War USA	37	14 (1947)
Climate change 3–4°C (global average, current pathway)	15–45	?
New Deal USA (1933–1936)	15 (average)	4.9 (1934)
Reconstruction Europe 1960s	6	5 (average)
War on Terror (USA) (2001–2010)	1.2 (peak, 2008)	2
Limiting climate change to 2°C (global average)	1–3	?

Source: Broadberry & Harrison (2005), Bureau of Economic Analysis data, Cappella (2012), Dupor (2017), Eichengreen (1995), Hanke & Krus (2012), PBL (2014), Rockoff (2014, 2016), Zielinski (2018); authors' calculations

With regard to the second, limiting climate change through successful mitigation, we see that these costs are much lower than those of, for example, WWII — the war most often used for comparison. During WWII the costs of war in the USA peaked in 1945 at 35.8 percent of GDP (Zielinski, 2018), while the estimated costs of preventing climate change are 1-3 percent of GDP (PBL, 2014). This is, for instance, lower than the costs to the USA of the recent wars in Iraq and

Afghanistan, which peaked in 2008 at 1.2 percent of GDP (Zielinski, 2018). During WWII in the USA there was a moderate monetary stimulus, while in the recent wars there was none.

Runaway climate change can incur economic costs similar to periods of war and geopolitical upheaval – periods that have historically resulted in high or even hyperinflation. As we discussed in chapter three, this was the case irrespective of the policy reaction of central banks. So, if safeguarding price stability is the primary objective, the strategy should be to avoid runaway climate change in the first place.

The question for central bankers is what they can contribute to government efforts to limit climate change, and not only as a secondary objective, but rather as an indispensable step in attaining their primary goal of price stability.

Climate mitigation and adaptation as stability objectives

What about the role of central banks in development and reconstruction? Let us consider the development of a globally sustainable energy infrastructure. The role central banks played in the crisis of the 1930s and in the reconstruction after WWII resembles, in both scale and time span, the current mitigation and adaptation challenge. We have seen that in most of these cases central banks supported development and reconstruction by keeping interest rates low, while also giving more active monetary support. Examples for this are Canada, France, Japan and Korea.

From the size of the costs of mitigation one could conclude that support through any kind of monetary policy should not be needed. However, climate change has distinct features that may make it harder to mobilize funding than in previous reconstruction and industrialization periods. Private funding may not materialize in sufficient amounts, as there may not be political support for sufficiently pricing externalities. For the same reason, public funding may fall short, as there may not be political support for either raising taxes or increasing government debt.

Rockoff (2016) points out that the will necessary to establish a transition, such as is now needed to limit climate change, has only ever appeared during war time. However, climate change challenge is different from war making it harder to finance:

1. The nature of the threat is much less tangible and acute. Climate change is a gradual process that creeps up on us before we notice it. Wars typically escalate much more quickly.
2. There is no clear external enemy. The problem lies rather in our own lifestyle (Scranton, 2019).
3. Limiting climate change requires an unprecedented level of global coordination. Some nations can free-ride on efforts of others.
4. By the time a climate change equivalent of Pearl Harbor presents itself, for instance in the form of an unprecedented natural calamity, it may well be too late to stay within the one and a half to two degrees limit.

5. Lastly, McKibben (2016) points out that large industrial actors and governments have no incentive to join climate change mobilization, as that would impact their bottom lines and reputations. McKibben argues that in the mobilization for WWII there were more winners, i.e. companies that needed to produce more rather than less.

For these reasons, governments may not be able to rise to the occasion. Therefore, the current mantra of central bankers that the first and best solution is for policy-makers to implement the necessary climate policies, like carbon pricing, may not materialize to a sufficient degree (Cœuré, 2018; NGFS, 2019). Central bankers need to consider the 'what if governments cannot do it alone'-scenario. In this scenario central banks need to play a more active role in order to avoid a situation where economic, financial and price stability is no longer within reach, hurting both the primary and secondary objectives of central banks.

The specific characteristics of climate change that make it hard for democratically elected governments to cooperate may be much less of a problem for the global central banking community. We saw that in some emerging economies central banks took the lead in environmental preservation. It could very well be that for similar reasons central banks can now play a more important role globally as well, with regard to limiting climate change.

Clearly, climate change needs to be fought on a global scale. No solution is possible unless similar efforts are made in all the large economic blocks — including the emerging economies. This requires an unprecedented level of coordination by governments.

Central banks are a special case when it comes to international cooperation. They have a long history of intensive cooperation — going back at least to the establishment of the Bank for International Settlements in 1930 — fifteen years before the United Nations. And while the USA was in the process of withdrawing from the Paris Climate Accord, the New York State Department of Financial Services, signed up to the NGFS. Central bank mandates are also globally much more aligned — in contrast to mandates of governments which show large ideological dispersion and serve very different constituencies.

Central bankers also have much longer tenures than politicians. For instance, since WWII, the USA had thirteen presidents (average tenure of 5.77 years), but only nine heads of the Federal Reserve (average tenure 8.3 years). This means that heads of central banks stayed longer in office by on average 30 percent. For comparison, the Netherlands had twenty-nine parliaments (average tenure of 2.58 years), but only six presidents of its central bank (average tenure of 12.5 years).

Years of government and central bank president in office
(average 1945-now)

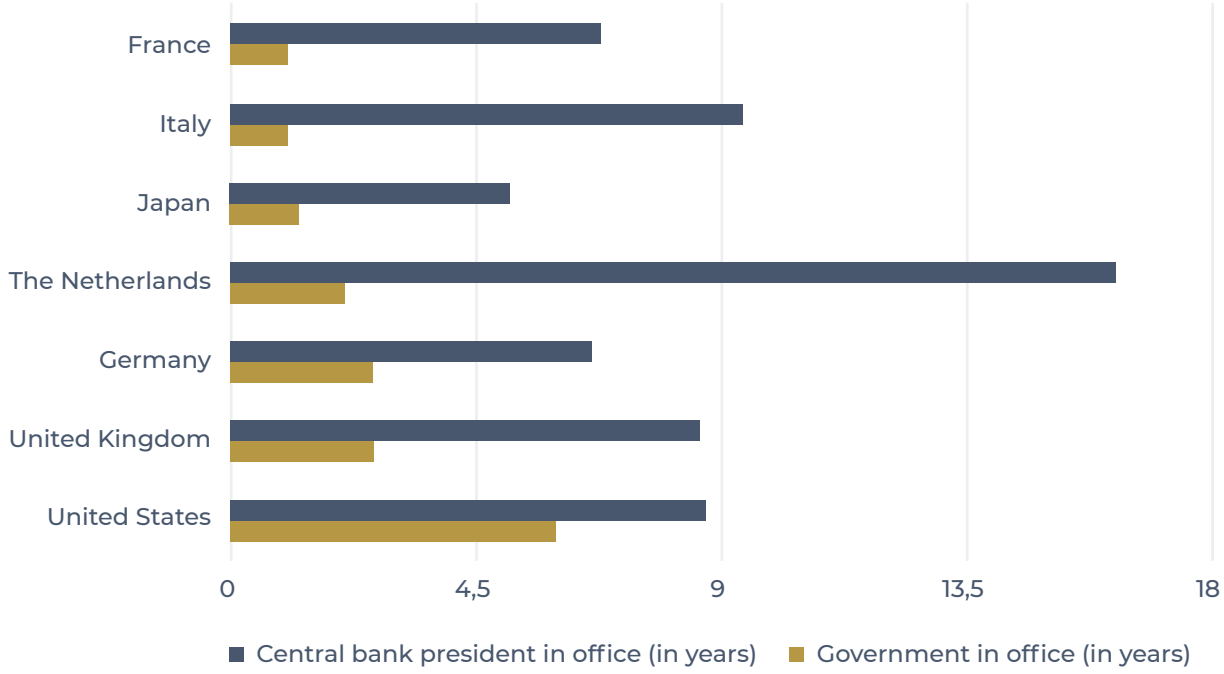

Figure 2 Source: parlgov.org

Conclusion: central bankers, globally, need to make a common developmental effort

With the Paris Accord governments signaled their willingness to limit climate change to below 1.5-2.0 degrees. This is a long term agreement — emissions are to be reduced over the coming decades.

Given their mandates, central banks need to support this effort — contributing to economic stability and progress. It does not prejudice the objective of price stability. In the current situation with persistent low interest rates and a pandemic causing economic pain, there seems to be ample room for monetary stimulus directed at accelerating the energy transition.

This paper has shown many historical precedents for a development role of central banks helping to finance large transitions. We have seen that central banks have made economic developments financially possible – developments of a similar size to the investments needed to limit climate change. And we have seen that they can do so without sacrificing price stability.

Most importantly, we have seen that central bankers share an interest in stabilizing the global climate — also from the perspective of price stability. The historical cases described in this paper show that maintaining price stability may be impossible in a scenario where climate change exceeds two degrees Celsius.

In such a scenario the economic damage may be comparable to the world wars — running in tens of percentage points of GDP.

Central Banks have a shared interest in preserving stability of prices and the wider economic and financial system, and to that end an interest in preventing climate change. Here lies the foundation for global coordination of their efforts — complementing and reinforcing efforts made by governments. Efforts that, as we have seen, are still wholly insufficient to reach the stated goal of limiting climate change to well below two degrees.

If central banks are successful at globally coordinating their development and reconstruction efforts to limit climate change, they will take the next step in their history of operating on an ever-larger geographical scale; thereby guarding the stability of currencies and the wider financial and economic system. For this, they will need to explore every avenue available.

6. HISTORICAL LESSONS FOR A MONETARY RESPONSE TO CLIMATE CHANGE

So, what lessons can be drawn from the history of central banking for an appropriate monetary reaction to the challenges of climate change? Here we bring the insights of the different chapters together in six lessons from monetary history.

1. Climate change seems incompatible with price stability

Climate change can cause unprecedented natural disasters, geopolitical upheavals and migration flows. The economic costs are measured in tens of percentage points of global GDP. The damage could be of an order of magnitude of the most disruptive and damaging wars. These wars were periods of high, or even hyperinflation. History shows that even smaller shocks of this nature have made it impossible to preserve price stability, whatever the monetary course of the central bank. This puts preventing climate change within the mandate of not only central banks as supervisors or as a secondary objective, but also as monetary policymakers with price stability as their primary objective.

2. Mitigating climate change is a development challenge on a manageable scale

The costs of runaway climate change dwarf the costs of limiting climate change — estimated at 1-3 percent of global GDP. While substantial, these costs are manageable. Both the scale and the time span of mitigation are comparable to the developments co-financed by central banks before and after WWII — developments that did not result in runaway inflation.

3. Fighting climate change may become politically feasible only when it is too late

Political action on climate change has been insufficient. It requires international coordination between countries with widely differing objectives, financial means and vulnerabilities to climate change. Despite the much lower costs, we may not

succeed in limiting climate change. Unlike war, there is no clear enemy in sight. Unlike natural disaster, the damage is not (yet) clearly visible. When a Pearl Harbor-moment arrives and galvanizes the political will to act, there may no longer be the possibility to effectively limit climate change.

4. Central banks are well positioned to catalyze climate mitigation

Central banks are particularly well suited to play a more active role, supporting government policies limiting climate change. They have one of the longest and most intensive histories of cooperation on a global scale — the scale at which cooperation is needed, and that has, so far, been lacking. Central bank mandates are globally much more aligned than the mandates of governments and central bankers have much longer tenures than politicians. Central banks also have unique and powerful instruments to support economic and financial development.

5. Central banks should formulate a common long-term strategy

In recent economic downturns central banks have developed unconventional instruments that have a strong impact on the real economy, influencing also the direction of its development. Such unconventional policies should stimulate in particular investments in the energy transition, thus also contributing to price stability in the medium and long term.

However, the energy transition will not be realized during one economic downturn. Monetary policymakers should, therefore, formulate a common global strategy to avoid runaway climate change, in which price stability may no longer be within reach.

Throughout history central banks have gone ‘every avenue available’ to help societies meet the challenges of their time. Now, central banks need to agree on a common course to safeguard the closely related objectives of stable prices and a stable global climate. By making investments in energy transition possible, central banks — as they did before and after WWII — take on their role in development.

If central banks are successful at globally coordinating these efforts to limit climate change, they will take the next step in their on-going history of operating on an ever-larger geographical scale. To explore every avenue available , a new dialogue on monetary policy is required: a dialogue on the pathways to sustainability from which a coordinated effort can follow that supports the governments’ efforts to achieve the global Paris Accord.

LITERATURE

Baack, B. (2008). *America's first monetary policy: Inflation and seigniorage during the Revolutionary War.* Financial History Review, 15(2), 15. https://doi.org/10.1017/S0968565008000127

Bagehot, W. (1873). *Lombard Street: A description of the money market.* London: HS King.

Bank of England. (2020, April 9). *HM Treasury and Bank of England announce temporary extension to Ways and Means facility.* www.bankofengland.co.uk/news/2020/april/hmt-and-boe-announce-temporary-extension-to-ways-and-means-facility

Bartsch, E., Boivin, J., Fischer, S., & Hildebrand, P. (2019). *Dealing with the next downturn: From unconventional monetary policy to unprecedented policy coordination.* Retrieved from www.blackrock.com/corporate/literature/whitepaper/bii-macro-perspectives-august-2019.pdf

Batten, S., Sowerbutts, R., & Tanaka, M. (2016). *Let's Talk About the Weather: The Impact of Climate Change on Central Banks* (Staff Working Paper No. 603; p. 38). Retrieved from Bank of England website: www.bankofengland.co.uk/-/media/boe/files/working-paper/2016/lets-talk-about-the-weather-the-impact-of-climate-change-on-central-banks.pdf

BBC. (2015, June 11). *S Korea cuts interest rates to record low amid Mers concerns.* BBC News. www.bbc.com/news/business-33089930

Benink, H. A., & Boonstra, W. W. (2014). *How Europe Could Escape deflation.* The OMFIF Commentary.

Bernanke, B. S. (2002). *FRB Speech. On Milton Friedman's ninetieth birthday. November 8, 2002.* Retrieved October 8, 2019, from www.federalreserve.gov/BOARDDOCS/SPEECHES/2002/20021108

Bernanke, B. S. (2008). *Speech: Federal Reserve Policies in the Financial Crisis. At the Greater Austin Chamber of Commerce, Austin, Texas.* Retrieved from www.federalreserve.gov/newsevents/speech/bernanke20081201a.htm

Bignon, V. & Flandreau, M. (2018). *The Other Way: A Narrative History of the Bank of France.* In R. Edvinsson, T. Jacobson, & D. Waldenström (Eds.), Sveriges Riksbank and the History of Central Banking. Cambridge, United Kingdom: Cambridge University Press.

Bindseil, U. (2019). *Central banking before 1800: A rehabilitation* (First edition). Oxford University Press.

BIS. (2019). *Consumer prices.* Retrieved October 23, 2019, from www.bis.org/statistics/cp.htm

Bollard, A., & Ranchhod, S. (2011). *Economic impacts of seismic risk: Lessons for Wellington.* Presented at the Rotary Club of Wellington and Victoria University of Wellington. Wellington, New Zealand. www.rbnz.govt.nz/-/media/ReserveBank/Files/Publications/Speeches/2011/4559344.pdf

Bolton, P., Despres, M., Pereira da Silva, L. A., Samama, F., & Svartzman, R. (2020). *The Green Swan: Central Banking and Financial Stability in the Age of Climate Change.* Bank for International Settlements, Banque de France.

Bordo, M. D. (1990). *The lender of last resort: alternative views and historical experience.* FRB Richmond Economic Review, 76(1), 18-29.

Bordo, M. D., & Hautcoeur, P. C. (2003). *Why Didn't France Follow the British Stabilization After World War One?* (No. w9860). National Bureau of Economic Research.

Bordo, M. D., & Orphanides, A. (2013). *The Great Inflation: The Rebirth of Modern Central Banking.* Chicago: University of Chicago Press.

Bordo, M. D., & Siklos, P. l. (2018). *Central Banks: Evolution and Innovation in Historical Perspective.* In R. Edvinsson, T. Jacobson, & D. Waldenström (Eds.), Sveriges Riksbank and the History of Central Banking (pp. 26–89). Cambridge, United Kingdom: Cambridge University Press.

Borio, C., & Toniolo, G. (2006). *One hundred and thirty years of central bank cooperation: A BIS perspective* (BIS Working Papers No. 197). Bank for International Settlements. www.bis.org/publ/work197.pdf

Broadbent, B. (2018). *The history and future of QE, Speech Society of Professional Economists, London.* Retrieved October 8, 2019, from www.bis.org/review/r180724c.pdf

Broadberry, S., & Harrison, M. (2005). *The economics of World War I: An overview.* In S. Broadberry & M. Harrison (Eds.), The Economics of World War I (pp. 3–40). https://doi.org/10.1017/CBO9780511497339.002

Burke, M., Hsiang, S. M., & Miguel, E. (2015). *Global non-linear effect of temperature on economic production.* Nature, 527(7577), 235.

Campiglio, E. (2016). *Beyond carbon pricing: The role of banking and monetary policy in financing the transition to a low-carbon economy.* Ecological Economics, 121, 220-230.

Cappella, R. (2012). *The Political Economy of War Finance* (PhD dissertation, University of Pennsylvania). Retrieved from https://repository.upenn.edu/edissertations/1175

CDC. (2004). *Fact Sheet: Basic Information about SARS* (p. 3). Center for Disease Control and Prevention. www.cdc.gov/sars/about/fs-SARS.pdf

Cheng, J., Skidmore, D., & Wessel, D. (2020, July 17). *What's the Fed doing in response to the COVID-19 crisis? What more could it do?* Brookings Institution. www.brookings.edu/research/fed-response-to-covid19/

CNN. (2010). *Quantitative easing 2 is here: Federal Reserve - Nov. 3, 2010.* Retrieved October 17, 2019, from https://money.cnn.com/2010/11/03/news/economy/fed_decision/index.htm

Cœuré, B. (2018). *Monetary policy and climate change.* Retrieved October 8, 2019, from www.ecb.europa.eu/press/key/date/2018/html/ecb.sp181108.en.html

Coppola, F. (2019). *The Case for People's Quantitative Easing.* Cambridge: Polity Press.

Court of Justice of the European Union. (2015). *The OMT programme announced by the ECB in September 2012 is compatible with EU law* [Press release]. Retrieved from https://curia.europa.eu/jcms/upload/docs/application/pdf/2015-06/cp150070en.pdf

Dawood, F. S., Iuliano, A. D., Reed, C., Meltzer, M. I., Shay, D. K., Cheng, P.-Y., Bandaranayake, D., Breiman, R. F., Brooks, W. A., Buchy, P., Feikin, D. R., Fowler, K. B., Gordon, A., Hien, N. T., Horby, P., Huang, Q. S., Katz, M. A., Krishnan, A., Lal, R., Widdowson, M.-A. (2012). *Estimated global mortality associated with the first 12 months of 2009 pandemic influenza A H1N1 virus circulation: A modelling study.* The Lancet Infectious Diseases, 12(9), 687–695. https://doi.org/10.1016/S1473-3099(12)70121-4

Department of Defense (DoD) of the United States (2014). *Quadrennial defense review.* https://archive.defense.gov/pubs/2014_Quadrennial_Defense_Review.pdf

Dikau, S., and Ryan-Collins, J. (2017). *Green Central Banking in Emerging Market and Developing Country Economies.* New Economics Foundation. Retrieved from: https://eprints.soas.ac.uk/24876/1/Green-Central-Banking.pdf

Dikau, S., and U. Volz, (2019). *"Central Bank Mandates, Sustainability Objectives and the Promotion of Green Finance,"* SOAS Department of Economics, Working Paper No. 222.

Dupor, B. (2017, February 10). *The Recovery Act of 2009 vs. FDR's New Deal: Which Was Bigger?* Federal Reserve Bank of St. Louis. www.stlouisfed.org/publications/regional-economist/first_quarter_2017/the-recovery-act-of-2009-vs-fdrs-new-deal-which-was-bigger

Economist. (2012). *QE, or not QE?* Retrieved October 17, 2019, from www.economist.com/finance-and-economics/-2012/07/14/qe-or-not-qe

Edvinsson, R., Jacobson, T., & Waldenström, D. (2018). *Introduction.* In R. Edvinsson, T. Jacobson, & D. Waldenström (Eds.), Sveriges Riksbank and the History of Central Banking (1st ed., pp. 1–25). Cambridge, United Kingdom: Cambridge University Press.

Eichengreen, B. (1995). *Mainsprings of Economic recovery in post-war Europe.* In B. Eichengreen (Ed.), Europe's post-war recovery (pp. 3–38). Cambridge, United Kingdom: Cambridge University Press.

Eichengreen, B. (2018). *The Two Eras of Central Banking in the United States.* In R. Edvinsson, T. Jacobson, & D. Waldenström (Eds.), Sveriges Riksbank and the History of Central Banking (1st ed., pp. 361–387). Cambridge, United Kingdom: Cambridge University Press.

Elgie, R., & Thompson, H. (1998). *The politics of central banks.* In Routledge Advances in International Relations and Politics: Vol. 7. London; New York: Routledge

Epstein, G. (2007). *Central Banks as Agents of Economic Development.* In H.-J. Chang (Ed.), Institutional Change and Economic Development (First edition, pp. 95–114). London, New York, Delhi: Anthem Press.

Epstein, G. (2009). *Post-war Experiences with Developmental Central Banks: The Good, the Bad and the Hopeful.* United Nations Conference on Trade and Development.

European Central Bank (2020a). *Guide on climate-related and environmental risks; Supervisory expectations relating to risk management and disclosure.* www.bankingsupervision.europa.eu/legal-framework/publiccons/pdf/climate-related_risks/ssm.202005_draft_guide_on_climate-related_and_environmental_risks.en.pdf

European Central Bank. (2020b). *ECB announces €750 billion Pandemic Emergency Purchase Programme (PEPP)* [Press release]. www.ecb.europa.eu/press/pr/date/2020/html/ecb.pr200318_1~3949d6f266.en.html

European Central Bank. (2020c). *ECB announces easing of conditions for targeted longer-term refinancing operations (TLTRO III)* [Press release]. www.ecb.europa.eu/press/pr/date/2020/html/ecb.pr200312_1~39db-50b717.en.html

European Central Bank. (2020d). *Monetary policy decisions* [Press release]. www.ecb.europa.eu/press/pr/date/2020/html/ecb.mp200604~a307d3-429c.en.html

European Commission. (2019). *Green finance.* Retrieved October 23, 2019, from European Commission website: https://ec.europa.eu/info/business-economy-euro/banking-and-finance/green-finance_en

European Parliament. (2019). *DRAFT REPORT on the Council recommendation on the appointment of the President of the European Central Bank.* Retrieved from www.europarl.europa.eu/doceo/document/A-9-2019-0008_EN.pdf

Evans-Pritchard, A. (2013). *Bundesbank declares 'war' on Mario Draghi bond bail-out at Germany's top court.* The Telegraph, www.telegraph.co.uk/finance/financialcrisis/10021894/Bundesbank-declares-war-on-Mario-Draghi-bond-bail-out-at-Germanys-top-court.html

Federal Reserve Bank of Minneapolis. (2019). Consumer Price Index (Estimate) 1800-. Retrieved October 23, 2019, from www.minneapolisfed.org/about-us/monetary-policy/inflation-calculator/consumer-price-index-1800-

Federal Reserve. (1943). *Thirtieth Annual Report of the Board of Governors of the Federal Reserve System Covering Operations for the Year 1943.* Retrieved from https://fraser.stlouisfed.org/title/117/item/2501

Federal Reserve. (2019). *Minutes of the Federal Open Market Committee, October 29-30, 2019* [Press release]. www.federalreserve.gov/newsevents/pressreleases/monetary-20191120a.htm

Federal Reserve. (2020a). *Federal Reserve issues FOMC statement* [Press release]. www.federalreserve.gov/newsevents/pressreleases/monetary2020-0315a.htm

Federal Reserve. (2020b). *Federal Reserve issues FOMC statement* [Press release]. www.federalreserve.gov/newsevents/pressreleases/monetary2020-0429a.htm

Fisher, P. (2010). *The Corporate Sector and the Bank of England's Asset Purchases.* Speech at the Association of Corporate Treasurers Winter Paper 2010. Retrieved from www.bankofengland.co.uk/-/media/boe/files/speech/2010/the-corporate-sector-and-the-bank-of-englands-asset-purchases-speech-by-paul-fisher.pdf

Flath, D. (2005). *The Japanese economy* (2nd ed). Oxford, England; New York: Oxford University Press.

Flink, S. J. (1930). *The German Reichsbank and economic Germany: a study of the policies of the Reichsbank in their relation to the economic development of Germany, with special reference to the period after 1923.* Harper & Brothers.

Freeman, R. (2006). *Reconstruction Finance Corporation: How Roosevelt's RFC Revived Economic Growth, 1933-45.* EIR Economics, 33(11), 12.

Fregert, K. (2018). *Sveriges Riksbank: 350 Years in the Making.* In R. Edvinsson, T. Jacobson, & D. Waldenström (Eds.), Sveriges Riksbank and the History of Central Banking (1st ed., pp. 90–142). Cambridge, United Kingdom: Cambridge University Press.

Friedman, M. and Schwartz, A. (1963). *A monetary history of the United States, 1867-1960.* Princeton University Press.

Global Commission on the Economy and Climate. (2014). *Infrastructure investment needs of a low-carbon scenario* (The New Climate Economy) [Technical note]. https://newclimateeconomy.report/workingpapers/wp-content/uploads/sites/5/2016/04/Infrastructure-investment-needs-of-a-low-carbon-scenario.pdf

Goodhart, C. A. E. (1991). *The evolution of central banks.* MIT Press.

Goodhart, C. A. E. (2011). *The changing role of central banks.* Financial History Review, 18(2), 135–154. https://doi.org/10.1017/S0968565011000096

Goodhart, C. A. E. (2018). *The Bank of England, 1694–2017.* In R. Edvinsson, T. Jacobson, & D. Waldenström (Eds.), Sveriges Riksbank and the History of Central Banking (1st ed., pp. 143–171). Cambridge, United Kingdom: Cambridge University Press.

Graeber, D. (2014). *Debt: The First 5,000 Years* (Rev. ed.). New York: Melville House.

Grauwe de, P. (2019). *Green money without inflation – Paul De Grauwe.* Retrieved from www.social-europe.eu/green-money-without-inflation

Gross, S. (2009). *Confidence and Gold: German War Finance 1914–1918.* Central European History, 42(2), 223–252. https://doi.org/10.1017/S0008938909000296

Haan de, J. (2018). *The Struggle of German Central Banks to Maintain Price Stability.* In R. Edvinsson, T. Jacobson, & D. Waldenström (Eds.), Sveriges Riksbank and the History of Central Banking (1st ed., pp. 388–417). Cambridge, United Kingdom: Cambridge University Press.

Haldane, A. and J. F. Qvigstad (2016). *The evolution of central banks – a practitioner's perspective.* In Bordo, M. D., Ø. Eitrheim, M. Flandreau and J. F. Qvigstad (eds.), Central banks at a crossroads: What can we learn from history?, chapter 15. Cambridge University Press.

Hanke, S. H., & Krus, N. (2012). *World Hyperinflations.* Retrieved from www.cato.org/sites/cato.org/files/pubs/pdf/workingpaper-8_1.pdf

Hautcoeur, P. C., Riva, A., & White, E. N. (2014). *Floating a "lifeboat": The Banque de France and the crisis of 1889.* Journal of Monetary Economics, 65, 104-119.

Howard, P.H. ,& Sterner, T. (2017). *Few and Not So Far Between: A Meta-analysis of Climate Damage Estimates.* Environ Resource Econ, 68, 197–225.

Humphrey, T. M. (1989). *Lender of last resort: the concept in history.* FRB Richmond Economic Review, 75(2), 8-16.

IPCC. (2018a). *Summary for Policymakers. In: Global Warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related.* Retrieved from www.ipcc.ch/site/assets/uploads/sites/2/2019/05/SR15_SPM_version_report_LR.pdf

IPCC. (2018b). *Framing and context. In: Global Warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related.* Retrieved from www.ipcc.ch/site/assets/uploads/sites/2/2019/05/SR15_Chapter1_Low_Res.pdf

Issing, O., & Wieland, V. (2012). *Monetary Theory and Monetary Policy: Reflections on the Development over the last 150 Years* (No. 67; Working Paper Series, p. 37). Institute for Monetary and Financial Stability, Goethe University, Frankfurt am Main.

Ito, T. (2010). *Great Inflation and Central Bank Independence in Japan* (No. w15726; p. w15726). National Bureau of Economic Research. https://doi.org/10.3386/w15726

Jilani, T. N., Jamil, R. T., & Siddiqui, A. H. (2020). *H1N1 Influenza.* In StatPearls. StatPearls Publishing. www.ncbi.nlm.nih.gov/books/NBK513241/

Jordà, Ò., Schularick, M., & Taylor, A. M. (2011). *Financial crises, credit booms, and external imbalances: 140 years of lessons.* IMF Economic Review, 59(2), 340-378.

Karak, M. (2019). *Climate Change and Syria's Civil War, JSTOR Daily.* Retrieved from https://daily.jstor.org/climate-change-and-syrias-civil-war

Keen, B. D., & Pakko, M. R. (2011). *Monetary policy and natural disasters in a DSGE model.* Southern Economic Journal, 77(4), 973-990.

Khalaf, R., & Arnold, M. (2020). *Lagarde puts green policy top of agenda in ECB bond buying.* Financial Times, July 8 2020.

Klooster, J. van 't, & van Tilburg, R. (2020). *Targeting a green recovery with green TLTROs, Positive Money EU and Sustainable Finance Lab.* www.positivemoney.eu/wp-content/uploads/2020/09/Green-TLTROs.pdf

Krogstrup, S., & Oman, W. (2019). *Macroeconomic and Financial Policies for Climate Change Mitigation: A Review of the Literature* (No. 19/185). International Monetary Fund.

Kumhof, M., & Benes, J. (2012). *The Chicago Plan Revisited.* IMF Working Papers, 12(202).

Laframboise, N., & Loko, B. (2012). *Natural Disasters: Mitigating Impact, Managing Risks* (IMF Working Paper WP/12/245). International Monetary Fund. http://elibrary.imf.org/view/IMF001/20041-9781475512717/20041-9781475512717/-20041-9781475512717.xml

Lagarde, C. (2021, January 25). *Climate change and central banking.* ILF conference on Green Banking and Green Central Banking, Frankfurt am Main. www.ecb.europa.eu/press/key/date/2021/html/ecb.sp210125~f87e826ca5.en.html

Leaman, J. (2001). *The Bundesbank myth: Towards a critique of central bank independence.* Palgrave.

Lerner, E. M. (1955). *Money, Prices, and Wages in the Confederacy, 1861-65.* Journal of Political Economy, 63(1), 20–40. https://doi.org/10.1086/257626

Mackintosh, S. (2015). *Making the Jump How Crises Affect Policy Consensus and Can Trigger Paradigm Shift.* Retrieved from http://unepinquiry.org/wp-content/uploads/2016/02/Making_the_Jump.pdf

Margulis, S., Hughes, G., Schneider, R., Pandey, K., Narain, U., & Kemeny, T. (2010). *Economics of adaptation to climate change.* Synthesis report.

Matikainen, S., Campiglio, E., & Zenghelis, D. (2017). *The climate impact of quantitative easing.* Policy Paper, Grantham Research Institute on Climate Change and the Environment, London School of Economics and Political Science.

McCollum, D. L., Zhou, W., Bertram, C., De Boer, H. S., Bosetti, V., Busch, S., & Fricko, O. (2018). *Energy investment needs for fulfilling the Paris Agreement and achieving the Sustainable Development Goals.* Nature Energy, 3(7), 589.

McKibben, B. (2016). *A World at War.* Retrieved October 8, 2019, from https://newrepublic.com/article/135684/declare-war-climate-change-mobilize-wwii

McKibbin, W,J., Morris, A., Panton, A., & Wilcoxen, P. (2017). *Climate change and monetary policy: Dealing with disruption.* Centre for Applied Macroeconomic Analysis, Crawford School of Public Policy, The Australian National University.

Monnet, E. (2018). *Controlling Credit: Central Banking and the Planned Economy in Postwar France, 1948–1973* (1st ed.). Cambridge University Press. https://doi.org/10.1017/9781108227322

Monnin, P. (2018). *Integrating Climate Risks into Credit Risk Assessment; Current Methodologies and the Case of Central Banks Corporate Bond Purchases.* CEP.

Network for Greening the Financial System. (2019). *A Call for action Climate change as a source of financial risk* (1). Retrieved from www.banque-france.fr/sites/default/files/media/2019/04/17/ngfs_first_comprehensive_report_-_17042019_0.pdf

Network for Greening the Financial System. (2020a). *Climate Change and Monetary Policy.* Initial takeaways, technical document. www.ngfs.net/sites/default/files/medias/documents/climate_change_and_monetary_policy_final.pdf

Network for Greening the Financial System. (2020b). *The macroeconomic and financial stability impacts of climate change: research priorities.* www.ngfs.net/sites/default/files/medias/documents/ngfs_research_priorities_final.pdf

New Economics Foundation. (2013). *Strategic Quantitative Easing Stimulating Investment to Rebalance the Economy.* Retrieved from https://neweconomics.org/uploads/files/e79789e1e31f261e95_ypm6b49z7.pdf

Nordhaus, W.D. ,& Moffat, A. (2017). *A Survey of Global Impacts of Climate Change.* Replication, Survey Methods, and a Statistical Analysis, NBER Working Paper No. 23646.

Parker, M. (2016). *The Impact of Disasters on Inflation* (No. 1982; Working Paper Series). European Central Bank. www.ecb.europa.eu/pub/pdf/scpwps/ecbwp1982.en.pdf

Parker, M. (2018). *The impact of disasters on inflation.* Economics of Disasters and Climate Change, 2(1), 21-48.

PBL Netherlands Environmental Assessment Agency. (2014). *Costs and Benefits of Climate Change Adaptation and Mitigation: An Assessment on Different Regional Scales.* Retrieved from www.pbl.nl/sites/default/files/downloads/PBL_2014_Costs_and_benefits_of_climate_change_adaptation_and_mitigation_1198_0.pdf

Pigato, M. A. (Ed.). (2018). *Fiscal Policies for Development and Climate Action.* The World Bank.

Piguet, E., & Laczko, F. (2014). *Regional Perspectives on Migration, the Environment and Climate Change.* In E. Piguet & F. Laczko (Eds.), People on the Move in a Changing Climate: The Regional Impact of Environmental Change on Migration (2nd ed., pp. 1–20). Dordrect Heidelberg New York London: Springer.

Pisani-Ferry, J. (2019). *How to Ward Off the Next Recession.* Retrieved October 8, 2019, from www.project-syndicate.org/commentary/europe-next-recession-alternative-policies-by-jean-pisani-ferry-2019-09

Poole, R. S., Head, B. V., Wroth, W. W., & Hill, G. F. (1888). *Catalogue of Greek coins: Attica, Megaris, Aegina.* A Catalogue of the Greek Coins in the British Museum. https://doi.org/10.11588/DIGLIT.45275

Reuters. (2011). *G7: agrees on joint FX intervention from March18.* Retrieved on 17 October 2019, from www.reuters.com/article/g7-japan-idUSTKG00709620110318

Richardson, G. (2013). *Federal Reserve's Role During WWII | Federal Reserve History.* Retrieved October 8, 2019, from www.federalreservehistory.org/essays/feds_role_during_wwii

Riel, A. van (2015). *Het financieel stelsel in historisch perspectief* (Working paper No. 14; p. 90). WRR. www.wrr.nl/binaries/wrr/documenten/working-papers/2016/02/17/het-financieel-stelsel-in-historisch-perspectief/WP014-Financieel-stelsel-historisch-perspectief.pdf

Robinson, E. S. G. (1951). *The coins from the Ephesian Artemision reconsidered.* The Journal of Hellenic Studies, 71, 156-167.

Rockoff, H. (2014). *War, Money, and Inflation in the United States from the Revolution to the Vietnam War.* mimeo., Rutgers University.

Rockoff, H. (2016). *The US economy in WWII as a model for coping with climate change* (No. w22590). National Bureau of Economic Research.

Ryan-Collins, J. (2015). *Is Monetary Financing Inflationary? A Case Study of the Canadian Economy, 1935-75* (Working Paper No. 848). Levy Economics Institute. www.levyinstitute.org/pubs/wp_848.pdf

Ryan-Collins, J., & van Lerven, F. (2018). *Bringing the helicopter to ground: A historical review of fiscal- monetary coordination to support economic growth in the 20th century.* Retrieved from https://neweconomics.org/uploads/files/Bringing-the-helicopter-to-ground.pdf

Salamé, L. & Sotto, T. (2020). *Interview with Christine Lagarde, President of the ECB, France 2.* Retrieved November 8 from www.ecb.europa.eu/press/inter/date/2020/html/ecb.in200605~6fbb422834.en.html

Schacht, H. (1967). *The Magic of Money.* London: Oldbourne.

Schieritz, M. (2019, June 19). *European Central Bank: Jens Weidmann Accepts Sovereign Bond Purchases.* Retrieved October 16, 2019, from www.zeit.de/wirtschaft/2019-06/ezb-chef-nachfolge-mario-draghi-jens-weidmann-englisch

Schnabel, I. (2020). *When markets fail – the need for collective action in tackling climate change.* Speech at the European Sustainable Finance Summit.

Schoenmaker, D. (2019). *Greening monetary policy.* Bruegel Working Paper Issue 02 February 2019.

Schoenmaker, D., van Tilburg, R., & Wijffels, H. (2015). *What role for financial supervisors in addressing systemic environmental risks?* Sustainable Finance Lab.

Scranton, R. (2019). *Climate Change Is Not World War.* Retrieved October 8, 2019, from www.nytimes.com/2019/09/18/opinion/climate-change-mobilization.html

Shizume, M. (2018). *A History of the Bank of Japan, 1882-2016.* In R. Edvinsson, T. Jacobson, & D. Waldenström (Eds.), Sveriges Riksbank and the History of Central Banking (1st ed., pp. 328–360). Cambridge, United Kingdom: Cambridge University Press.

Siklos, P. L. (1991). *War Finance, Reconstruction, Hyperinflation and Stabilization in Hungary, 1938–48.* https://doi.org/10.1007/978-1-349-21325-2

Sowerbutts, R., Schneebalg, M., & Hubert, F. (2016). *The demise of Overend Gurney.* Bank of England Quarterly Bulletin, Q2. www.bankofengland.co.uk/-/media/boe/files/quarterly-bulletin/2016/the-demise-of-overend-gurney.pdf?la=en&hash=04B001A02BD5ED7B35D-4FB3CF1DDC233A1D271BD

Spufford, P. (1989). *Money and its Use in Medieval Europe.* Cambridge, United Kingdom: Cambridge University Press.

Stern, N. (2007). *The Economics of Climate Change The Stern Review.* Cambridge, United Kingdom: Cambridge University Press.

Stiglitz, J. (2019). *The climate crisis is our third world war. It needs a bold response | Joseph Stiglitz.* Retrieved October 8, 2019, from www.theguardian.com/commentisfree/2019/jun/04/climate-change-world-war-iii-green-new-deal

Sylla, R., Wright, R. E., & Cowen, D. J. (2009). *Alexander Hamilton, central banker: crisis management during the US financial panic of 1792.* Business History Review, 83(1), 61-86.

Taskforce on Climate-related Financial Disclosures. (2018). *Status Report.* Retrieved from www.fsb-tcfd.org/wp-content/uploads/2018/08/FINAL-2018-TCFD-Status-Report-092518.pdf

Thomas, H. (1828). *The Wards of London: Comprising a Historical and Topographical Description of Every Object of Importance Within the Boundaries of the City. With an Account of All the Companies, Institutions, Buildings, Ancient Remains ... and Biographical Sketches of All Eminent Persons Connected Therewith, Volumes 1-2.* London: J. Gifford.

Thornton, H. (1802). *An Enquiry into the Nature and Effects of the Paper Credit of Great Britain* (Vol. 595, No. 6). J. Hatchard.

Tol, R. S. (2013). *Targets for global climate policy: An overview.* Journal of Economic Dynamics and Control, 37(5), 911-928.

Tol, R.S. (2018). *The Economic Impacts of Climate Change.* Review of Environmental Economics and Policy, Volume 12, Issue 1, 4–25

Tooze, A. (2019, July 20). *Why Central Banks Need to Step Up on Global Warming.* Retrieved October 8, 2019, from https://foreignpolicy.com/2019/07/20/why-central-banks-need-to-step-up-on-global-warming

Tucker, P., 2018. *Unelected Power: The Quest for Legitimacy in Central Banking and the Regulatory State,* Princeton University Press, New York.

Turner, A. (2015). *The Case for Monetary Finance – an Essentially Political Issue.* 54. Washington, DC: International Monetary Fund.

Tymoigne, É., & Wray, L. R. (2006). *Money: An alternative story.* In P. Arestis & M. Sawyer (Eds.), A Handbook of Alternative Monetary Economics (p. 524). Cheltenham, UK: Edward Elgar

UNFCC. (2015). *Paris Climate Agreement.* Retrieved from https://unfccc.int/sites/default/files/english_paris_agreement.pdf

United Nations Environment Programme. (2016). *The Adaptation Finance Gap report.* Retrieved from https://unepdtu.org/publications/the-adaptation-finance-gap-report/

United Nations Environment Programme. (2015). *The Financial System We Need: Aligning the Financial System with Sustainable Development.* Retrieved from http://unepinquiry.org/wp-content/uploads/2015/-11/The_Financial_System_We_Need_EN.pdf

United Nations Environment Programme. (2018). *The Emissions Gap Report 2018.* Retrieved from http://wedocs.unep.org/bitstream/handle/20.500.11822/26895/EGR2018_FullReport_EN.pdf?sequence=1&isAllowed=y

Uittenbogaard, R. (2014). *Evolution of central banking? De Nederlandsche Bank,1814 -1852.* Springer Berlin Heidelberg.

Velde, F. R. (2020). *What Happened to the US Economy During the 1918 Influenza Pandemic? A View Through High-Frequency Data.* Federal Reserve Bank of Chicago. https://doi.org/10.21033/wp-2020-11

Vernengo, M. (2006). *Money and Inflation.* In P. Arestis & M. Sawyer (Eds.), A Handbook of Alternative Monetary Economics (1st ed., pp. 471–489). Bodmin, Cornwall: MPG books Ltd.

Volz, U. (2017). *On the Role of Central Banks in Enhancing Green Finance* (Inquiry Working Paper No. 17/01). Retrieved from UNEP Inquiry website: http://unepinquiry.org/wp-content/uploads/2017/02/On_the_Role_of_Central_Banks_in_Enhancing_Green_Finance.pdf

Webb, S.B. (1984). *The Supply of Money and Reichsbank Financing of Government and Corporate Debt in Germany, 1919–1923.* Journal of Economic History, 44(2), 499–507.

White, B. (1997). *Preparing for natural disasters-where does the Reserve Bank fit in?* Reserve Bank of New Zealand Bulletin, 60.

Westerhuis, G., & van Zanden, J. L. (2018). *Four Hundred Years of Central Banking in the Netherlands, 1609-2016.* In R. Edvinsson, T. Jacobson, & D. Waldenström (Eds.), Sveriges Riksbank and the History of Central Banking (1st ed., pp. 242–264). Cambridge, United Kingdom: Cambridge University Press.

Weitzman, M. L., (2009). *"On Modeling and Interpreting the Economics of Catastrophic Climate Change,"* Review of Economics and Statistics 91(1):1-19.

WHO. (2015). *Summary of probable SARS cases with onset of illness from 1 November 2002 to 31 July 2003.* World Health Organization. www.who.int/publications/m/item/summary-of-probable-sars-cases-with-onset-of-illness-from-1-november-2002-to-31-july-2003

WHO. (2020). *MERS Situation Update: January 2020.* World Health Organization. https://applications.emro.who.int/docs/EMCSR254E.pdf

Wolf, M. (2019). *The ECB must reconsider its plan to tighten.* Retrieved October 10, 2019, from www.ft.com/content/76b03b18-3e93-11e9-9bee-efab61506f44

Wood, G. E. (2000). *The lender of last resort reconsidered.* Journal of Financial Services Research, 18(2-3), 203-227.

World Bank. (2018). *Groundswell: Preparing for Internal Climate Migration.* Retrieved from https://openknowledge.worldbank.org/bitstream/handle/10986/29461/WBG_ClimateChange_Final.pdf?sequence=18&isAllowed=y

Zielinski, R. C. (2018). *How Do War Financing Strategies Lead to Inequality? A Brief History from the War of 1812 through the Post-9/11 Wars.* Studies, 16(1), 59-80.

Zarlenga, S. (2002). *The Lost Science of Money: The Mythology of Money; The Story of Power.* American Monetary Institute.

SUSTAINABLE
FINANCE
LAB

This is a Sustainable Finance Lab publication
www.sustainablefinancelab.nl