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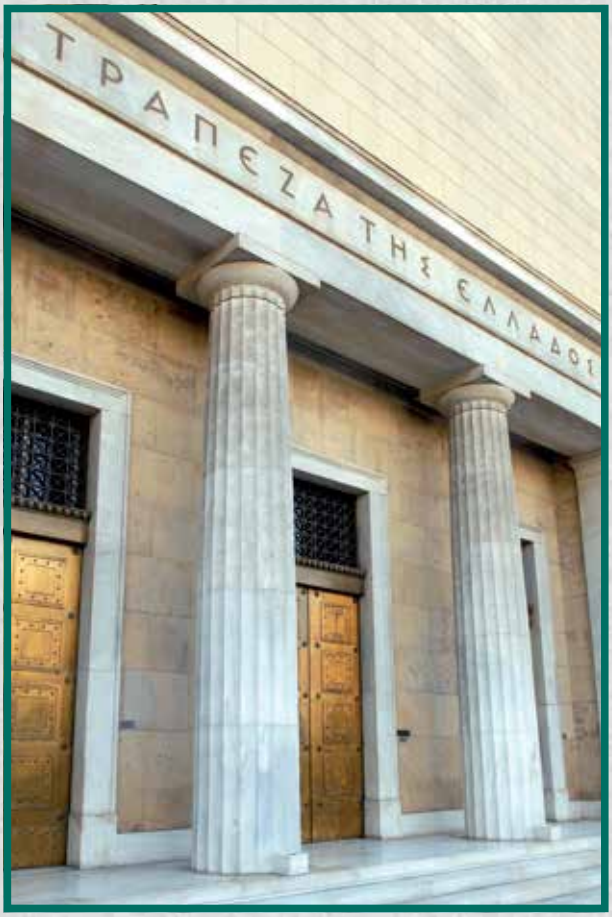

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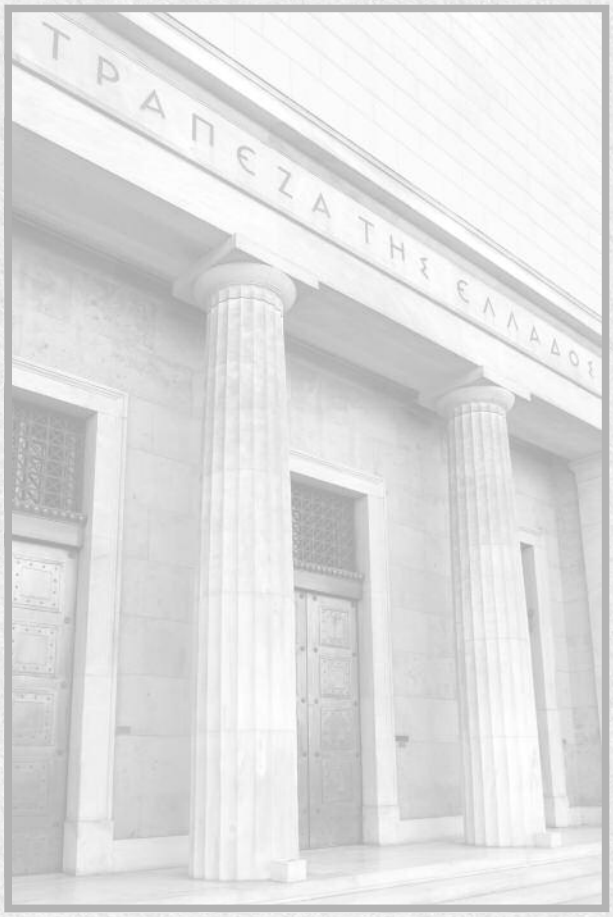

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COVID-19 AND OTHER PANDEMICS: A LITERATURE REVIEW FOR ECONOMISTS

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ABSTRACT

We provide a comprehensive review of the literature on the economic impact of pandemics and identify the transmission channels at play. The primary channel comes from the supply side, as pandemics reduce both the quantity and the quality of labour. They can also lead to a destruction of capital, as businesses close and investment is curtailed. On the demand side, consumption is particularly vulnerable to the impact of both reduced income and declining consumer confidence. A third channel works through the financial system. While the natural rate of interest might be expected to fall, leading to a period of low interest rates, financial institutions are likely to come under stress. Rising uncertainty, along with an increase in the number of borrowers with debt servicing difficulties, may dampen investment and generate a liquidity squeeze, exacerbating the demand effects of the pandemic. All three channels work to reduce current and potential output. Spillovers and asymmetries can explain the varying impact of the pandemic across countries, but it seems that open economies, embedded in global value chains, are especially vulnerable. Nonetheless, the literature provides ample evidence on how to limit the impact of pandemics using monetary and fiscal policy combined with measures to ease liquidity constraints on the financial sector. In the context of the EU, the coordination and mutualisation of the policy response to the pandemic can prove to be very beneficial.

Keywords: COVID-19; pandemic; lockdown; social distancing; propagation; spillovers

JEL classification: E2; E3; E5; G1

COVID-19 ΚΑΙ ΑΛΛΕΣ ΠΑΝΔΗΜΙΕΣ: ΕΠΙΣΚΟΠΗΣΗ ΤΗΣ ΒΙΒΛΙΟΓΡΑΦΙΑΣ ΓΙΑ ΟΙΚΟΝΟΜΟΛΟΓΟΥΣ

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ΠΕΡΙΛΗΨΗ

Η μελέτη αποτελεί μια επισκόπηση της βιβλιογραφίας όσον αφορά τις οικονομικές επιπτώσεις μιας πανδημίας και των διαύλων μετάδοσής τους. Ο κύριος δίαυλος προέρχεται από την πλευρά της προσφοράς, καθώς οι πανδημίες μειώνουν τόσο την ποσότητα όσο και την ποιότητα της προσφερόμενης εργασίας. Ενδέχεται επίσης να οδηγήσουν σε καταστροφή κεφαλαίου, καθώς κάποιες επιχειρήσεις αναγκάζονται να μειώσουν τις επενδύσεις τους ή και να παύσουν τη λειτουργία τους. Από τη σκοπιά της ζήτησης, είναι ιδιαιτέρως πιθανόν να πληγεί η κατανάλωση, λόγω της μείωσης του διαθέσιμου εισοδήματος και της καταναλωτικής εμπιστοσύνης. Ένας τρίτος δίαυλος είναι χρηματοπιστωτικός. Παρότι το φυσικό επιτόκιο είναι πιθανόν να μειωθεί, προμηνύοντας μια περίοδο χαμηλών επιτοκίων, είναι αναμενόμενο ότι τα χρηματοπιστωτικά ιδρύματα θα υποστούν πιέσεις. Η αύξηση της αβεβαιότητας και η άνοδος του ποσοστού των δανειοληπτών σε δυσχέρεια οδηγούν σε περιορισμό της ρευστότητας και επιτείνουν τις αρνητικές επιπτώσεις της πανδημίας στη ζήτηση. Διαμέσου των τριών αυτών διαύλων, τόσο το παραγόμενο όσο και το δυνητικό προϊόν υφίστανται μείωση. Οι οικονομικές επιπτώσεις μιας πανδημίας ενδέχεται να διαφέρουν από χώρα σε χώρα, λόγω ασυμμετριών και φαινομένων διάχυσης. Ωστόσο, φαίνεται ότι οι ανοικτές οικονομίες, που είναι ενταγμένες στις διεθνείς αλυσίδες αξίας, είναι ιδιαιτέρως ευάλωτες σε αυτές τις επιδράσεις. Στο πλαίσιο της Ευρωπαϊκής Ένωσης, ο συντονισμός και η αμοιβαιοποίηση των οικονομικών μέτρων για την αντιμετώπιση των επιπτώσεων της πανδημίας μπορεί να αποβεί εξαιρετικά επωφελής.

COVID-19 AND OTHER PANDEMICS: A LITERATURE REVIEW FOR ECONOMISTS*

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1 INTRODUCTION

The COVID-19 pandemic is arguably the largest peace-time potential threat to life on a global scale for a century. In probably the most well-known simulation study, Ferguson et al. (2020) argue that COVID-19 could be the deadliest pandemic since the Spanish Flu, with half a million deaths in the UK and over 2 million in the US. COVID-19 and the unprecedented non-pharmaceutical interventions (NPIs) and preventative policies to contain it place urgency on trying to gauge the likely economic impacts.[1]

While fatality rates are difficult to gauge, due to large uncertainty about the number of cases, it seems that COVID-19 is unlikely to be as deadly as the Spanish Flu, which claimed at least 50 million lives (see Table 1). A notable difference is that the Spanish Flu primarily affected prime-age workers, which suggests more severe economic impacts of the 1918 influenza pandemic, particularly for potential output.[2] But 21st-century epidemics can spread more widely and more quickly, having a ruinous impact on the economy of the affected country and a contagion effect on the global economy. The more complex nature of modern global supply chains, the intense mobility of human populations, the greater role of services, and the improvements in information and communication technologies are important factors for understanding the macroeconomic effects of COVID-19. While 102 years after the Spanish Flu, there is a more sound knowledge of infectious diseases as well as a wider range of potential interventions effective in preventing their spread, most of the countries worldwide still face the same challenge of mitigating the disruptive impacts of the pandemic.

A large set of papers has emerged on macroeconomic issues surrounding the COVID-19 pandemic. The world has entered into uncharted territory, with little history to guide policy makers on what the expected economic fallout will be, which societal interventions are warranted to contain its spread, and how a sys-

* We would like to thank Dimitris Malliaropulos for useful comments on earlier drafts as well as our colleagues in the Economic Analysis and Research Department for their suggestions when we presented the paper. The present study draws on research published up until end-April 2020. The views expressed are those of the authors and do not necessarily reflect those of the Bank of Greece. The authors are responsible for any errors or omissions.

1 The 20th century has witnessed two influenza pandemics since the Spanish Flu of 1918: the Asian flu of 1957 and the Hong Kong flu of 1968. The 21st century has seen a number of pandemics, most notably the Severe Acute Respiratory Syndrome (SARS) in 2002, H1N1 ("bird flu") in 2009, the Middle East Respiratory Syndrome (MERS) in 2012, and Ebola, which peaked in 2014-16.

2 99% of the victims of the Spanish Flu were below 65 years of age, and around half of them were aged between 20 and 40.

Table 1 Nineteen deadly pandemics since early modern times

Event	Start	End	Death toll
Black Death	1347	1352	75,000,000
Plague in Spain	1596	1631	600,000-700,000
Italian Plague	1629	1631	280,000
Great Plague of Sevilla	1647	1652	2,000,000
Naples Plague	1656	1656	1,250,000
Great Plague of London	1665	1666	100,000
Great Northern War Plague	1700	1721	176,000-208,000
Great Plague of Marseille	1720	1722	100,000
First Asia Europe Cholera Pandemic	1816	1826	100,000
Second Asia Europe Cholera Pandemic	1829	1851	100,000
Russia Cholera Pandemic	1852	1860	1,000,000
Fourth Cholera Pandemic	1863	1875	600,000
Global Flu Pandemic	1889	1890	1,000,000
Sixth Cholera Pandemic	1899	1923	80,000
Encephalitis Lethargica Pandemic	1915	1926	1,500,000
Spanish Flu	1918	1920	100,000,000
Asian Flu	1957	1958	2,000,000
Hong Kong Flu	1968	1969	1,000,000
H1N1 Pandemic	2009	2009	203,000

Source: Cirillo and Taleb (2020).
Note: The list is not exhaustive, but focuses on pandemics on which data are available.

temic response should be organised. What is the economic impact of a pandemic? Are the economic effects temporary or persistent? What is the impact of public health responses on the economy? Does the early and extensive use of NPIs, such as social distancing and lockdowns, which slow the spread of the pandemic, reduce its medium-term economic severity despite the inevitably heavy short-run toll?[3]

There are several policy proposals, with a large number of them collected in Baldwin and di Mauro (2020a). For example, Gourinchas (2020) argues that "flattening the infection curve inevitably steepens the macroeconomic recession curve". Although the measures that help address the health crisis can make the economic crisis worse —at least in the short run— the consensus amongst economists seems to be that containment is the appropriate policy. Economic policy can act decisively to limit the economic damage and thus "flatten the curve".

The remainder of this paper is structured as follows: in Section 2 we seek to shed some light on the above questions by, first, focusing on the literature that looks at the economic impact of past pandemics, including the Black Death and the Spanish Flu. We then move on to Section 3 to explore how economists are modelling the impact of the current pandemic within their empirical models. An examination of both strands of the literature allows us to identify the channels through which pandemics

3 NPIs intend to reduce infectious contacts between persons and form an integral part of plans to mitigate the impact of an influenza pandemic. The potential benefits of NPIs are supported by both mathematical models and historical evidence on the impact of such interventions in past pandemics (see for example Bootsma and Ferguson 2007; Markel et al. 2008; Hatchett et al. 2007).

impact economies. In particular, it is possible to quantify the impact on various macroeconomic aggregates, including GDP, inflation, wages, poverty, trade, non-performing loans (NPLs) and social capital. The literature also points to potential policy measures that can mitigate the impact of the pandemic. Section 4 draws on the assessment recently made by international institutions to discuss the role of asymmetries and the spillover effects of COVID-19. Section 5 draws on all previous sections to summarise the key transmission channels and provide economic policy implications. Section 6 concludes.

2 REVIEW OF RESEARCH ON THE ECONOMIC IMPACT OF PAST PANDEMICS

2.1 EMPIRICAL RESEARCH ON PAST PANDEMICS

The economic history literature on the relationship between pandemics and economic outcomes is hardly new (see Tables 2 and 3 for a summary). Most historical studies have typically focused on one event in one country or region and have traced local outcomes for up to a decade at most. Due to the absence of recent pandemics, work has primarily relied on aggregated data at the regional or national level.[4]

By far the most severe pandemic in terms of fatality rates was the **Black Death (Plague)**, which decimated anywhere between 30% and 60% of Europe's population in the 14th century.[5] Most work has shown that, by sharply reducing the size of the working population, the Plague led to a substantial increase in nominal wages for workers that persisted into the 15th century. Real wages took considerably longer to reach pre-Plague levels, especially for skilled workers (Munro 2005), as the supply shock-driven food inflation was higher than wage inflation. One reason for this was institutional: governments in several regions instituted formal wage restraints, particularly for rural workers (Munro 2005). The impact on per capita income is less clear, since rents also fell in the aftermath of the Black Death (Hirshleifer 1987; see also Robbins 1928).[6] Jedwab et al. (2019), using a granular dataset for a large sample of European cities, argue that population changes fit well a Malthusian growth paradigm, where production relies on fixed factors (land and natural resources) with little to no technological improvements, making the lessons learnt from the Black Death of little value for modern pandemics.

Due to its unprecedented devastation, the Black Death is likely to have for ever altered the economic and social landscape of Europe. Jedwab et al. (2019) provide evidence that rural villages were abandoned, as inhabitants moved to more affected cities to exploit the abundance of fixed factors of production. Voigtländer and Voth (2012) provide the most shocking example of persistent social effects. Scapegoating of Jews during the Black Death was quite prevalent in Central Europe, and mass killings took place in several cities in Germany. The authors show that cities with anti-Jewish pogroms during the Black Death had markedly higher patterns of violent antisemitism in the 1920s. While this is not causal evidence of Black Death affecting antisemitism, it is strong evidence of the endurance of cultural traits, which are likely to have been in some way shaped by the Black Death.

The most widely cited major pandemic was the **Spanish Flu**, due to its relatively recent occur-

4 The economics pandemic literature has typically not considered HIV/AIDS together with other major pandemics, despite its large-scale death toll (over 30 million). The economic effects of HIV/AIDS are likely very different because it is much more difficult to transmit than pandemics caused by flu, cholera or plague, and can hence be more manageable; flu episodes can occur very suddenly, giving rise to outbreaks. HIV/AIDS is also slow-acting (death occurs within years versus days for the rest). The WHO has classified HIV/AIDS as a global epidemic, instead of a pandemic.

5 The Black Death —a combination of bubonic and pneumonic plagues— killed roughly one-quarter of the Western European population between 1348 and 1351, and recurring epidemics continued to inflict high death tolls on the continent over the next quarter-century. It is unclear whether the Black Death caused more absolute fatalities than the Spanish Flu, but the relative magnitude in terms of total population was far higher.

6 Bloom and Mahal (1997) re-examine the effect of the Plague on the wages of unskilled agricultural workers in England during epidemics that occurred between 1310 and 1449. They find a positive but statistically insignificant relationship between real wages and population growth, with similar results for France. However, their study is hampered by its very small sample size.

Table 2 Summary of main empirical papers on past pandemics

	Summary of findings	Short-term impact	Long-term impact	Channel of transmission
Black Death				
Munro (2005)	Real wages initially fell but eventually grew substantially and persistently.	Negative effect on real wages despite higher nominal wages.	Large gains in real wages lasting for a century.	Labour shortages led to poor harvests in the short run, raising food inflation faster than wages. Wage controls imposed by landowners. In the long run, these effects waned and the shortage of labour relative to capital led to persistent wage gains.
Voigtländer and Voth (2012)	Antisemitism in the 1920s higher in cities with anti-Jewish pogroms in Black Death. Cities with high levels of trade or immigration show less persistence.		Local continuity of violence against Jews over 600 years (votes for the Nazi Party, deportations after 1933, attacks on synagogues).	Persistence of cultural traits.
Jedwab et al. (2019)	Affected cities recovered their population over the very long run.	Negative effects on city size.	Recovery according to Malthusian model.	Migration to areas with labour shortages and abundant fixed production factors (trade potential).
Spanish Flu				
Brainerd and Siegler (2003)	Substantial macroeconomic effects in the US, even after controlling for differences across states. Likely a contributing factor to post-WWI recessions.	Substantial business failures which caused the economy to be below trend, on average, between 1919 and 1921.	One more death resulted in an average annual increase of at least 0.2% in growth over the next 10 years.	Effect of prime-age influenza mortality rates (rather than overall mortality rates) on growth. Higher capital deepening (business failures' effect smaller than labour supply effect), lower labour force growth, increased investment in human capital.
Almond (2006)	Children of infected mothers fared worse in later life.		Depressed human capital.	Sickness during pregnancy.
Garrett (2009)	Wages in the US grew in relative terms in more exposed areas.	Approximately 4% of total wage growth (1914-19) is attributed to influenza mortalities.		Reduction in labour supply raised marginal product of labour. However, it is not always clear to what extent the results are attributable to WWI.
Karlsson et al. (2014)	Sweden; persistent decline in rental income and increase in poverty; no effect on earnings. More affected regions grew slower after the pandemic.	Rental income decline.	Rental income decline and higher poverty rates.	Labour quality fell in affected areas, mitigating wage growth due to labour scarcity. Also explains higher poverty and lower marginal product of capital.
Correia et al. (2020)	Areas that were more severely affected see a sharp and persistent decline in real economic activity, controlling for other factors. Early and extensive NPIs have no adverse effect on local outcomes; instead, a relative increase in real economic activity after the pandemic.	18% decline in state manufacturing output; rise in bank charge-offs. Reacting 10 days earlier increases employment by 5% in post-period; 50 additional days raise employment by 6.5%; one s.d. higher number of days induces a 7.5% larger local banking sector after 1918.	More affected areas remain depressed relative to less exposed areas from 1919 through 1923. The reduction in bank assets is persistent.	Reductions in both supply and demand. NPIs can have economic merits, beyond lowering mortality. Important channel of transmission of both demand and supply shocks could have been the banking sector.
Barro (2020)	NPIs have no significant impact on cumulative mortality in the US.	Short duration; but peak mortality does fall.		
Velde (2020)	Little short-term economic effects of the pandemic in the US. Recessions short and modest.			Considers a number of high-frequency indicators to show little impact during the pandemic, but large recession after the pandemic. Puzzling results given other papers showing large long-term effects.
Barro et al. (2020)	Declines in GDP and consumption. Effects are fully permanent or fully temporary or somewhere in between. Decreased realised real returns on stocks and, especially, on short-term government bills. Higher inflation at least temporarily.	Increased inflation rates (at least temporarily). Effect on stock negative but not significant; negative and significant effect on bonds.	Reduction of real per capita GDP by 6%. Larger effects for consumption. For the US only 1.5 % decrease in GDP and 2.1% in consumption. Effects on asset return not reversing	Effects of the Great Influenza Pandemic and WWI on economic growth (treated as (mostly) exogenous variables), gauged by growth rates of real per capita GDP and real per capita consumption (personal consumer expenditure). WWI and Great Influenza Pandemic are viewed as unanticipated and contemporaneously perceived as having some persistence but ultimately being temporary.
Le Moglie et al. (2020)	Spanish Flu mortality associated with lower social trust.		Long-run impact on descendants of immigrants.	Social distancing measures impeded social interactions. Persistence of cultural traits.
All pandemics				
Jordà et al. (2020)	Large and persistent reduction in natural interest rate; opposite for real wages.	Limited effects in the short run (until ten years).	Substantial effects lasting for at least four decades, longer in some countries.	Excess supply of capital relative to labour; wars (which destroy capital) opposite effect. With sufficiently low depreciation, higher growth potential can be accommodated with low investment, leading to lower natural rates. Wage effects as in Munro (2005).

rence and truly global nature.[7] Brainerd and Siegler (2003) were the first to examine its effects[8] on subsequent growth. Using data from a sample of US states, they find a positive correlation, even after controlling for a number of differences across states.[9] They suggest that one more death per thousand resulted in an average annual increase of at least 0.2 percentage point in the rate of economic growth over the next ten years. However, they find that flu deaths in 1918 and 1919 among prime-age adults are a significant predictor of business failures in 1919 and 1920, implying that the economy may have been below trend, on average, between 1919 and 1921. In other words, some of the growth from 1919-21 to 1930 is only a return to trend after this large temporary shock. The concurrent presence of higher business failures immediately after the pandemic and higher subsequent growth in affected areas may reflect a combination of factors: higher capital deepening (if the destruction of capital as a result of business failures were small enough, relative to the reduction in labour supply); lower labour force growth (as the young were especially affected); increased investment in human capital; or simple convergence. At the same time, long-term effects are hard to infer due to the boom of the 1920s and the subsequent crash of financial markets in 1929.

Garrett (2009) examines the immediate effect of influenza mortalities on manufacturing wages in US cities and states, jointly with the effect of World War I (WWI). The hypothesis is that influenza mortalities, by reducing the supply of manufacturing workers, raised the marginal product of labour and thus real wages. Since, in the short term, labour immobility across cities and states is likely to have prevented wage equalisation across states, a substitution to capital is unlikely to have occurred. The study finds that states and cities with greater mortalities experienced greater wage growth – roughly 2 to 3 percentage points for a 10% change in per capita mortalities. Approximately 4% of total wage growth from 1914 to 1919 is attributed to influenza mortalities. However, it is not always clear to what extent the results attributable to the effect of influenza are distinct from the impact of WWI.

More recently, Karlsson et al. (2014), using a difference-in-differences analysis of high-quality administrative data from Sweden, estimate the effects of the 1918 influenza pandemic on earnings, capital returns and poverty. They find that the pandemic led to a significant increase in poverty rates, and a reduction in capital returns; but, contrary to others, they do not find significant effects on earnings. At the same time, they show that more affected regions grew slower in the aftermath of the pandemic. Thus, the combination of falling capital income and growth in more affected areas but with no difference in earnings may explain the labour supply reaction, i.e. the reduction in average worker quality. In this way, the study shows that labour heterogeneity needs to be taken into account when analysing the effects of a pandemic.

A few recent papers have revisited the effect of the Spanish Flu on the US economy, with mixed results. Correia et al. (2020) study a variety of economic outcomes using city-level variation in mortality. They find that more exposed areas experienced a sharper and more persistent decline in economic activity relative to other areas, controlling for possible contemporaneous shocks, interacted with local characteristics. Consistent with Brainerd and Siegler (2003), they find that severely and moderately affected areas had similar levels of population, employment, and income per capita before 1918. They also address endogeneity concerns by exploiting the fact that regions differed in susceptibility to influenza outbreaks,

7 Why the wave was so deadly —with mortality rates 5 to 20 times higher than normal— and why it primarily affected young adults is still unclear, despite much recent research on the 1918 influenza epidemic by microbiologists.

8 Bloom and Mahal (1997) examine the effect of the 1918 influenza pandemic in India, which experienced an estimated 17 to 18 million deaths, and find no relationship between the magnitude of the population decline and changes in acreage sown per capita.

9 Brainerd and Siegler (2003, p. 7) conclude that "the statistical evidence also supports the notion of influenza mortality as an exogenous shock to the population".

Table 3 Summary of papers which model past pandemics

	Assumptions	Model/Aim	Scope	GDP impact			Comments
Meltzer et al. (1999)	Gross attack rate 15%-35%. Predefined probability distributions for a set of input variables by age and risk group. Four options of vaccination schemes.	Monte Carlo simulation. Economic impact of vaccine-based interventions.	US	USD 71.3-166.5 billion Disease-associated medical costs, indirect costs from losses of time and income by careers, and morbidity/mortality costs measured as expected foregone lifetime earnings. Excluding disruptions in commerce and society.			Loss of life accounted for approximately 83% of all economic losses at any given attack rate. The largest returns come from interventions that prevent the largest number of deaths. Vaccinating priorities should be set depending on the policy objective. Other multiplier effects resulting from disruptions in commerce and society need also to be valued. Large uncertainty about the gross attack rate of an actual pandemic.
Lee and McKibbin (2004)	Temporary shock (6 months): increase in country risk premium, drop in demand for services and increase in costs in the services sector. Country-specific index of "global exposure to SARS". Persistent shocks of equal size fade out equiproportionately over a 10-year period. Rational expectations and forward-looking intertemporal behaviour.	G-Cubed (Asia-Pacific) model. Economic costs of SARS.	Global	**Temporary shock** Global GDP loss close to USD 40 billion in 2003; Hong Kong (2.63% of GDP) with the services sector the largest contributing factor; China (1.05%) with effect evenly spread across factors.	**Persistent shock** Global GDP loss close to USD 54 billion in 2003. China, Hong Kong, Malaysia, the Philippines, Singapore and Taiwan larger loss vs OECD and others lower GDP loss. Greater capital outflow from affected countries into the least affected countries. Net capital outflows from China and Hong Kong are estimated to 0.8% and 1.4%, respectively. Persistence in rise of risk premium causes large capital outflow; sharp contraction in investment leads to persistent decline in production capacity.		Medical expenditures and demographic consequences of SARS are insignificant. The results overall point towards the argument that in a complex interrelated world, a disease outbreak might have a huge economic impact for the global economy and not only for the affected economies. The recession is found to last for a number of years afterward.
Bloom et al. (2005)	Mild pandemic (attack rate 20%; case fatality rate 0.5%; one year). Scenario 1: psychological impact affects demand for two quarters. Scenario 2: four quarters. Exogenous consumption shock of 3% and contraction in the export of services; demand shock only in Asian countries; 2-week period of labour supply shock (not working due to the disease).	Oxford Economic Forecasting (OEF) global model. Short-run economic impact of a human-to-human influenza.	Asia	**Scenario 1** Asia: 2.3% GDP demand shock; 0.3% GDP supply shock.	**Scenario 2** More severe. Global GDP shrinkage 0.6%: world recession. Global trade of goods and services contraction by 14%.	**Long-term impact** Even after 5 years in Scenario 2 Asia's GDP growth will be lower by 3.6 percentage points.	Demand and supply effect. Direct: Asian consumers reduce activity. Indirect: rest of world reduces consumption, impacting trade and investment. Open economies more vulnerable, exporters of services hard-hit. Timely policy responses can help prevent and mitigate the economic impact of a pandemic. Cooperation and coordination among countries.

Table 3 Summary of papers which model past pandemics *(continued)*

	Assumptions	Model/Aim	Scope	GDP impact			Comments
McKibbin and Sidorenko (2006)	Mild: similar to 1968-1969 Hong Kong flu. Moderate: similar to 1957 Asian flu. Severe: similar to 1918-1919 Spanish flu. Ultra: Spanish Flu but with higher mortality rates for older people. Epidemic shocks: indices of possibility of each severity to occur, sickness index for morbidity rate. Attack rate 30%. Reduction in consumption, increase in cost of doing business, increase in country risk premia. Global exposure of the country to the disease.	Asia Pacific G-Cubed model (extended for the UK). Estimate macro consequences of influenza pandemic.	Global	**Mild scenario** 1.4 million deaths worldwide and global GDP would fall by approximately 0.8%, with mortality and morbidity shocks being the main drivers assuming that monetary policy can effectively contaminate demand changes.	**Moderate scenario** As severity of the pandemic increases, the importance of cost increases rises, resulting in a larger shrinkage of global GDP, but with the negative effect being larger for Asia and developing countries. More substantial GDP losses (9.3% for Hong Kong and 7.3% for the Philippines).	**Severe scenario** Contraction in most affected economies reflects much larger shocks and large reallocation of global capital. World is substantially affected (up to 26% contraction in Asia).	**Ultra scenario** Over 142.2 million deaths, and income losses of over 12% of GDP (USD 4.4 trillion) worldwide. Over 50% in some developing countries such as Hong Kong in 2006. Large-scale collapse of Asia causes global trade flows to dry up and capital to flow to safe havens. Prices rise in the short run, the result depends on whether demand or supply effect is larger. Monetary tightness (as a response to declining output, inflation changes or exchange rate changes) results in higher economic impact and may have a great importance for bond markets together with fiscal response. Policy makers should invest a lot in averting an outbreak because of the significant potential consequences for the global economy.
Burns et al. (2006)	Replication of the results of McKibbin and Sidorenko (2006). Human-to-human pandemic with similar mortality rate to the Spanish Flu (1.08% of people die across the world) For a year, 20% decline in air travel and in services sector. Global economic linkages of trade flow adjustment and capital flow reallocation.	Simulations. Breakdown of the economic impacts (mortality, morbidity and demand changes).	Global	1918-like pandemic scenario: developing countries would be hit the hardest (5.3% fall in GDP). High-income countries 4.7% fall in GDP. Great global recession (4.8% fall in GDP). Human-to-human pandemic: total impact 3.1% with the highest impact coming from shifts in demand (1.9% of GDP).			Initial impact purely from additional deaths. Public and private efforts to mitigate the spread of the disease by imposing travel restrictions and social distancing have a large impact on real activity. As the disease spreads to the rest of the world, global economic activity declines significantly in an effort to monitor the outbreak.
Fan et al. (2016)	Estimates of the probabilities of pandemics on an annual basis. Two severity scenarios: moderate scenario has age-specific mortality distributions like 1957 and 1968 and severe scenario has age-specific mortality distributions like 1918. Expected severity is defined in terms of standardised mortality units.	Inclusive cost of a pandemic.		**Moderate scenario** Annual excess mortality rate in the lower-middle income countries is expected to be about 0.06% (18,000 deaths) For the world, the excess expected number of deaths is 37,000. Expected annual income losses are USD 16 billion.	**Severe scenario** Annual excess mortality rate in the lower-middle income countries is expected to be about 1.2% (370,000 deaths). For the world, the excess expected number of deaths is 680,000. Expected annual income losses are USD 64 billion.	**Total impact** Annual income loss: 1.6% fall in lower-middle income countries and 0.62% fall for the world economy. Expected annual inclusive cost of 0.7% of global income.	As the severity of the pandemic increases, the intrinsic cost of premature death and illness rises, and this is far more obvious for the lower-middle income countries.

and instrument Spanish Flu mortality with the previous year's influenza mortality for the region. They find strong effects on manufacturing employment and output, bank assets, and car registrations, pointing to both supply and demand channels, as well as financial frictions.[10] The estimates imply that the pandemic reduced manufacturing output by 18% for regions with average exposure,[11] while national banks saw an increase in losses charged off relative to assets in 1920-21, indicating an increase in NPLs in 1919-20.

Velde (2020), on the other hand, uses a variety of high-frequency data to argue that the short-term economic effects of the pandemic were quite modest. Industrial output fell sharply but rebounded after a few months, the financial system was robust, and business failures were minimal. Business failures did rise substantially, and several measures of economic activity (including retail trade and payments) contracted severely in the second half of 1920, with industrial production reaching a trough in May 1921. However, the 1920 wave was much smaller than the 1918-19 wave, and occurred in February. As Velde (2020) notes, the discrepancy between his results and those of Correia et al. (2020) and Brainerd and Siegler (2003), who show negative effects on long-term outcomes, presents a challenge for economics research, highlighting the need to find a state variable that propagates the shock of 1918 to 1923 and later.

Correia et al. (2020) also consider the economic effects of NPIs. They build on the epidemiology literature establishing that NPIs decrease influenza mortality, and use variation in the timing and intensity of NPIs across cities to study their economic effects. They find that cities that intervened earlier on and more aggressively experienced a relative increase in manufacturing employment, manufacturing output, and bank assets in 1919, after the end of the pandemic. The effects are economically sizeable. Reacting 10 days earlier to the outbreak of the pandemic in a given city increased manufacturing employment by around 5% in the post-pandemic period. Likewise, implementing NPIs for an additional 50 days increased manufacturing employment by 6.5% after the pandemic. In 1919 and 1920, an increase in banking assets was observed in cities with early and longer interventions after 1918, which helped to mitigate the exacerbation of the crisis that resulted from bank deleveraging due to higher defaults. Altogether, their findings suggest that pandemics can have substantial economic costs, and NPIs can have economic merits, beyond lowering mortality.

They conjecture that the results may be driven by the fact that the pandemic itself can have important economic effects, as people cut back on consumption and labour supply, and that NPIs can reduce the length of disruption by solving coordination problems. On the other hand, a particularly strong channel for this pandemic was probably the fact that it targeted prime-age adults, and so NPIs had strong effects in preserving the local labour force. An important channel of transmission of both demand and supply shocks could have been the banking sector. The temporary nature of the pandemic should in principle lead to increased demand for liquidity (Holmström and Tirole 1998), and healthy banks could then smooth the shock and mitigate the decline in demand and production. Widespread defaults, however, may stress the banking system, impairing its assets, and potentially amplifying the pandemic to a financial crisis. This has important implications for COVID-19; bridge loans to levered actors to prevent unnecessary defaults and destruction of productive capacity are key, and it is no surprise that they are an essential element of rescue packages. Nevertheless, it should be noted

10 Local manufacturing should be somewhat insensitive to changes in local demand, so lower relative manufacturing employment would be indicative of a supply shock. The opposite holds for car registrations, while for bank assets both types of effects are possible; supply shocks may lead to defaults, while lower demand may shrink lending. Credit rationing could be an important amplifier of the shock.

11 A concern is that data on manufacturing outcomes are only available for 1914 and 1919, which makes it hard to control for the effect of WWI. However, data on car registrations and bank assets are annual, thereby sharpening identification substantially.

that Velde (2020) finds little short-term effects of mortality on bank outcomes at the city level, making the connection to long-run outcomes puzzling.

On the other hand, Barro (2020) finds no evidence of a relationship between NPIs and mortality. Though the curve was flattened, in that the ratio of peak to average deaths did fall, the total effect was unrelated to NPIs. He argues that this is because the measures were not implemented long enough to have substantial effects, as they had an average duration of around one month. Yet it is possible that some types of NPIs may be more effective than others, as he finds significant negative effects for restrictions on public gatherings.

Furthermore, Lilley et al. (2020) collect a larger sample of data and argue that the results of Correia et al. (2020) regarding the effects of NPIs are driven by pre-existing trends in population, and hence manufacturing employment and output. In fact, they find that NPIs are strongly related at the city level with population growth ten years before the pandemic, causing a spurious relationship between NPIs and employment growth. Once this is taken into account, results are uninformative about the true effects of NPIs.[12]

Barro et al. (2020) study the macroeconomic impact of the 1918 influenza pandemic at the country level for 42 countries, separating the effect of WWI by controlling for the deaths of soldiers in combat. The analysis yields flu-generated declines for GDP and consumption in the typical range of 6%-8%, respectively.[13] The results cannot rule out effects of the flu pandemic on the level of real per capita GDP that are fully permanent, or fully temporary, or somewhere in between. The authors also provide some evidence that higher flu death rates decreased realised real returns on stocks and, especially, on short-term government bills. There is no prediction that the short-term negative effect will be reversed. Finally, the results on inflation confirm that the 1918 influenza pandemic and, especially WWI, increased inflation rates at least temporarily.

With regard to lessons for the COVID-19 episode, it should be stressed that the industrial structure is substantially different now than a century ago. Notably, services now account for a much larger share of the economy compared with the late 1910s, whereas the opposite holds for manufacturing or agriculture. A large portion of services are demanded at a specific point in time, with a smaller role for pent-up demand than is the case with durable or even non-durable goods. For instance, restaurant meals foregone due to closures will not be recovered once lockdowns are lifted (even abstracting from lower demand due to continued fear of infection or income uncertainty), unlike purchases of dishwashers or furniture. As such, even if the downturn resulting from the Spanish Flu was short-lived, this does not necessarily imply that the COVID-19 effects will follow a similar path.

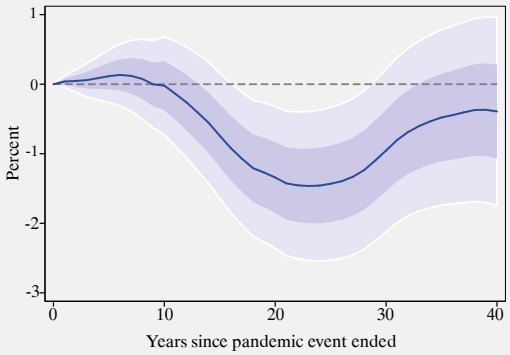
Other interesting papers that study the effect of the Spanish Flu include Almond (2006) and Le Moglie et al. (2020). Almond (2006) explored a longer-term effect of the Spanish Flu: whether in utero exposure to the influenza had negative economic consequences for individuals later in their lives. The hypothesis is that individuals' health endowments are positively related to human capital and productivity and thus also to wages and income (the fetal origins hypothesis). Using 1960-80 decennial

12 In a later response to the findings of Lilley et al. (2020), Correia et al. argue that the population values used by the authors are problematic, as they are not census-based and reflect extrapolations from values between 1900 and 1910, leading to measurement error. Furthermore, they argue that the spurious relationship between NPIs and employment growth documented in Lilley et al. (2020) is not present with employment growth five years before the pandemic. Accounting for population growth gives results close to the original ones. See http://scorreia.com/research/pandemics-llr-response.pdf.

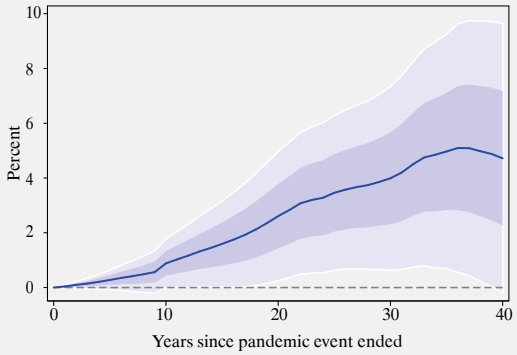
13 The flu death rate for 1918-20 has an overall correlation of -0.25 with a country's real per capita GDP in 1910. This may largely reflect the impact of better health services and better organisation on the probability of death from the disease (reflecting partly risk of infection and partly the mortality rate given infection). An offsetting force, however, is that more advanced economies are likely to have greater mobility and interactions, which foster the spread of contagious diseases.

Impulse responses to major pandemics

A. Response of the European real natural rate of interest following pandemics



B. Response of real wages in Europe following pandemics



Source: Jordà et al. (2020).
Note: Response of the real natural rate of interest and of real wages to a pandemic in Europe, one to 40 years into the future. Shaded areas are 1 and 2 s.e. bands around response estimates.

census data, Almond (2006) found that cohorts in utero during the 1918 pandemic had reduced educational attainment, higher rates of physical disability, and lower incomes. "Children of infected mothers were up to 15% less likely to graduate from high school. Wages of men were 5-9% lower because of infection" (Almond 2006, p. 673).

In a very recent paper, Le Moglie et al. (2020) study the social effects of the Spanish Flu. The extremely high rates of infection and fatality (over 2%, relative to less than 0.1% for the typical flu), together with public health guidelines to limit physical contact, similar to the measures taken against COVID-19, had a substantial effect on social interactions. Using a representative survey of the descendants of immigrants to the US, they show that descendants of immigrants coming from countries with higher influenza mortality had significantly lower levels of social trust, with an additional death per thousand population being associated with a 1.4 percentage point decrease in trust, relative to descendants of immigrants who had migrated from the same countries before the Spanish Flu. A possible mechanism is the comparison between countries that were neutral and belligerent in WWI; in the former, lack of censorship meant that societies internalised the threat of the disease and the need for social distancing.

Some studies have also looked at more localised pandemics, such as the **Severe Acute Respiratory Syndrome (SARS)** outbreak in Asia, which caused economic disruption even though a global health crisis was averted. Studies of the macroeconomic effects of the SARS epidemic in 2003 found significant effects on economies through large reductions in consumption, an increase in business operating costs, and a re-evaluation of country risks reflected in increased risk premia (for a review, see McKibbin and Fernando 2020). Shocks to other economies were transmitted according to the degree of the countries' exposure to the disease and to the affected economies. The Asian Development Bank estimated that the economic impact of SARS amounted to around USD 18 billion, or 0.6% of GDP, in East Asia (Fan 2003), mainly through its effects on consumption.[14]

14 Other studies of SARS include Chou et al. (2003) for Taiwan, and Siu and Wong (2004) for Hong Kong. These studies focus mostly on assessing the damages induced by SARS in affected industries such as tourism and the retail services sector. Siu and Wong (2004) reported that retail sales figures dropped by 15.2% between late 2002 and April 2003. They also reported substantial declines of 10.4% in passenger travel to Hong Kong over a similar time period.

Finally, Jordà et al. (2020) study the effect of pandemics across all major events since the Black Death, looking at outcomes up to 40 years out. They study rates of return on assets[15] using a dataset that covers France, Germany, Italy, the Netherlands, Spain, and the UK, focusing on 15 major pandemic episodes, where more than 100,000 people died. The results show that following a pandemic, the natural rate of interest declines for decades thereafter, reaching its nadir about 20 years later, with the natural rate about 150 basis points lower than what would have been the case if the pandemic had not taken place, and returns to trend around four decades later (see panel A of the chart). The heterogeneity of the responses is quite striking. For France, Italy, and Spain the effects of pandemics are much larger (3%-4%) relative to Germany, the Netherlands and the UK. This reflects, among other explanations, the timing of the pandemics across countries, the relative exposure, the relative size of the working population, and the relative degrees of industrialisation. The authors also look at some more limited evidence on real wages and find that the response of real wages is almost the mirror image of the response of the natural rate of interest, with its effects being felt over decades, a result consistent with the baseline neoclassical model (see panel B of the chart). Real wages gradually increase until about three decades after the pandemic, where the cumulative deviation in the real wage peaks at about 5%. All results are robust to controlling for wars, possible major trend breaks and after omitting the Black Death and the Spanish Flu. The results indicate that pandemics are followed by decades of depressed investment opportunities, possibly due to excess capital per unit of labour. The authors also speculate that there may also be a higher propensity to save (due to higher risk aversion or a rebuilding of depleted wealth), but they do not really provide any evidence for this. Instead, they show that wars are associated with an increase in natural rates, suggesting that sharp changes in capital per unit of labour may trump demand effects.

2.2 MODELLING THE ECONOMIC IMPACT OF PAST PANDEMICS

Meltzer et al. (1999) examine the likely economic effects of an influenza pandemic in the US and evaluate several vaccine-based interventions. They use a Monte Carlo mathematical simulation model with predefined probability distributions for a set of input variables by age and risk group. At a gross attack rate (i.e. the number of people that become clinically ill out of the total population) of 15%-35%, the estimated total economic impact (i.e. disease-associated medical costs, indirect costs from losses of time and income by careers, and morbidity/mortality costs measured as expected foregone lifetime earnings) for the US economy ranged from USD 71.3 billion to USD 166.5 billion (excluding disruptions to commerce and society), and the estimated deaths ranged from approximately 89,000 to approximately 207,000 people. The costs associated with mortality accounted for approximately 83% of all costs. Thus, the results indicate that in the event of a pandemic any intervention should aim at lowering the death rates. The authors also argue that vaccinating priorities should be set depending on the policy objectives (preventing deaths, maximising economic returns, or other), leading to different vaccine-based intervention plans. However, the results for the economic returns of vaccination schemes presented in the paper are sensitive to the assumed gross attack rate and cost of vaccination. Furthermore, the authors use an economic value of life of USD 1 million, while conventional current estimates put it at around USD 10 million for the US, implying that these estimates may be an order of magnitude higher in current US dollars. Finally, the authors acknowledge that (a) other multiplier effects resulting from disruptions in commerce and society need also to be valued and incorporated in the model, and (b) the range of the

15 Aggregate real interest rates are constructed by weighting real interest rates on long-term debt by GDP shares (Maddison 2010). The underlying assets are debt contracts, "which are not contracted short-term, which are not paid in-kind, which are not clearly of an involuntary nature, which are not intra-governmental, and which are made to executive political bodies".

gross attack rate of an actual pandemic is quite wide, thereby leading to considerable uncertainty about a pandemic's potential economic impact.

Bloom et al. (2005) use the Oxford economic forecasting global model to estimate the potential short-run economic impact for Asia of a pandemic resulting from a mutation in the avian flu that spreads from human to human. They look at two scenarios, both assuming a mild pandemic spread around a year with a 20% attack rate and a 0.5% case-fatality rate. Under the first scenario, there is a consumption shock of 3% and a reduction in the trade of services, which last for two quarters and only affect Asian countries. Supply shock is assumed as a two-week absenteeism from work. The economic impact for Asia is estimated at around USD 99.2 billion from the demand side and USD 14.2 billion from the supply side. Under the second scenario, where the shocks last for four quarters, the impact is greater since there is also a reduction in consumption in the rest of the world, leading to a global GDP shrinkage of 0.6% and a contraction of 14% in global trade of goods and services. This implies that open economies and exporters of services are more vulnerable to international shocks. For Asia, GDP growth is predicted to remain low even five years after the pandemic. Taking all these together, the results show that timely policy responses can help prevent and mitigate the economic impact of a pandemic, also necessitating cooperation and coordination among countries.

Lee and McKibbin (2004) use a global model (called "G-Cubed Asian Pacific" model), consisting of 20 countries and 6 sectors, to estimate the impact of SARS arguing that (a) direct medical costs and demographic effects because of the epidemic might be low (or at least ambiguous for the supply-side effect), and (b) there are important linkages between and within economies through both international trade and capital flows. Hence, a global model that takes into account integrated economies, rational expectations and forward-looking intertemporal behaviour (although this is acknowledged to be an unrealistic assumption for the real world when a new disease appears) is more adequate to get a full picture of the channels of transmission and of the economic costs from a global disease. Under the assumption of a temporary shock (captured as an increase in country risk premium, a drop in demand in the services sector and an increase in costs in the services sector) of six months to the affected economies, and by calculating a country-specific index of "global exposure to SARS" (depending, among other things, on geographical distance to China and governance response) to scale the shock to other countries, the authors find that despite a relatively small number of cases and deaths, the global costs of SARS were significant and not only limited to the countries directly affected. They estimate GDP losses of between 2.63% and 0.5% for China, Hong Kong, Singapore and Taiwan. Analysis of the data revealed that the retail sector and travel industries suffered the largest declines. The model also predicts how the expectations about future developments related to the disease might affect the potential economic costs of SARS. The more persistent SARS is assumed to be (lasting up to ten years), the larger the negative economic impact in affected economies, but the smaller the impact in the rest of the world, which reflects the direction of capital flows to the least affected countries. The calculations suggest that the cost of SARS in 2003 for the world economy was close to USD 40 billion in the event of a temporary SARS effect and around USD 54 billion in the event of a persistent SARS shock (not including actual costs in later years if in fact SARS does persist). The recession is found to last for a number of years afterward. Under a persistent shock, for the affected economies, the primary impact comes from the rise of the country risk premium, leading to a sharp decrease in investment. Net capital outflows from China and Hong Kong are estimated to 0.8% and 1.4%, respectively, with a positive effect on their trade balances due the exchange rate depreciation. The results overall point towards the

argument that in a complex interrelated world, even if toll rates are low and demographic effects are insignificant compared with other major epidemics, a disease outbreak might have a huge economic impact for the global economy and not only for the affected economies.

McKibbin and Sidorenko (2006) adapt the Lee and McKibbin (2003) G-Cubed Asian Pacific model (also extended here to include the UK) to examine the global economic consequences of a range of pandemic influenza severities: a mild pandemic similar to the 1968-69 Hong Kong flu, a moderate pandemic similar to the 1957 Asian flu, a severe pandemic similar to the 1918-19 Spanish Flu and an "ultra" pandemic scenario (toward the upper end of the range of estimates for severity in 1918), which is not based on any known previous pandemic but has the characteristics of the Spanish Flu in addition to higher mortality rates for older people. In the model, the various epidemic shocks (estimated using some indices capturing the possibility for each country that each severity might occur and a sickness index that captures morbidity rate), given an attack rate of 30%, affect Asian economies through a large reduction in consumption (modelled as endogenous shifts), an increase in the cost of doing business (scaled for the services sector exposure of the economy across countries and for the mortality shocks across scenarios) and an increase in country risk premia (calculated as a composite indicator of the responsiveness of the health services sector to the pandemic, the quality of governance and the exposure of the country to foreign capital). At the same time, shocks are transmitted to other economies depending on the global exposure of the country to the disease. Shocks are shown to be temporary, lasting only for 2006 for most countries and fading out until 2008 when real activity recovers. The authors estimate that the ultra scenario would lead to over 142.2 million deaths, and to income losses of over 12% of GDP (USD 4.4 trillion) worldwide and over 50% in some developing countries such as Hong Kong in 2006. Even under a mild scenario it is estimated that a pandemic would cost 1.4 million lives worldwide and global GDP would fall by approximately 0.8%, with mortality and morbidity shocks being the main drivers, assuming that monetary policy can effectively contaminate demand changes. As the severity of the pandemic increases, the importance of cost rises as well, resulting in a larger shrinkage of global GDP, but with the negative effect being stronger for Asian and developing countries, where contraction of demand is larger, mortality rates are higher and capital outflows are more substantial. Under the severe scenario, contraction in some countries of Asia reaches 26% relative to the baseline scenario of no pandemic, partly reflecting large reallocation of capital to more "safe" economies. The composition of the results shows a great difference among countries, with developing countries being the most adversely affected. Although prices rise in the short run, the result depends on whether the demand-side or the supply-side effect is stronger. Monetary tightness (as a response to declining output, inflation changes or exchange rate changes) results in a more severe economic impact and may have a great relevance for bond markets, together with fiscal response. The paper concludes that although there is high uncertainty about how an influenza pandemic evolves with little historical guidance on how people tend to react under a severe situation and how such a crisis should be managed, policy makers should invest a lot in averting an outbreak because of its significant potential consequences for the global economy (see Table 4).

Previous studies by the World Bank (see Jonas 2013) looked at pandemic risk and estimated that a 1918-like pandemic could cost USD 3 trillion globally. Burns et al. (2006) replicate the results of McKibbin and Sidorenko (2006) and find that, under a 1918-like pandemic scenario (severe scenario), developing countries would be hit the hardest (5.3% fall in GDP) relative to the high-income countries (4.7% fall in GDP) and there would be a great global recession (4.8% fall in GDP). The authors also

Table 4 Summary of estimated effects from two recent pandemics

SPANISH FLU, 1918-1919				
GDP growth (%)	**1908-13**	**1914**	**1914-18**	**1919**
	Average	*Annual*	*Average*	*Annual*
Australia	5.16	-7.70	0.89	-1.84
Canada	8.69	-6.70	3.54	-11.14
United Kingdom	2.88	1.00	3.02	-13.89
Japan	2.52	-3.00	5.56	7.94
United States	5.48	-7.70	6.09	-5.22

ASIAN FLU, 1957-1958		
GDP growth (%)	**1953-57**	**1958**
	Average	*Annual*
Australia	4.38	4.80
Canada	5.28	1.79
United Kingdom	3.06	-0.21
Japan	8.43	5.83
United States	2.62	-0.49

Source: McKibbin and Sidorenko (2006).

present results under a different scenario of a human-to-human pandemic with a similar mortality rate to the Spanish Flu (1.08% of people die across the world) and provide a breakdown of the economic impacts from mortality, morbidity and demand changes (where it is assumed a 20% decline in air travel and in services). The total economic impact is a 3.1% fall in world GDP, with the strongest impact coming from shifts in demand (1.9% of GDP), i.e. public and private efforts to mitigate the spread of the disease by imposing travel restrictions and social distancing have a large impact on real activity. The main policy implication of the simulation study is that there is a big immediate impact on the affected countries, but as the disease spreads to the rest of the world, global economic activity declines significantly in an effort to contain the outbreak (see Table 5).

In a different strand, Fan et al. (2016) assess the inclusive cost of a pandemic that adds to the income loss the intrinsic value of premature mortality and morbidity. They use estimated probabilities of pandemics on an annual basis under two severity scenarios to provide estimates of mortality rates and of the associated cost. Expected severity is defined in terms of standardised mortality units[16] and it is assumed that the moderate scenario has age-specific mortality distributions like 1957 and 1968 and the severe scenario has age-specific mortality distributions like 1918. The results show that the annual excess mortality rate due to a pandemic in the lower-middle income countries is expected to be about 0.06% (18,000 deaths) under the moderate scenario and about 1.2% (370,000 deaths) under the severe scenario. For the world, the excess expected number of deaths is 37,000 and 680,000 people, respectively. Translating these figures into an annual income loss gives a 1.6% fall in lower-middle income countries and a 0.62% fall for the world economy

16 The standardised mortality unit (SMU) represents a 10-4 mortality risk and is used to represent small numbers as integers.

Table 5 Possible economic impacts of a flu pandemic

(% change in GDP, first year)

	Mild	Moderate	Severe
World	-0.7	-2.0	-4.8
High-income countries	-0.7	-2.0	-4.7
Developing countries	-0.6	-2.1	-5.3
East Asia	-0.8	-3.5	-8.7
Europe and Central Asia	-2.1	-4.8	-9.9
Middle East & North Africa	-0.7	-2.8	-7.0
South Asia	-0.6	-2.1	-4.9
Deaths (millions)	**1.4**	**14.2**	**71.1**

Source: Burns et al. (2006).
Note: The mild scenario is modelled on the Hong Kong flu of 1968-69; the moderate flu has the characteristics of the 1957 Asian flu; and the severe scenario is benchmarked on the 1918-19 Spanish Flu.

(annual mortality cost). For the world, the expected annual income losses amount to USD 16 billion under the moderate pandemic and USD 64 billion under the severe pandemic scenario. This means that as the severity of the pandemic increases, the intrinsic cost of premature death and illness rises as well, and this is far more obvious for the lower-middle income countries. Adding these two costs together gives an expected annual inclusive cost of 0.7% of global income.

3 UNDERSTANDING THE ECONOMIC IMPACT OF COVID-19

3.1 MODELLING COVID-19: CONVENTIONAL ECONOMIC MODELS

Motivated by the recent outbreak of COVID-19, a number of papers use full-scale macro models to gauge its potential economic impact and explore the relative merits of alternative economic policy responses. According to the literature, the economic impact of the current pandemic can be thought of as entailing both a supply shock, stemming from the self-imposed social distancing and the state-imposed lockdown, and a demand shock, i.e. a negative shock to consumption resulting from reduced opportunities to consume. Moreover, the pandemic increases risk and uncertainty both in the real economy and in the financial sector. However, modelling a pandemic to examine its impact on the economy is challenging, due to the large degree of uncertainty with respect to the nature, the persistence and the size of the shocks arising from the pandemic. Indeed, different papers adopt very different approaches.

Fornaro and Wolf (2020) choose to model the impact of the pandemic as a drop in labour productivity growth. They opt for an unexpected, very highly persistent shock, as they want to explore the pessimistic scenario that the COVID-19 outbreak leads to a long-lasting supply disruption. However, they point out that the persistence of the shock (supply disruption) is crucial to their analysis, as it induces agents to revise their expectations of future income downwards.[17] They find that such a shock leads to a decline in demand and, given the downward revision of agents' future income expectations, to a decline in output and employment. If we assume that the decline in demand also leads to a decline in investment,

17 In earlier theoretical work, Torój (2013) had proposed that, within a standard DSGE model, an epidemic can be modelled as a reduction in labour utilisation under unchanged labour cost. Such a shock has a smaller impact than a negative labour supply shock, as the latter directly affects the nominal wage. It is argued that such a representation is adequate when computing the costs of short-lived diseases like epidemics of influenza, if one assumes away any possible long-run consequences stemming from higher morbidity or mortality.

the initial shock may generate a "supply-demand doom loop", as a decline in investment endogenously generates a further drop in productivity. Within this model, monetary stimulus can mitigate the impact of COVID-19 on employment and output, and will have a multiplicative positive effect by containing the doom loop. If, however, monetary policy is limited by the zero lower bound, then agents' expectations of lower income become self-fulfilling and may lead to a stagnation trap. In this case, fiscal policy should be used to support public and private investment, thus helping labour productivity (and expectations) to rebound. In this context, it is unclear whether inflation will be pushed upwards or downwards, but the central bank does face a trade-off between stabilising inflation and employment.

Bayer et al. (2020) assume that a random fraction of workers (10% or 30%, depending on the scenario) is in quarantine, i.e. they have zero productivity, a state from which they recover quickly (there is a 50% exit probability at the end of each period). The shock leads to a reduction in output, while its randomness introduces income risk into the model, as it is ex ante unknown exactly which households will be quarantined and which will not. The setup is a HANK-DSGE model with numerous frictions and incomplete financial markets, due to which idiosyncratic risk is uninsurable at the household level. The authors find that the quarantine shock, which reduces the effective labour force, leads to a sharp decline in consumption and investment upon impact, and thus to a reduction in output. The increase in income risk leads to a decline in aggregate demand and an increase in households' precautionary cash holdings, as they try to self-insure. The decline in demand prompts a decline in investment and thus a further decline in output. In other words, the ensuing recession is due to both depressed supply and depressed demand. Output falls by a maximum of 3.5% in the trough period Q3, in the scenario where 10% of the labour force is in quarantine for one quarter, and by a corresponding 11% if 30% of the labour force is in quarantine. Recovery is slow – it takes up to three years to fully recover from the shock, as some of the job losses are persistent. The authors explore the potential impact of the recently announced US fiscal package and find that the transfer component has a high multiplier (between 0.4 and 1.2), depending also on the responsiveness of monetary policy to inflation. Key for this high multiplier are the transfers which are directly paid to the unemployed and/or the quarantined households, as these have a high marginal propensity to consume, and the transfers ex ante reduce their income risk.

Guerrieri et al. (2020) assume that a fraction of agents are "unable" to work in the first period, because the epidemic has rendered their occupation unsafe. They explore the circumstances under which a negative supply shock, such as one induced by a pandemic, can generate a demand shortage and thus an output decline larger than the initial shock – a type of shock which they term "Keynesian" supply shock. The authors show that, in the model specification with two sectors and incomplete markets, when the initial supply shock only hits one sector, such "Keynesian" supply shocks can materialise. They also model a "business exit multiplier", which occurs when firms are put out of business due to the epidemic, prompting a cascade of "business exits", as their employees cut back on their consumption – a second type of "Keynesian" supply shock. Low substitutability across sectors and incomplete markets with liquidity constrained consumers, all contribute towards the possibility of such shocks. Fiscal policy is overall less effective in such a model. However, optimal policy, which comprises a containment of the epidemic, a loosening of monetary policy and a social insurance policy which compensates workers in the affected sectors, alleviates the possibility of a "Keynesian" supply shock and makes it easier for public health objectives to be pursued.

Faria-e-Castro (2020) models the COVID-19 pandemic as a demand-side shock, i.e. a large

negative shock to the marginal utility of consumption that induces households to reduce current consumption. The shock is imposed on the sectors that produce contact-intensive services – according to the author, these comprise hospitality and leisure, certain types of retail (bricks and mortar) and air travel. Additionally, it is assumed that the output of these sectors is unlikely to be consumed by the government so that, in the model, a rise in government spending does not boost demand for contact-intensive services. The author calibrates the size of the shock so that the rate of unemployment rises to 20%, to capture the worst-case scenario put forward by the Treasury Secretary to Members of the US Congress on 17 March 2020. He assumes that the pandemic lasts exactly three quarters, i.e. that there is a shock of equal size in each quarter and that the economy returns immediately to the initial state once the pandemic is over. Constrained agents (modelled as borrowers), who have a high marginal propensity to consume, will be affected and thus non-service consumption will also decline. Constrained agents will default on their loans more often, leading banks to charge higher interest rates on loans, thus further depressing overall consumption, demand for labour and inflation. Expansionary monetary policy helps, but if constrained by the zero lower bound, a deep recession can ensue. By design, the economy rebounds immediately after the shock. The author considers one-quarter fiscal interventions of five alternative types (increase in government consumption, cut in labour income tax, increase in unemployment insurance, unconditional transfers to all agents and a per-wage subsidy to services sector firms) designed to have a comparable impact on the fiscal balance. The latter intervention is the only one which protects employment in the services sector. The measure that yields the highest GDP multiplier is government consumption. However, the author acknowledges that there may be strong complementarities between policies, which are not further examined.

McKibbin and Fernando (2020) use a global model (a hybrid between a DSGE model and a computable general equilibrium model) which explicitly models 20 countries and 4 sub-regions for the rest of the world and 6 sectors, with cross-country trade linkages. In line with similar work of theirs for SARS, they consider seven epidemiological scenarios: three scenarios where the epidemic only hits China (with varying mortality and morbidity rates) and affects the rest of the world only via changes in trade, capital flows and risk premia; three scenarios of a pandemic affecting all countries; and one scenario of a mild annually recurrent pandemic. These epidemiological scenarios are then mapped into the following economic shocks:

- A labour supply shock which comprises a mortality rate and a morbidity rate. The mortality rate is set on the basis of data on the SARS epidemic (0.02%-0.9% depending on the scenario). The morbidity rate reflects (i) the share of the population that will contract the virus and will have to stay at home for 14 days (1%-30%) and (ii) the notion that for every sick person a carer will also take sick leave, while 70% of the female labour force participation will have to stay at home for 14 days due to school closures. This is then adjusted from country to country based on indices reflecting the extent of linkages to China, urban population density and health security *inter alia* (adjustments benchmarked against China). In the pandemic scenarios, China suffers a shock to its labour supply ranging between -1.05% and -3.44% (annualised), which implies a shock to labour supply of about half the size for European countries.

- A shock to the equity risk premium which, for the milder scenario, is calibrated on the basis of the US equity markets' observed initial response to COVID-19. This is then used as a benchmark and adjusted for different scenarios and for different countries based on country-specific indices of country

risk, financial risk, governance risk, health policy, etc.

- A shock to the cost of production (beyond labour inputs) in each sector and country, meant to reflect the fact that trade as well as land, air and sea transport have been affected (though this is purely a cost effect, rather than a quantity effect). The authors calculate the cost input of these sectors to the six aggregate sectors in the model. They benchmark the shock for the mild scenario to the percentage increase in the cost of production observed in the Chinese manufacturing sectors during SARS. This is then scaled across sectors and countries depending on how exposed they are to China and to land, air and sea transport.

- A shock to consumption (over and above the decline in consumption which stems from depressed income), due to changes in preferences, benchmarked against the reduction in consumption expenditure observed in China over the SARS epidemic.

The authors calculate that the impact on GDP for the euro area ranges from -2% to -8.5% approximately. The pandemic causes a sharp drop in consumption and investment which, combined with the risk shocks, leads to a dampening of economic expectations, a sharp drop in equity prices and a move towards safe-haven bonds and cash, despite an endogenous easing of monetary policies. Capital flows out of severely affected economies like China and other emerging market economies and developing countries and into safer advanced economies which experience a currency appreciation. This generates a corresponding adjustment of current accounts: countries which experience a capital flight see higher exports and lower imports, while the trade balance of advanced economies deteriorates. The recovery is V-shaped in all countries and scenarios, except for the recurrent outbreak scenario.

A similar but much simpler exercise is undertaken by Luo and Tsang (2020), who first calculate the impact of the loss of labour input in Hubei province on its own production and that of any other province in the country; then, using input-output tables and the industry composition of each province, they back out the loss in aggregate output due to this loss of labour input. Subsequently, they attempt to estimate the loss in global output based on global trade linkages.[18] Luo and Tsang (2020) calculate that China will suffer an output loss of about 4% per month of lockdown, while global output will correspondingly drop by 1% due to the economic contraction in China. About 40% of the impact is indirect (rather than a direct result of lower labour supply in the affected region) coming from spillovers through the supply chain inside and outside China.

3.2 MODELLING COVID-19: ECONOMIC MODELS WITH AN EPIDEMIOLOGICAL BLOCK

An entirely new and innovative strand of economic literature has emerged, as academics strive to understand the impact of the COVID-19 pandemic on economic variables. In a seminal paper, Eichenbaum et al. (2020) were the first to explicitly model the interaction between economic decisions and the rate of infection by embedding a standard epidemiological model within a DSGE framework, i.e. by explicitly modelling the probabilities that economic agents transition between the states: susceptible, infected, and either recovered or "removed" (the SIR-macro model). The agents' optimising behaviour in each of these states is also explicitly modelled. Both consumption and labour supply increase the agents' individual probability of infection (as well as the overall infection rate) and thus economic agents optimally reduce their labour supply and consumption – that is, without the introduction of a shock as in previous models. The economic and epi-

18 In the same spirit, Fernandez (2020) also attempts to calculate the economic impact of COVID-19. For example, under the assumption of a 3-month lockdown, Greece is projected to suffer a contraction of 6.5% in GDP. However, no details of the model or the calculations are given.

demiological implications of alternative scenarios are then examined.[19]

The agents' micro-founded behaviour reduces the economy-wide rate of infection and death and generates a sharp recession, which peaks 32 weeks from the outbreak at a maximum deviation from the steady state of 8% (the baseline scenario). If there is concern that the healthcare system may become overwhelmed (modelled by making the mortality rate an increasing function of the number of people infected), people cut back on work and consumption even more aggressively, as they self-impose stricter social distancing. In this case, the timing of the trough is earlier, but it is much deeper (reaching -22% on the trough week) and somewhat more protracted than in the baseline scenario. From an epidemiological policy perspective, it is optimal to gradually impose compulsory social distancing measures and to tighten them whenever infection rates increase and reduce them whenever infection rates decline, until a critical share of the population achieves immunity (optimal containment scenario). Such a policy results in a recession which peaks a few weeks later than in the baseline scenario but is extremely protracted, reaching a maximum deviation of approximately -20% from the steady state on the trough week. When the model instead incorporates a positive probability of a vaccine being discovered, it is optimal from an epidemiological perspective to immediately introduce severe social distancing measures and to keep them in place until the vaccine arrives, resulting in an immediate (i.e. not bell-shaped) recession, the trough of which is more protracted but less deep (maximum deviation from the steady state at 14%). It should be noted that, in terms of the long-run post-epidemic equilibrium, the impact of social distancing is positive: while both consumption and labour supply are lower in the new post-epidemic equilibrium, their decline is smaller because a smaller cumulative number of deaths has been achieved.

A number of papers build on the seminal work of Eichenbaum et al. (2020). Jones et al. (2020) extend the model by adding (i) multiple consumer goods with different contagion risk and (ii) the possibility of working from home which requires learning-by-doing. They find two additional effects. First, the fatalism effect, whereby if agents think they will inevitably contract the virus, they may feel it is best to contract it early on. Second, the front-runner effect, which also yields the same result: economic agents who worry that the healthcare system may become overwhelmed at a later date may opt to get infected today to ensure better healthcare. Both effects imply that optimal government interventions should be more front-loaded.

Krueger et al. (2020) introduce different infection probabilities across sectors but assume that it is easy to substitute contact-intensive services (e.g. having a pizza at a pizzeria) with equivalent non-contact intensive ones (e.g. takeaway pizza). Similarly, they assume that workers are able to quickly relocate to sectors now in demand, e.g. waiters will do deliveries. Under this specification, the "Swedish approach" to the epidemic, which prescribes no government intervention, suffices to mitigate up to 80% of the human and economic cost. In other words, in their model, endogenous shifts in private consumption across sectors act as a mitigation mechanism during the epidemic. However, the authors acknowledge that their findings crucially hinge on both substitutability and labour market flexibility.

Glover et al. (2020) model a number of distinctions between agents: (i) young workers

19 A number of recent papers explore variations and extensions of the standard SIR epidemiological model which underlies the economic model of Eichenbaum et al. (2020); see for example Atkeson (2020), Berger et al. (2020), Casares and Khan (2020), Ferguson et al. (2020) and Stock (2020). However, they do not embed these epidemiological models within a macroeconomic model and thus do not explore the economic implications of the pandemic. Rather, their focus is on healthcare cost dynamics, forecasting the duration of the pandemic, exploring the optimal length of the lockdown and considering possible alternative approaches to testing – e.g. broader testing of asymptomatic patients coupled with a more limited lockdown and thus a smaller economic fallout. An exception of sorts is Greenstone and Nigam (2020) who employ the Ferguson et al. (2020) simulation model for the US to estimate the number of lives saved as a result of social distancing and then attempt to "monetize" them. This provides a quantification of the social distancing measures' economic benefits.

versus old pensioners; (ii) healthy versus sick workers; and (iii) basic sector (which cannot be quarantined) versus luxury sector (which can). They highlight the fact that the pandemic affects these cohorts differently; to some the epidemic poses a major health risk, while not to others. Similarly, mitigating measures such as the quarantine have a heterogeneous impact on agents: some will lose their income due to the quarantine, while others won't. In sum, both the pandemic itself and its mitigation have distributional effects, as gains and losses are unequally distributed. Mitigation measures generate a need for redistributive policies, i.e. a need to tax agents who still work in order to compensate those who cannot work for the income lost. The authors show that optimal redistribution and mitigation policies interact, e.g. governments which find redistribution measures too costly may decide that a lower mitigation effort is optimal. Ultimately, the optimal policy will reflect a compromise between the policy paths preferred by different subgroups of the population.

Finally, Velasco and Chang (2020) focus on the dilemma of the healthy: to forego today's income by adhering to the quarantine in order to be healthy tomorrow and enjoy tomorrow's income, or to work today and risk foregoing tomorrow's income in case they get infected. They find that the initial income level matters for this choice: poorer workers are unlikely to willingly forego today's salary. Thus, quarantines are more difficult to enforce in poorer economies than in advanced ones. However, economic policy can affect this choice. If the policy maker compensates agents for their income loss, they will be willing to comply with social distancing measures. Alternatively, the policy maker may commit to implementing expansionary policy in the next period, so that agents find it optimal to adhere to social distancing measures today in order to enjoy the next period's higher income. In all cases, policy credibility is crucial. The authors conclude that economic policy can change the contagion dynamics via its impact on incentives.

It should be noted that most of the aforementioned papers were written with the aim of understanding the immediate implications of COVID-19 for the economy, i.e. with a short- to medium-term perspective in mind. Indeed, they barely touch upon the potential long-run economic implications of the COVID-19 pandemic. Furthermore, in most of the papers mentioned above that use DSGE models, the pandemic shocks are temporary. Thus, the economy eventually returns to its pre-shock long-run equilibrium. A notable exception are papers in the spirit of Eichenbaum et al. (2020) where, in the long run, there is a permanent decline in the labour force, equal to the cumulative number of deaths, leading to a permanent reduction in GDP. All in all, this literature suggests that the duration of the downturn depends crucially on the duration of the lockdown, the degree of persistence of the resulting economic shock and, where applicable, the mortality rate. However, the authors acknowledge that they abstract from a number of potentially important determinants of an epidemic's economic impact, such as hysteresis effects from unemployment, protracted bankruptcy costs and the destruction of supply chains inter alia, all of which could affect the long-run performance of the economy and have positive and normative implications. These and other economic aspects of COVID-19 are discussed in a non-technical manner in two recent VoxEU/CEPR e-books (Baldwin and di Mauro 2020a and 2020b).[20]

3.3 THE IMPACT OF THE COVID-19 PANDEMIC ON ECONOMIC EXPECTATIONS

The COVID-19 pandemic may also be affecting the economy through its impact on economic expectations, an avenue not directly explored in the aforementioned literature. Fet-

20 The COVID-19 outbreak has also prompted new work on the measurement and timing of economic activity. Leiva-Leon et al. (2020) propose an empirical framework for measuring the degree of economic weakness of the global economy in real time and use it to gauge the impact of the COVID-19 pandemic. Laeven and Valencia (2020) have updated their systemic banking crises database to facilitate comparisons between the current crisis and past ones, improve understanding of how economically damaging this crisis may be and inform policy making.

zer et al. (2020) use experimental data, survey data and internet search data to measure COVID-19 perceptions and explore how they affect economic expectations.[21] They document a rapid surge in economic anxiety since the COVID-19 outbreak. They find that the experiment participants' beliefs regarding mortality rates and contagiousness causally affect their anxiety regarding both the aggregate economy and their personal economic situation. However, the participants' aforementioned beliefs exhibit substantial heterogeneity and often grossly overestimate both contagiousness and mortality rates, thus potentially affecting their economic decisions disproportionately. Bartik et al. (2020) undertake a similar survey exploration of small businesses and find that firms too have widely varying beliefs about the likely duration of COVID-19-related disruptions, while they also tend to anticipate problems with accessing state aid, such as bureaucratic hassles and difficulties establishing eligibility. These papers highlight the economic importance of clearly and effectively conveying to the public the scientific facts on COVID-19, as well as the need for timely policy measures which will both decrease economic hardship and reduce perceived economic uncertainty, so as to limit the economic impact of the pandemic.

3.4 THE IMPACT OF THE COVID-19 PANDEMIC ON FINANCIAL MARKETS

Finally, a few recent papers explore how the COVID-19 pandemic is affecting financial market participants' behaviour and perceptions. Baker et al. (2020a) empirically document that no previous infectious disease outbreak, including the Spanish Flu, impacted the stock market as strongly as the COVID-19 pandemic. They attribute this to: (i) the ease and speed with which information on the pandemic is disseminated, which generates high stock market volatility; (ii) the high interconnectedness of the world economy, which implies that economic disruption in one location has large spillover effects; but mostly to (iii) the COVID-19 containment policies, which are much more extensive and widespread than similar efforts in the past and lead to a sharp decline in labour supply.

Hassan et al. (2020) construct time-varying measures of the exposure of individual firms to COVID-19, as well as measures of firm-specific sentiment and riskiness with regard to the COVID-19 pandemic. They do so for a global sample of firms, by applying a text-classification technique on their quarterly earnings conference calls with market participants. These measures reflect both firms' and markets' concerns as, during the conference calls, firm managers have to respond directly to questions from market participants about their firm's prospects and thus address issues they might not have raised voluntarily. The authors thus identify which firms are expected to gain or lose from the pandemic and which are most affected by the associated uncertainty. They find that, in the first quarter of 2020, firms' primary concerns related to the collapse of demand, increased uncertainty, and disruptions in supply chains. Other important concerns relate to capacity reductions, closures, and employee welfare. By contrast, financing concerns are mentioned relatively rarely. A limited number of firms foresee opportunities in new or disrupted markets due to the spread of the disease. Finally, there is some evidence that firms which have experience with SARS or H1N1 have more positive expectations about their ability to deal with the COVID-19 outbreak.

Ramelli and Wagner (2020) focus on the industry-level cross-section of returns and find that, within the same industry and controlling for standard firm characteristics, more leveraged firms and those with limited cash holdings suffered more severely, even those with little or no international activities or linkages to China. In contrast to Hassan et al. (2020), they

21 In a similar vein, Briscese et al. (2020) show that ensuring the public's expectations of the lockdown duration are unbiased matters for the success of the policy. Other papers draw on principles of behavioural economics to explore how COVID-19-related messages can be conveyed more effectively to the broader public; see for example Haushofer and Metcalf (2020).

conclude that investors were mainly concerned about firms with corporate debt and limited liquidity, thus amplifying the COVID-19 economic crisis through financial channels.

Zechner et al. (2020) study how dividends have behaved during the recent period of turbulence. They find that, although firms normally attach great importance to smoothing their dividend payouts, so as to provide shareholders with projectable income streams, the opposite is true in disaster states. Despite robust 2019 earnings, many companies have slashed previously announced dividends to protect their liquidity, or are expected by the market to do so, while in some European countries regulators have forced companies to stop paying dividends or have tied government subsidies intended to help them cope with the crisis to dividend cuts. Thus, it seems that the liquidity which dividends represent for shareholders disappears in precisely those states in which predictable cash payments would be valued most highly. This explains the recent sharp increase in the risk premium on dividend claims.

3.5 THE IMPACT OF THE COVID-19 PANDEMIC ON LABOUR MARKETS AND DIFFERENT SEGMENTS OF SOCIETY

Several papers explore the ways in which the COVID-19 pandemic has affected labour markets and different social groups. Dingel and Neiman (2020) classify all occupations in terms of work-from-home feasibility. By merging this classification with occupational employment data for the US, they find that 37% of US jobs can plausibly be performed at home. Hensvick et al. (2020) compute the share of teleworking undertaken in the US over the period 2011-18, by occupation and industry, as an indication of the extent to which teleworking could be employed during the pandemic, and find that it varies greatly.

Alon et al. (2020) explore whether the economic downturn caused by the current COVID-19 outbreak may have implications for gender equality during both the downturn and the subsequent recovery. During typical recessions, male employment is affected more severely than female employment. This reflects both differences in the sectoral composition of their employment (women tend to be employed in more "secure" sectors, e.g. the government) and the fact that women often opt to increase their labour force participation as a response to their male partners' employment uncertainty. Conversely, the decline in employment which stems from social distancing measures may have a relatively larger impact on sectors with high female employment shares. In addition, school closures increase child care needs, which likely has a particularly large impact on working mothers. The effects of the crisis on working mothers are likely to be persistent, due to high returns to experience in the labour market. In the long run however, the adoption of flexible work arrangements may ultimately promote gender equality in the labour market. Moreover, the fact that fathers may also often be obliged to take primary responsibility for child care during the epidemic could help erode discriminating social norms and have a permanent positive effect on male participation in child care, as is known to be the case for compulsory paternity leave.

Allcott et al. (2020b) use location data from a large sample of smartphones to show that, controlling for other factors, areas with more Republicans engage in less social distancing. They then present new survey evidence of significant gaps between Republicans and Democrats in beliefs about their personal risk and the future path of the pandemic.

Baker et al. (2020b) study transaction-level household data and find that households drastically altered their spending behaviour, as the number of COVID-19 infections began to grow. Initially, spending increased sharply, particularly in retail, credit card spending and food items. This was followed by a sharp decrease in overall spending. They detect substantial heterogeneity across partisan affiliation, demographics and income. Specifically,

Republicans were more likely to stockpile, possibly because they are on average older, but also perhaps because they are more concerned about the financial implications of the epidemic. Other cohorts that undertook relatively more stockpiling were pensioners, households with children, and women.

4 ASYMMETRIES AND SPILLOVER EFFECTS OF COVID-19: KEY TAKEAWAYS FROM THE ASSESSMENT OF INTERNATIONAL INSTITUTIONS

International organisations, such as the European Commission, the OECD, the IMF and the World Bank, have attempted to quantify the effects of COVID-19 and to integrate its impact into their fully fledged forecasts for the world economy. The quantification of the impact, which is largely based on simulation analysis, is surrounded by a high degree of uncertainty, due to the unpredictability of factors, such as the success of containment measures and the possible occurrence of successive outbreaks. This section focuses on some of their findings with respect to the asymmetric impact and the spillover effects of the COVID-19 pandemic within and across countries and regions.

The economic impact of COVID-19 can be greater in certain regions compared with others, mainly due to differences in financial conditions and available policy space. Emerging market economies (EMEs) are particularly vulnerable to the financial channel of transmission of the crisis, compared with most advanced economies (AEs). This has been evident in the tightening of financial conditions in these countries and the unprecedented capital outflows due to increased risk aversion and a flight by investors to safety and liquidity (see, for example, UNIDO 2020). Whereas a group of 25 EMEs including China, India, South Africa and Brazil had a net inflow of investments of USD 79 billion in 2019, a total of USD 97 billion in portfolio equity and debt investments has already exited these countries during 2020Q1, according to the Institute of International Finance (2020). These capital flows are larger than during any recent crisis episode, including the global financial crisis in 2008. The capital flight has renewed fears of insolvency and sovereign default. This could be further accelerated by currency depreciations in EMEs and notably in countries such as Argentina, Turkey or South Africa.

In addition, in many EMEs, fiscal automatic stabilisers are weaker relative to AEs, due to the magnitude of the informal sector and less developed social safety nets. Under these conditions, macroeconomic policies to support employment and incomes, such as unemployment benefits and subsidised leaves, have limited effect. As a result, lockdown measures can be more costly and lead to widespread unemployment and bankruptcies, with significant income losses in lower-income economies, particularly affecting the poorest members of society. ILO (2020) estimates for the impact of COVID-19 on global employment suggest that lower-income countries are more vulnerable, largely due to higher informal employment.[22]

Moreover, although public and corporate sectors are highly leveraged across the world, they are a particular source of vulnerability for EMEs. Coupled with the high share of external debt, debt denominated in foreign currencies and heavy reliance on short-term debt, EMEs could be subject to serious balance sheet mismatches. Several EMEs are also net energy exporters and, hence, would be heavily exposed to the negative supply shock of low commodity prices, which is mainly driven by plunging global energy demand.

The IMF (2020), in its *World Economic Outlook* of 13 April 2020, highlights these potential asymmetric effects of COVID-19 between AEs and EMEs, notably due to tighter credit conditions and differences in policy space. The

22 Lower middle-income countries are set to register the highest rate of working hours lost (12.5%) in 2020Q2, compared with the pre-crisis baseline (2019Q4). By contrast, working hours in high-income countries are set to decline by 11.6%.

asymmetries are manifested in both the short-term and the longer-term ("scarring") effects of the pandemic and in the containment measures. More specifically, based on a global model and a detailed sector-based analysis, the IMF presents a simulation exercise with three adverse scenarios for global GDP compared with its forecast baseline, according to which global GDP growth is projected at -3.0% for 2020, i.e. a 6.3 percentage point downward revision compared with the January 2020 *WEO Update*. The three scenarios assume: (i) a lockdown that lasts 50% longer than in the baseline; (ii) a second outbreak in 2021; and (iii) both a longer lockdown and a second outbreak, respectively. The model assumes that the impact is driven by containment measures and a tightening of financial conditions, and is mitigated by fiscal and monetary policy measures. Despite policy support, the pandemic leaves scarring effects on capital, productivity and trend employment.

Moreover, the model incorporates asymmetric effects of COVID-19 brought about by the lack of available policy space in EMEs, which limits their ability to improve financial market conditions and to mitigate the scarring on the economy, compared with AEs. As a result, the impact of COVID-19 on this group of countries is amplified. The decline in GDP for 2020 and 2021 is estimated to be of similar magnitude to that in AEs, despite the fact that the services sectors, which are most affected by COVID-19, have a relatively smaller economic significance in EMEs compared with AEs. Notably, output decline in the medium term is greater in EMEs relative to AEs due to the ineffectiveness of policy in mitigating the scarring of the economy. In the most adverse scenario, the output loss in 2024 is around 3.5% for AEs, against almost 4.5% for EMEs.

The World Bank (2020a), in a publication on 8 April 2020, presents a simulation exercise using a BVAR model to predict growth for developing countries in the "Europe and Central Asia" (ECA) region, compared with the January 2020 projections. Trade, transport and tourism, as well as financial conditions and commodity prices are assumed to be the main transmission channels of the COVID-19 impact for this particular group of countries. Global financial stress and flight-to-safety put pressure on currencies and are expected to lead to tightened financial conditions, with possible negative repercussions for corporate balance sheets. Also, given that countries in the region are significant energy exporters, the fall in oil and metal prices, mainly due to reduced imports from China, is expected to affect exports and strain fiscal positions in the region. The results of the analysis predict 5.4 percentage points lower GDP growth for the region in 2020 in the baseline scenario, and 7.0 percentage points lower growth in the downside scenario, which assumes that the containment measures, financial market pressures and low commodity prices last beyond 2020H1. This translates into a GDP growth rate of -2.8% for 2020 in the baseline scenario and of -4.4% in the downside scenario.

Kohlscheen et al. (2020), in a BIS paper of 6 April 2020, simulate the propagation of COVID-19 putting emphasis on the amplification effects from spillovers across countries.[23] In particular, they employ a quarterly global BVAR over the period 1997-2019 with five major economic blocs: the US, China, the euro area, "other advanced economies" and "other EMEs". The economic impact of the virus depends on: (i) the direct effects of confinement measures and their duration; (ii) the extent to which the direct effects persist and magnify; and (iii) the size of spillovers and spillbacks across regions. The model sheds light on the multiplier effects of the initial slowdown in activity, the persistence of the slowdown within each region, and the extent of spillovers.

Global economic spillovers are set to be large. The authors estimate that, on average, the full-year GDP loss in the regions included in the model would be between 1.5 and 2 times the ini-

23 The group of "other advanced economies" comprise Australia, Canada, Switzerland, the UK, Japan and Sweden, while the group of "other EMEs" comprise Brazil, India, South Korea and Mexico.

tial impulse from containment measures. In their V-shaped scenarios, the recovery in 2020H2 is modest, and even at end-2021, the level of GDP in all regions would still be below the pre-virus forecast. In their W-shaped scenarios (i.e. a second wave of confinement follows two quarters after the first wave), the weakness in economic activity persists for even longer; in most regions examined, GDP growth is negative throughout 2020 and a sustained recovery would not begin until 2021, or around six months later than in the V-shaped scenarios.

The persistence of weak activity partly reflects two types of spillovers. One is due to the risk that uncoordinated lockdowns lead to repeated virus outbreaks and confinements across the globe. The other is the more traditional trade and financial interlinkages. For AEs, spillovers from EMEs account for between 25%-30% of the GDP shortfall in 2020Q4. The spillovers are larger for the euro area, due to a larger share of exports in GDP, than for the US. Moreover, domestic mitigation alone is ineffective. Even if a country successfully limits its domestic slowdown, it will not be immune from insufficient or ineffective policies in other parts of the world. The authors run a scenario where the effect of domestic containment measures on euro area GDP is -2.5%, but the shock still hits other regions by -5%. The decline in euro area GDP after four quarters would still be 6.5% in the V-shaped and 9.9% in the W-shaped scenario, relative to the baseline. This outcome reinforces the importance of international cooperation in designing policies to limit the spread and the re-emergence of the virus and combat its economic consequences.

In the same vein, the OECD's (2020a) estimates in early March 2020, based on NiGEM simulations for the G20, highlight the positive spillover effects induced from policy coordination.[24] These suggest that collective country action yields higher output gains than individual country responses via positive confidence and trade spillovers; in particular, coordinated fiscal, monetary and structural policies should raise the level of GDP by 0.75% in the first year, 1.25% in the second year and 1.0% in the long run. By contrast, individual country responses would increase GDP by only 0.4%, 0.75% and 0.7%, respectively.

Moreover, several international institutions highlight the fact that the asymmetric impact of COVID-19 is driven by a varying sectoral demand composition, reflecting the share of the affected sectors in consumption spending and total output.

More specifically, in a two-step approach, the OECD (2020b) in late March 2020 (updated in mid-April) provides an illustrative exercise on the initial, short-term impact of the lockdown from COVID-19 on the level of real GDP in OECD economies. First, from a sectoral output approach, it is assumed that value added declines by 50%-100% in the sectors affected by the lockdown. Second, from a spending approach, cutbacks in categories of consumer spending are assumed to range between 50% and 100%. Common effects are assumed within sectors in all countries. A caveat is that cross-sectoral spillovers, potential indirect effects or other offsetting factors, such as policy measures, are not taken on board. Estimates suggest that real output loss on impact ranges between 20% and 25% in the G7, and between 15% and 35% in major AEs and EMEs, the highest being in Greece. Differences across countries reflect a varying sectoral composition of output. The spending-based assessment underpins an even sharper short-term impact on consumer spending in all countries.

The European Commission (2020) —in addition to its DSGE simulations for the impact of COVID-19 on the EU economy presented in its Spring 2020 Economic Forecast on 6 May 2020— puts forward an input-output sectoral model to assess the sectoral and country spillovers from lockdown measures during the

24 Coordinated policy responses include a debt-financed fiscal easing of 0.5% of GDP in all countries for three years, a reduction in interest rates and competition-enhancing reforms which raise TFP by 1% after five years.

COVID-19 pandemic. Based on the Trade-SCAN input-output multi-country model, simultaneous shocks to sectoral final demand are applied to the EU and the rest of the world. Final demand is assumed to decline by about 5%, which is consistent with the respective QUEST "baseline" simulations. Model estimates imply a high degree of propagation of demand shocks across countries and sectors, with the final effect being higher than the initial direct hit to demand; euro area GDP contracts by 5.7% in 2020 on average, while output losses range between -5.0% in Finland and -8.0% in Greece and Malta. Differences across Member States reflect their relative exposure to tourism and the importance of input-output spillovers in the tourism sector.

Finally, the WTO (on 8 April 2020) simulates the GDP effects of the COVID-19 pandemic using a recursive dynamic CGE model, namely the WTO Global Trade Model, which contains detailed sectoral breakdowns and intermediate linkages that enable the study of upstream and downstream effects of the sectoral shocks. The WTO presents three alternative scenarios. In the optimistic scenario, the containment measures will stay in place for three months, followed by a V-shaped recovery. In the less optimistic scenario, measures stay in place for six months, leading to a U-shaped recovery. In the pessimistic scenario, the measures will have to stay in place for the entire 2020, leading to an L-shaped recovery, as heightened economic uncertainty postpones consumption of durable manufactured goods. The short-term global output losses range between 5% and 11% in 2020 relative to the baseline, while regional patterns show the biggest output drops in EMEs. ASEAN (South-East Asia), Mexico and the Newly Industrialised Countries (e.g. Korea, Hong Kong, Taiwan) are projected to see the sharpest decline in GDP. For the US, the reduction in trade is projected to be much larger than the reduction in GDP, as the share of goods traded by air and the share of exports in services are large. Moreover, the relative contribution of different shocks changes over time. In the V-shaped scenario, labour supply, trade costs and sectoral demand shocks contribute 42%, 20%, and 38%, respectively, to the fall in global GDP. In the U-shaped and L-shaped scenarios, the contribution of the sectoral demand shocks rises to above 50%. The largest differences among countries are driven by the sectoral demand component, reflecting the high share of these sectors in total household consumption.

5 A BIRD'S EYE VIEW: CHANNELS, IMPACT AND POLICY IMPLICATIONS

This comprehensive overview of various strands of the literature and of empirical assessments by international institutions allows us to draw some conclusions about the economic impact of pandemics in general and of COVID-19 in particular.

First, we can identify the channels through which pandemics affect the economy. The most obvious channel comes from supply-side effects. Pandemics reduce both the quantity and the quality of labour. Crucially, the quantitative impact will depend on the mortality rate of the epidemic, as well as on the extent to which the working age population is affected. Labour supply may also be affected by the exclusion of different social groups who are deemed likely to spur the spreading of the pandemic, as well as through the impact of the pandemic on migratory flows. In the short term, the labour supply effect is also influenced by the morbidity rate – the extent to which lockdowns lead to workers being unable to work during that period. In losing parts of the working age population, human capital effects are also likely to influence the quality of labour supply in the post-pandemic era. These effects, working through labour supply, negatively impact on both actual and potential output, pointing to longer-term effects from pandemics. Pandemics can also generate destruction of capital effects, as businesses close and investment is curtailed, thus adding to the negative impact on current and potential output.

Aside from supply-side effects, pandemics are likely to induce demand effects. Consumption is particularly vulnerable to the impact of both reduced income and increasing uncertainty which dents consumers' confidence. Uncertainty will also have the effect of, at best, delaying investment and, at worst, dampening it for a period of time. Overall, the savings rate in the private sector should increase as uncertainty over a future health care crisis looms and cash flow constraints pose challenges to debt servicing.

Moreover, the impact of both supply and demand effects is also likely to depend on the reaction of individuals. How quickly and to what extent workers lock down is determined by their beliefs about their exposure to the virus and their views regarding the ability of the health system to cope. Individual reactions will also impact on the ability of the economy to quickly exit lockdown. Even if statutory measures are relaxed, individual behaviour may take more time to adjust.

A final channel works through the financial system. While the natural rate of interest might be expected to fall, leading to a period of low interest rates, financial institutions are likely to come under increasing stress. Rising uncertainty, along with an increase in the number of borrowers with debt servicing difficulties, is likely to generate a liquidity squeeze, which exacerbates the demand effects of pandemics. Moreover, risk premia are expected to rise and the evidence suggests that COVID-19 has had stronger effects on financial markets than past pandemics.

Whether it is the supply channel or the demand channel that dominates is not so important. Even if a shock originates from the demand side, it can then feed back into the supply side through the investment channel. Lower demand reduces labour productivity, as output falls. This then generates lower investment, which further depresses labour productivity and, ultimately, demand. This is what Fornaro and Wolf (2020) call the "supply-demand doom loop". Such doom loops are common in models that include more than one sector – one particularly affected by the lockdown (high-contact sectors) and a second which is less affected. The shock to the most affected sector is easily passed on to less affected sectors, creating vicious circles.

Building upon these channels it is possible to identify the impact of pandemics on some key economic aggregates. All three channels work to reduce current and possibly potential output. Growth is negatively affected in the short run, but usually rebounds in subsequent years. However, output can still remain below trend. The impact on inflation depends on the relative balance of supply versus demand shocks. If the supply shocks are large, as they were during the Black Death, then inflation can rise as shortages develop. On the other hand, if demand effects dominate, deflationary pressures will be present. With respect to inflation, the impact of the demand shock on commodity prices also works to lower inflationary pressures. The impact on trade is usually greater than that on output and this makes open economies and economies that are closely embedded in global value chains especially vulnerable. Travel is usually one of the most affected sectors and thus economies which rely on tourism exports will be more negatively affected than those that are primarily goods exporters. Goods exporters, in today's world, aside from experiencing the impact of weaker demand, also face potential supply shortages, as production chains are disrupted. The destruction of livelihoods, as businesses close and unemployment rises, can have negative implications for poverty, especially in countries that lack a strong welfare state. In general, the distributional impact of the pandemic and its particularly strong impact on specific sectors suggest the need for governments to engage in redistributional policies in order to share the burden more fairly across society. Finally, social capital can also be destroyed during pandemics, as curtailing social interaction leads to a decline in trust. Lower social capital has been shown to reduce growth prospects over the longer term.

The negative effects of the pandemics can be asymmetric across sectors and regions due to various factors. First, uncoordinated confinements can lead to repeated and unsynchronised virus outbreaks across the globe. Second, the absorptive capacity of the exogenous health shock depends on country-specific idiosyncratic factors, such as labour market flexibility, foreign capital dependence, trade openness and policy space. Differences in the initial economic conditions can lead to a varying impact of the pandemic across countries. Third, trade and financial linkages, among others, increase spillovers and amplify the effects of the first-order demand and supply shocks from the pandemic, notably from COVID-19. The total GDP shortfall from COVID-19 could be as much as twice the direct impact of the virus and the confinement measures, highlighting the sizeable effect of multipliers and spillovers in propagating contractions within and across economies. These spillovers are largely evident between AEs and EMEs, but also among AEs.

The negative effects of the pandemics can, of course, be mitigated by policy, and the policy tools that governments have at their disposal are much broader than those that were available to countries during the two largest pandemics – the Black Death and the Spanish Flu. The channels outlined above provide the background for discussing policy responses.

The supply-side effects: One of the strongest effects from past pandemics from the supply side arises from the loss of life and hence the impact on labour supply. COVID-19 is not expected to have such a direct effect on labour supply. The lockdowns have limited the impact of the pandemic on health, and labour supply is disrupted in the short term more or less depending on the length of the lockdown. The supply-side effects in this pandemic are likely to arise from the destruction of economic relations – that is, the laying off of workers and the subsequent rise in unemployment along with business failures, which lead to the destruction of capital. Policy is thus focused on minimising the scarring effects by maintaining economic relations as intact as possible through the lockdowns. Thus, policies to subsidise wages help prevent workers from being laid off. The more widespread use of wage subsidies in Europe compared to the US helps to explain the differing unemployment outcomes. Similarly, policies to provide liquidity support to businesses aim at keeping viable firms alive. In this way, when lockdowns end, economic relations are still fairly intact and it is easier to get production up and running. Of course, some businesses will fail and unemployment will rise. To prevent the latter from having lasting effects on the quality of labour supply, Active Labour Market Policies (ALMPs) have to be a priority area for improvement, especially in Greece where their past performance has been somewhat patchy.

The demand-side effects: Monetary policy loosening either through interest rate reductions or the extension of non-standard measures can help ease liquidity constraints for companies by preventing liquidity shortages either directly or indirectly (through banks or various financial markets which have seized up). The ECB's Pandemic Emergency Purchase Programme (PEPP) is a step in the right direction to ensuring that liquidity provision is maintained.

However, fiscal policy also has to play a significant role. Most countries have been announcing large fiscal stimuli whether it is through transfers to subsidise wages, measures to delay tax and social security payments, or the extension of eligibility for unemployment benefits beyond their usual fixed period. Considerations of redistribution across more and less affected groups are also beneficial in encouraging recovery.

Aside from financing transfers, fiscal policy also has to support investment —both private and public— in the recovery period. The large increase in uncertainty will have led to the postponement of investment plans and makes business less optimistic in developing new plans. As an individual business, it is rational to postpone. An investment will only be prof-

itable if others also invest raising aggregate demand, productivity and hence disposable income and, finally, consumption. The public sector has a role to play in this regard, since such investments usually generate large multiplier effects in the economy and are likely to make smaller private sector investments more profitable. Thus, EU policies for injecting funds into investment projects —either directly through Commission resources or via the European Investment Bank— are welcome. Moreover, investment raises productivity, which can contribute to a demand rebound and help avoid the demand-supply doom loops found in the literature.

However, such stimuli will place an increasing burden on debt levels throughout the euro area. For this reason, some form of mutualisation of the cost is necessary if national programmes are to be feasible and credible. Some have argued that the EU should issue perpetual bonds (Giavazzi and Tabellini 2020; Soros 2020). This proposal is a sound one —the EU has the economic and political power to issue such bonds just as the UK and the US have done in the past (the UK, for example, used perpetual bonds to finance both the Napoleonic Wars and WWI). The EU also has the motive— a powerful symmetric shock facing individual Member States. Indeed, the very act of issuing such bonds would send a strong signal to markets about government commitments to the EU project.

Financial channel: we can also draw some policy lessons for the financial sector. The financial sector has the potential to exacerbate the supply and demand shocks that are the result of a pandemic. First, financial institutions are likely to face liquidity constraints, as interbank markets dry up and, potentially, deposits fall. Second, the impact of the pandemic on income and employment causes debt servicing difficulties among both households and firms. This in turn is likely to lead to rising non-performing loans (NPLs), at a time when a number of EU countries already face higher than usual NPL ratios.

Potential liquidity constraints in euro area banks are being addressed by the Eurosystem. First, Greek government bonds (GGBs) have become eligible both for the PEPP and also as collateral. Moreover, haircuts associated with monetary transactions on all collateral (including GGBs) have been reduced significantly. The ability to tap liquidity from the Eurosystem using credit claims has been expanded. All these measures improve the liquidity situation of Eurosystem banks in general and Greek banks in particular, as they provide the opportunity for banks to resort to the Eurosystem for liquidity in greater amounts rather than relying on interbank markets, which often prove to be more expensive and susceptible to sudden shifts in sentiment.

Turning to the impact of the crisis on the asset quality of banks, evidence suggests that asset quality will deteriorate. At a time when NPLs are already high in certain EU countries, this circumstance poses a particular challenge. National systems to deal with NPLs may not be enough, since they rely on investors from elsewhere to invest in the NPL clean-up. If, however, the demand for such capital injections from outside investors rises, it is not clear that there will be enough outside investors willing to meet that demand. The more systemic the increase in NPLs and thus the need to find a solution across the euro area/EU as a whole, the more likely it is that some form of centralised solution might be required. It is against this background that calls for an EU-wide bad bank are being heard.

6 CONCLUSIONS

In short, pandemics have strong impacts on economies – both in the short run and potentially in the long run. Research relying on historical episodes as well as modern modelling techniques can shed light on the channels through which economies are affected. However, modern states have many more policy weapons at their disposal and the models provide ample evidence on what can be done to limit the impact of such pandemics. Many of

these policies are already being employed. In the context of the EU, their credibility would benefit considerably from a more coordinated and mutualised response to the crisis.

Finally, we can highlight the need for global cooperation. Although policy efforts can mitigate the adverse direct effects of the exogenous shock and preserve economic relationships, incomes and production structures, differences in the available policy space can magnify structural divergences across economies. Advanced economies are expected to be more effective than emerging market economies in coping with the effects of the pandemic as a result of larger policy space. Still, divergences can be observed even among advanced economies. In this regard, domestic mitigation alone is not sufficient to cope with the crisis. Even if countries successfully limit the domestic economic slowdown, they will not be immune from insufficient or ineffective policies in other countries. Hence, positive spillovers stemming from policy coordination can underpin domestic efforts to lessen the economic hardship across the world as a whole.

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SOVEREIGN CREDIT RATINGS AND THE FUNDAMENTALS OF THE GREEK ECONOMY

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ABSTRACT

We discuss the factors behind sovereign credit ratings and reproduce their quantitative component, focusing on the case of Greece. The sovereign credit rating of Greece is still lower than the investment grade threshold. However, some of the fundamentals of the Greek economy are shown to be better than the average of the rating category it belongs to at present (BB) and better even than higher rating categories. Based on the reproduction of the score component of sovereign credit ratings of the three major Credit Rating Agencies, we show that an improvement in the institutional factors of the Greek economy to the level of the early 2000s can lead to a significant increase in Greece's score, thus contributing to an upgrade to the investment grade category.

Keywords: credit ratings; sovereign risk; Greek economy; institutions; governance indicators

JEL classification: E44; G24; H63

ΟΙ ΠΙΣΤΟΛΗΠΤΙΚΕΣ ΑΞΙΟΛΟΓΗΣΕΙΣ ΚΑΙ ΤΑ ΘΕΜΕΛΙΩΔΗ ΜΕΓΕΘΗ ΤΗΣ ΕΛΛΗΝΙΚΗΣ ΟΙΚΟΝΟΜΙΑΣ

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ΠΕΡΙΛΗΨΗ

Το παρόν άρθρο περιγράφει τις παραμέτρους των κρατικών πιστοληπτικών αξιολογήσεων και αναπαράγει την ποσοτική συνιστώσα τους, εστιάζοντας στην περίπτωση της ελληνικής οικονομίας. Η πιστοληπτική διαβάθμιση της ελληνικής οικονομίας βρίσκεται χαμηλότερα από το όριο της επενδυτικής κατηγορίας, όμως ορισμένα από τα θεμελιώδη μεγέθη της είναι καλύτερα από τα μέσα επίπεδα της κατηγορίας στην οποία ανήκει (BB) ή ακόμη και ανώτερων κατηγοριών. Με βάση την αναπαραγωγή του ποσοτικού σκέλους των κρατικών πιστοληπτικών διαβαθμίσεων των τριών μεγάλων οίκων πιστοληπτικής αξιολόγησης, υποδεικνύεται ότι η βελτίωση της θέσης της ελληνικής οικονομίας στους δείκτες του θεσμικού περιβάλλοντος, σε επίπεδα παρόμοια εκείνων που είχαν καταγραφεί στις αρχές της δεκαετίας του 2000, θα συμβάλει σε ενδεχόμενη αναβάθμισή της στην επενδυτική κατηγορία.

SOVEREIGN CREDIT RATINGS AND THE FUNDAMENTALS OF THE GREEK ECONOMY[1]

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1 INTRODUCTION

Credit ratings are important inputs to portfolio allocation decisions, as they are widely used by investors as measures of default risk.[2] Previous research has shown that both sovereign and corporate credit ratings are closely associated with the level of risk premia in the underlying bonds.[3] Understanding credit ratings and disentangling their information is a crucial task both for investors and borrowers, thereby facilitating in an economically efficient way their decisions.

According to the methodologies of Credit Rating Agencies (CRAs), credit ratings are assessments of the *ability* and the *willingness* of a debt issuer to pay back the debt in full. In the process of this assessment for sovereigns, CRAs analyse several categories of fundamentals of the domestic economies, while the final ratings also incorporate judgment about the prospects of the economy and potential developments that pose upside or downside risks to the initial assessment.[4] Sovereign credit ratings have a wider importance for the national economy; they are linked to country risk assessments and the so-called "country ceiling", i.e. the maximum rating that can be assigned to any entity of the public or the private sector originating from the same economy.

In this paper, we estimate a model of sovereign credit ratings based on the methodologies of the three major CRAs using data from 93 countries over a long time span and then apply it to the data for Greece. This allows us to decompose Greece's sovereign credit ratings into their main determinants and quantify the contribution of each determinant to the overall rating. Finally, we assess the importance of institutional factors such as the quality of governance for the prospects of an upgrade of the Greek sovereign rating to the investment grade category credit rating.[5,6]

The paper is organised as follows: The next section discusses the methodologies followed by the three large CRAs (i.e. Fitch, Moody's and Standard and Poor's) for rating sovereign entities. Section 3 compares the fundamentals of Greece with those of sovereigns belonging to the same and other rating categories. In Section 4 we present the econometric model and the estimation results of credit scores, discuss the driving factors of the Greek sovereign rating for the period 2006-2018 and report the results of an impact analysis around the prospect of an upgrade of the Greek sovereign rating to the investment grade category. Finally, Section 5 concludes.

2 SOVEREIGN CREDIT RATING METHODOLOGIES

The process of assigning credit ratings to sovereign entities followed by CRAs[7] entails two

1 Excellent research assistance by Ms Vanessa Kolonia is gratefully acknowledged. The views expressed here are those of the authors and not of the Bank of Greece or the Eurosystem. Any remaining errors are ours.
2 For example, Morahan and Mulder (2013) find that four out of five investment managers use credit ratings in their portfolio allocation process.
3 For sovereign risk premia and ratings, see, among others, Livingston et al. (2010), Aizenmann et al. (2013), de Santis (2012), El-Shagi and von Schweinitz (2018) and Malliaropulos and Migiakis (2018); for corporate bonds, see Fons (1994), Longstaff et al. (2005), Heinke (2006) and Grothe (2013).
4 A number of studies criticise CRAs for providing inflated ratings, e.g. White (2010), Fulghieri et al. (2013) and Boermans and van der Kroft (2020). The issue of comparing credit ratings to "true measures of credit risk" is beyond the scope of this paper.
5 The investment grade category includes ratings equal to or better than BBB-/Baa3; ratings below this threshold (i.e. BB+/Ba1 or worse) are classified as sub-investment grade.
6 Since January 2020, Fitch's sovereign credit rating for Greece stands at BB, Moody's assigns a rating two notches lower than Fitch (i.e. B1) and Standard and Poor's one notch lower (i.e. BB-).
7 In the present paper, we examine the three large, by international standards, CRAs (in alphabetical order): Fitch, Moody's and Standard and Poor's (S&P).

Table 1 Variables used as input to the quantitative models of CRAs

Fitch	Moody's	Standard and Poor's
Structural factors • Governance • GDP per capita • GDP as % of world GDP • Time since last default • Broad money	*Institutions and governance strength* • Quality of legislative and executive institutions • Strength of civil society and the judiciary • Fiscal policy effectiveness • Monetary and macroeconomic policy effectiveness	*Political score* • Effectiveness, stability and predictability of policymaking, political institutions and civil society • Transparency and accountability of institutions, data and processes • Debt payment culture • External security risks
Macroeconomic factors • Real GDP growth • Volatility of real GDP • Inflation rate	*Economic strength* • Real GDP growth • Volatility of real GDP • Nominal GDP • GDP per capita	*Economic score* • GDP per capita • Real GDP p/c trend growth • Economic concentration and volatility
Public finances • General government debt as % of GDP • General government interest payments as % of revenues • General government budget balance as % of GDP • Foreign currency public debt as % of general government debt	*Fiscal strength* • General government debt as % of GDP • General government debt as % of revenues • General government interest payments as % of revenues • General government interest payments as % GDP	*Fiscal score* • General government debt as % of GDP • Change in net general government debt as % of GDP • General government interest payments as % of revenues • Contingent liabilities (financial institutions, public sector enterprises, off-budget contingent liabilities)
External finances • Reserve currency status • Sovereign net foreign assets • Commodity dependence • Reserves • External interest service • Current account balance plus FDI	*Event risk* • Domestic political risk • Ease of access to funding • Risk of banking sector credit event • Total domestic bank assets to GDP • External vulnerability risk	*External score* • Reserve currency status • External liquidity (ratio of gross external financing to current account receipts (CAR) plus foreign exchange reserves) • External indebtedness (ratio of net external debt to CAR)
		Monetary score • Exchange rate regime • Monetary policy credibility

stages: the quantitative or objective and the qualitative or subjective one. In the first (quantitative) stage, each sovereign is assigned a score or is ranked in relation to other sovereigns, based on the country's economic and political fundamentals. In the second (qualitative) stage, the quantitative score is adjusted using experts' opinions on the challenges or opportunities[8] that the economy is expected to face in the near future. Usually, the qualitative adjustment does not change the score assigned in the initial stage by more than one to three notches.

During the first stage, CRAs incorporate into their quantitative analytical tools a distinct list of variables representing the fundamentals of each economy. For example, Fitch uses sixteen variables as inputs to its sovereign rating model. These are classified in four categories: structural features, macroeconomic performance policies and prospects, public finances, and external finances (Fitch 2018). Similarly, Moody's uses seventeen variables, which

8 Political and geopolitical developments, nonlinearities in the public debt features and upcoming economic challenges are some of the issues considered at this stage.

belong to four categories: economic strength, institutions and governance strength, fiscal strength, and susceptibility to event risk (Moody's 2019). Finally, Standard and Poor's incorporates sixteen factors in its model that belong to the following categories: political score, economic score, external score, fiscal score, and monetary score (Standard and Poor's 2017).

While the terminology and the number of categories imply that there is some deviation between the various quantitative models used by CRAs, when we look closer into the individual variables that are included in each category, we find a remarkable similarity of the factors taken into consideration for assigning sovereign credit ratings. Table 1 outlines the individual variables used by each CRA in their quantitative models.

The details of each category of variables used in the process of the quantitative assessment reveal the similarity of the factors assessed across the three large CRAs. For example, real GDP growth, volatility of real GDP, GDP per capita, general government debt as a percentage of GDP and general government interest payments are used by all three CRAs. Institutional factors also play a prominent role in the quantitative assessment of all three CRAs. These factors reflect: (a) transparency and accountability; (b) effectiveness of the administration and political institutions; (c) the sovereign's debt payment culture (Standard and Poor's), the time since the last default (Fitch) or the government default history (Moody's); (d) the quality of the legislation and the rule of law; and (e) the perceived level of corruption. In order to measure institutional factors, Fitch and Moody's use the World Bank's Worldwide Governance Indicators (WGIs); Fitch uses the average score of the six individual indicators, while Moody's makes use of the indicators for regulatory quality and government effectiveness.[9]

Overall, the factors taken into account in the stage of quantitative assessment of the credit profile of each sovereign are very similar across credit rating agencies. Also, the weights assigned to the broad categories are similar across the three CRAs: the most important ones are the institutional factors, followed by economic and fiscal factors, while external, monetary and event-risk factors are mostly used for adjustment/calibration purposes.

Nevertheless, the three CRAS' methodological frameworks bear some differences with respect to the structure of their scorecards. In particular, the relative importance of the individual variables may differ due to differences in their weighting schemes for individual variables, while other variables, such as market-based indicators, are also taken into account by Standard and Poor's and Moody's. In practice, however, these differences do not result in systematic divergences of more than two or three notches in the final credit ratings assigned to the same sovereign by the three CRAs.

3 HOW DOES THE GREEK ECONOMY COMPARE TO OTHER ECONOMIES IN TERMS OF CREDIT FUNDAMENTALS?

All CRAs rely on rankings of the values of the fundamentals vis-à-vis those of other sovereigns of the same or other categories. Hence, it could be useful to compare the fundamental variables of the Greek economy with the median of the rating categories in order to identify both the strengths and the weaknesses of the Greek economy from the point of view of rating agencies.

In order to do this, we analyse annual data of the individual variables used by CRAs for a sample of 110 countries over the period 2006-2018.[10] We only take into account categories and not notch-deviations within categories, e.g.

9 However, in the qualitative stage Moody's also makes use of three additional indicators: voice and accountability; rule of law; and control of corruption.

10 The data set for 17 countries does not cover the entire period. So, while we use the data available for these countries in order to construct the rating buckets they belong to in each year, depending on data availability, we exclude them from our econometric estimation (see Section 4).

sovereigns rated AA+ and AA- are included in the AA category, sovereigns rated A+ and A- are included in the A category, and so on. The categories are dynamic, i.e. sovereigns migrate to higher or lower categories at the end of each year if they are upgraded or downgraded by at least two CRAs. This ensures that the statistical properties of the fundamentals in each category are representative of the rating category and not of specific groups of sovereigns.

In order to compare Greece's fundamentals with those of other sovereigns in the same or neighbouring rating categories, we compute the median and the 10% and 90% quantiles of each rating category. We then compare Greece's fundamentals with the median and the interquantile range of each rating category. In this way, we construct a statistical criterion similar to the one used by CRAs for classifying sovereigns into rating categories before ranking their fundamentals according to the weighting scheme or taxonomy of their scorecard.

The way this statistical criterion works can be easily understood: consider, for example, the case where the value of a given fundamental variable for Greece, in a specific year, is better (worse)[11] than the 90% (10%) quantile of the rating category where the country belongs. This would suggest that the country's credit rating is likely to be upgraded (downgraded) based on this fundamental. The Appendix reports detailed charts of the median and the interquantile range of a wide array of variables used by CRAs for each rating class (AAA to B) based on the data of 110 countries in our sample. The Appendix charts (A1-A15) also report the data for Greece and how they compare with the data of other countries in each rating class. We briefly discuss the main observations from these charts in the following paragraphs.

Institutional factors

One of the most important factors across CRAs is the quality of institutions and the political landscape; this factor is measured either by individual or by aggregate indicators of the quality of governance, such as the ones provided by the World Bank's Worldwide Governance Indicators (WGIs). Based on the average of the six individual indicators provided by the World Bank (see Chart A1 in the Appendix), Greece constantly ranks above the median of its present rating category and even better than the BBB category. However, there is room for improvement, as Greece still lies below the median of sovereigns above single-A, which include other developed economies and most euro area countries.

Chart 1 plots Greece's ranking in each of the six governance indicators reported by the World Bank for the years 2001, 2008, 2012 and 2018.[12] The chart shows that the position of Greece vis-à-vis the rest of the countries in the World Bank's governance indicators has deteriorated in the years following the global financial crisis. The greatest fall has been observed in the political stability indicator, which includes the absence of violence, where Greece fell by almost two deciles in the overall ranking, from the 55th percentile in 2008 to the 39th percentile in 2012. Since then it has improved by 11% in the percentile ranking, according to the World Bank's 2018 WGI report.[13] However, Greece remains lower than its ranking in 2001-2002,[14] when it ranked at the 75th percentile, i.e. among the top 25% countries of the distribution. Also, in the rule of law, Greece ranked at the 59th percentile in 2018, which was even lower than its ranking in 2012 (64th percentile), having fallen by about 15 percentiles since 2008. Similar, though smaller, falls have been recorded in the rest of the governance indicators, such as government efficiency, control of corruption, regulatory quality, and voice and

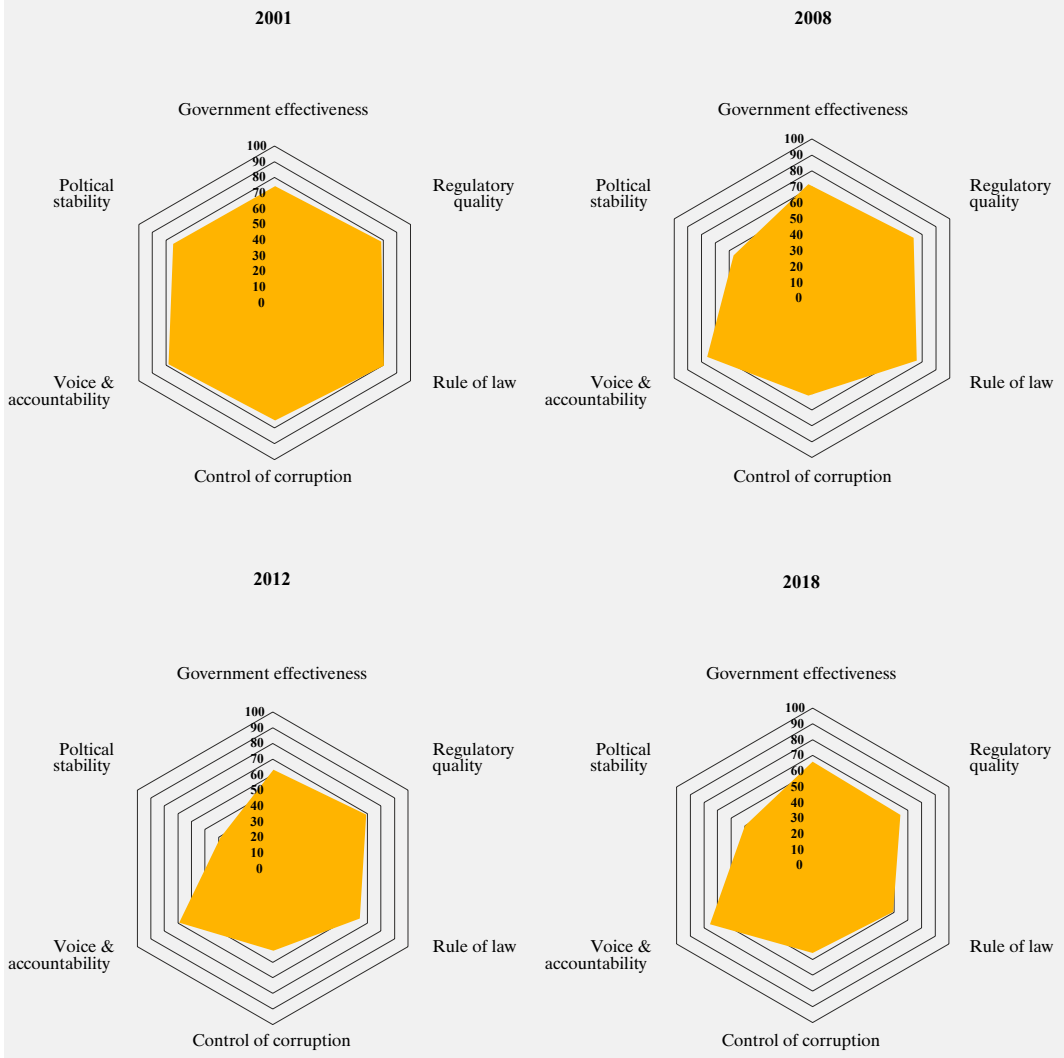
11 We use the terms "better" and "worse", instead of "larger" and "smaller", as the direction of the effect of each variable on the rating depends on the sign the variable has in the scorecard of the CRAs. For example, the debt-to-GDP ratio worsens the rating, whereas real GDP growth improves the rating.

12 Note that the rating agencies introduce the levels of the governance indicators with a one-year lag, i.e. the ratings assigned in 2019 take into account the figures reported by the World Bank for 2018.

13 This report was released in September 2019 and is the most recent one.

14 Until 2002 the World Bank's governance indicators were published every two years. Greece's historically highest ranking in the "political stability and absence of violence/terrorism" indicator was recorded in the 2001-2002 report.

Chart 1 Greece's ranking in World Bank's governance indicators



Source: World Bank, Worldwide Governance Indicators database.
Note: The chart shows the percentile ranking of Greece in each of the six individual governance indicators of the World Bank in its reports for the years indicated above each graph. Scores and percentile rankings of the World Bank's Governance Indicators are available at www.govindicators.org.

accountability. Thus, a possible policy objective for Greece could be to regain the position that the country had in the World Bank's governance indicators before the eruption of the crisis.

Broad money is used by rating agencies to measure the level of financial intermediation in the economies (Fitch 2018). As shown in Chart A2, Greece seems to be in an advantageous position, relative to its current rating category (BB, including BB+ and BB-) on the basis of the broad money rating factor, as its level, which also bears a positive sign in the CRAs' score-cards, is higher than that of the top 10% of the

sovereign entities belonging to the same category. Moreover, on the basis of the same factor, Greece compares favourably even vis-à-vis the upper class of BBB-rated countries, with the value of the variable being close to the median of the A category. This finding, combined with fact that Greece, as a member of the euro area, is assigned the highest score under the criterion of "reserve currency", indicates the strong advantages for its rating, stemming from its monetary and financial structure.

The institutional factors taken into account by CRAs also include GDP per capita as a measure of the income level of an economy (see Chart A3). According to this criterion, Greece fares better than its current rating category (in fact, above the BBB median). GDP as a percentage of world GDP (as shown in Chart A4), another measure used by rating agencies to capture the shock-absorption capacity of the economy, provides a similar picture. However, the restructuring of public debt, which bears a heavy weight among the criteria used in CRAs' scorecards, poses a disadvantage for the Greek economy in the category of institutional factors.

Macroeconomic factors

The only advantage of the Greek economy in the macroeconomic factors' category is that of lower inflation, compared with the economies included in almost all rating categories (see Chart A5); given the negative sign of this factor, the low level of inflation in Greece increases its relative position. However, low real GDP growth (as shown in Chart A6) compared with other BB-rated sovereigns reduces the probability of a rating upgrade. Finally, higher volatility of Greek GDP (see Chart A7) as a result of the deep recession of 2009-2013 will continue to weigh on the probability of an upgrade, due to the fact that real GDP volatility is measured over a 10-year period.

Fiscal factors

Fiscal consolidation has improved the picture of Greek public finances. The positive primary budget balance, achieved for the first time in 2014, led Greece above the BB category ever since, despite the fact that the overall rating of the country was much lower at that time. The continued effort has enabled Greece to exceed the median and interquantile range of its rating category as well as that of sovereigns rated at the BBB category (as shown in Chart A8). Moreover, it brings Greece's figure above the medians of even upper rating classes, such as single-A and double-A rating categories.

By contrast, Greece's high general government debt-to-GDP ratio (as shown in Chart A9) exceeds the medians of all rating categories. Thus, as this factor carries a weight much heavier than that of the budget balance, it lowers the total contribution of fiscal factors. This is partially counterbalanced by the fact that the share of public debt denominated in foreign currency is lower than both the BB and the BBB rating range, being close to the A-rated median (see Chart A10). Finally, the high public debt ratio is also offset by reduced interest expenses, due both to the lower coupon rates of the more recent bond issues and to the low cost of funding of the loans taken by Greece from the official sector (see Chart A11).

External factors

Last but not least, the external factors of the Greek economy reduce the prospects of rating upgrades. In particular, the Greek State has very low net foreign assets (see Chart A12); the interest service to foreign creditors is higher than the BB-category median; the current account balance, including FDI, as a ratio of GDP is close to the BB median (see Chart A13); and the reliance of the Greek economy on one sector (tourism), reflected in the so-called "commodity dependence" factor, is strong (see Chart A14). That said, it should be noted that the sovereign net foreign assets factor does not account for the fact that part of foreign borrowing has been used by the Greek State to build a sizeable cash buffer (nearly 10% of GDP at the end of 2019).

4 THE GREEK SOVEREIGN CREDIT RATING

4.1 REPRODUCING THE QUANTITATIVE COMPONENT OF RATINGS

The aim of this section is to replicate the quantitative component of ratings for Greece.[15] To that end, we estimate an ordered probit model for 93 sovereigns worldwide using annual data for the period from 2006 to 2018.[16] In particular, we estimated the following setup, equation (1), which is based on the structure of Fitch's scorecard, as already presented in Table 1:

$$c_{it} = a_1 + \sum_{i=1}^{k} c^s(x_{it}) \cdot s_{it} + \sum_{i=1}^{k} c^m(x_{it}) \cdot m_{it} + \sum_{i=1}^{k} c^f(x_{it}) \cdot f_{it} + \sum_{i=1}^{k} c^x(x_{it}) \cdot x_{it} + e_{it} \quad (1)$$

where c_{it} is the credit rating assigned to sovereign $i=1,2...N$ for each year $t=1,2,...T$, a_1 is

15 Previous studies aimed at quantifying the effect of factors on sovereign ratings include *inter alia* Afonso et al. (2009), D'Agostino and Lennkh (2016), Brůha et al. (2017) and Lennkh and Moshammer (2018).

16 The source of the data is Fitch Ratings.

Table 2 Ordered probit estimation results

Category K= $\{x_1, x_2, ...x_i\}$	Variable x_{it}	Estimated coefficient $C(x_{it})$	Transformation $F(x_{it})$
Global a_1	Intercept	5.042** (0.455)	None
Institutional i_{it}	WB governance	0.094** (0.003)	Rank
	GDP per capita	0.026** (0.002)	Rank
	Share in world GDP	0.643** (0.030)	Nat. log.
	Default	-1.667** (0.226)	Time since event
	Broad money	0.097 (0.084)	Nat. log.
Macroeconomic m_{it}	Real GDP volatility	-0.556** (0.069)	Nat. log. (10y std.dev.)
	Real GDP growth	0.015 (0.015)	3y ave.
	Inflation	-0.104** (0.014)	3y ave.
Fiscal f_{it}	Gen.Gvt debt (%GDP)	0.027** (0.002)	3y ave.
	Gen.Gvt interest expenses (%rvn)	-0.019** (0.007)	3y ave.
	Gen.Gvt budget balance (%GDP)	0.081** (0.009)	3y ave.
	Foreign currency public debt	-0.015** (0.002)	3y ave.
External x_{it}	Reserve currency status	0.587** (0.042)	Eval.
	Sovereign net foreign assets	0.011** (0.001)	%CXR
	Commodity dependence	-0.003 (0.003)	3y ave.
	Reserves	0.047** (0.011)	%CXP
	External interest service	-0.004 (0.001)	3y ave.

Notes: The table presents the estimated coefficients of the individual variables of the ordered probit model described in equation (1), with the credit ratings of 93 sovereigns as the dependent variable. The sample is 2006-2018. The final column to the right describes the way the variable is transformed in order to be incorporated into the reproduced scorecard. CXR: current account receipts. CXP: current external payments. Asterisks (** and *) denote significance (at the 1% and 5% level, respectively).

the global intercept, s_{it} is the vector of the institutional/structural variables, m_{it} is the vector of macroeconomic variables, f_{it} is the vector of fiscal variables and x_{it} is the vector of external variables, with k being the number of variables in each category.[17] Finally, e_{it} is the panel data residual from the estimation. Table 2 presents the estimated coefficients for each variable and the transformation of each variable, as described by Fitch in its sovereign ratings methodology.

Based on the estimation of the coefficients, as shown in Table 2, we can reproduce the scorecard of Fitch by taking into account the coefficient $c(x_{it})$ and the transformation $F(x_{it})$ of each variable. In particular, the score of each variable is calculated as follows:

$$Score(x_{it}) = c(x_{it}) \cdot F(x_{it}) \quad (2)$$

Similarly, the score for each category of variables is the sum of its individual variables:

$$Score(K_t) = \sum_{i=1}^{k} c(x_{it}) \cdot F(x_{it}) \quad (3)$$

Finally, the aggregate score of each country is the sum of the scores of the categories and the global intercept:

$$Score = \alpha + \sum_{j=1}^{4} Score(K_j) \quad (4)$$

We use the aggregate score to rank each country and produce its initial rating. To do so, we use a rule that associates each score with a rating category, as shown in Table 3.

The replication of the scores of the fundamentals of the Greek economy, based on the above setup, facilitates both the monitoring of developments in the sovereign credit rating of Greece and the quantification of the impact of past and expected or assumed developments in Greece's fundamentals. Also, it enables the estimation of the contribution of each individual variable to the quantitative component of the final rating.

Chart 2 plots Greece's estimated score along with the actual rating (computed as the average rating assigned by the three CRAs; for the ratings of individual CRAs, see Chart A15 in the Appendix) as well as the individual contribution of each variable over the 2006-2018 period. The chart shows that the estimated score for Greece follows closely the average sovereign credit rating assigned to the country by the three large CRAs. The two lines follow each other in close connection until 2009,[18] indicating that the rating assigned to Greece until the outbreak of the crisis was largely in line with the economy's fundamentals, as measured by the quantitative component (score) of

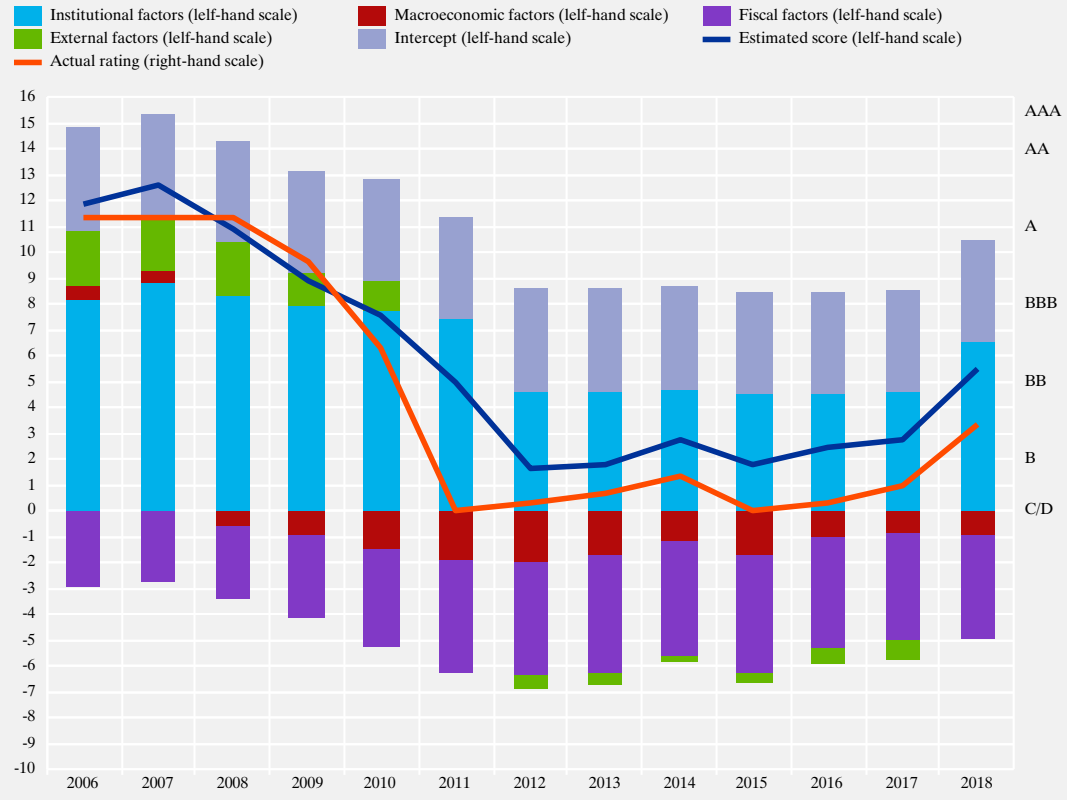
Table 3 Translating scores into ratings

AAA>15.5	AAA>15.5
15.5>AA>12.5	15.5>AA+>14.5
	14.5>AA>14
	13.5>AA+>12.5
12.5>A>9.5	12.5>A+>11.5
	11.5>A>11
	10.5>A->9.5
9.5>BBB>6.5	9.5>BBB+>8.5
	8.5>BBB>8
	7.5>BBB->6.5
6.5>BB>3.5	6.5>BB+>5.5
	5.5>BB>5
	4.5>BB->3.5
3.5>B>0.5	3.5>B+>2.5
	2.5>B>2
	1.5>B->0.5
0.5>C/D	0.5>C or D

17 The category of institutional factors includes the following variables: the average of the World Bank's Worldwide Governance Indicators, GDP per capita, GDP as % of world GDP, broad money, and time since last default. The economic activity/macroeconomic factor includes: real GDP growth, real GDP volatility and the annual rate of change in CPI. The fiscal factor includes: general government debt as % of GDP, general government interest payments as % of revenues, general government budget balance as % of GDP and foreign currency public debt as % of general government debt. Finally, the external factor includes: the status of reserve currency, sovereign net foreign assets as % of GDP, the degree of commodity dependence, the level of foreign exchange reserves, the external interest service and the current account balance plus FDI.

18 Greece was rated at A+ on average by the three CRAs during 2009; by the end of that year a downgrade cycle had begun, which escalated with the restructuring of the Greek public debt in 2012. Ever since, with a short interruption in 2015, CRAs have continuously upgraded Greece's sovereign credit rating.

Chart 2 Estimates of the quantitative component of Greece's sovereign rating



Note: The chart presents the score (blue line) for Greece, calculated as the sum of the contributions of the individual variables included in each category (institutional, macroeconomic, fiscal and external), with the addition of the intercept. The orange line is the average of the sovereign rating assigned to Greece by Fitch, Moody's and Standard and Poor's.

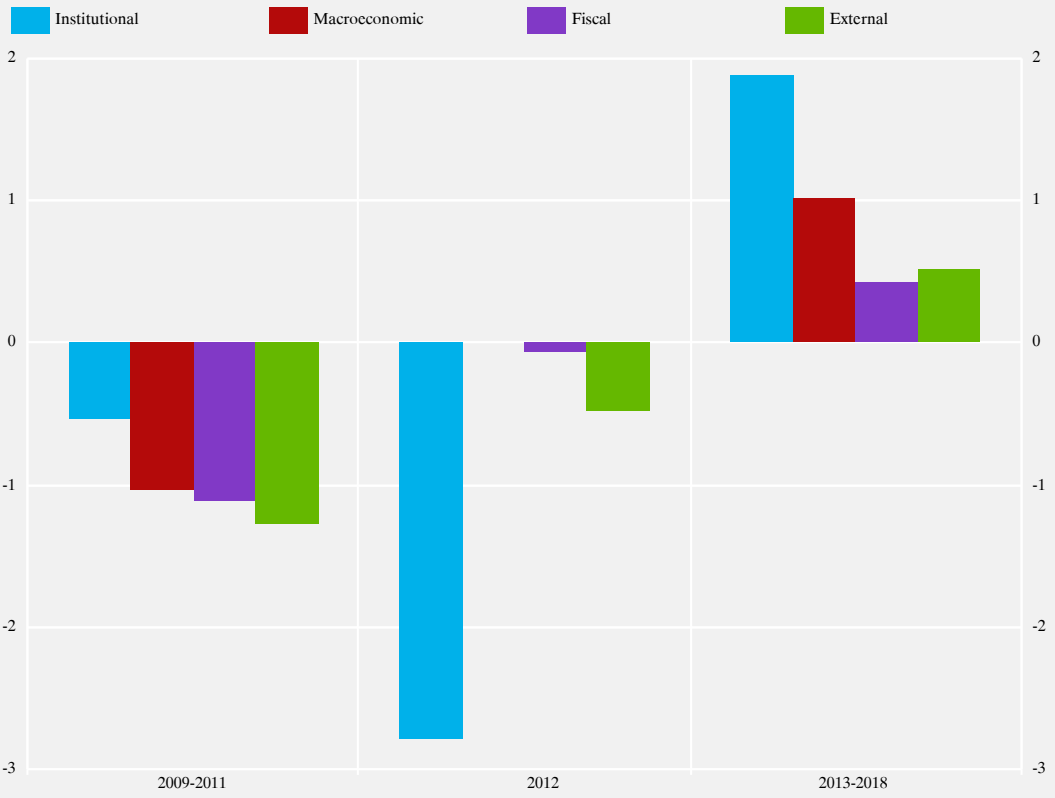
CRAs' ratings.[19] After 2010, the actual rating of Greece drops two to three notches below the estimated score, which measures the effect of fundamentals on the rating. This divergence is due to the judgmental component, which largely captures the effect of the Greek debt restructuring in March 2012.[20] An alternative interpretation of the divergence between actual ratings and estimated scores after 2010 is that CRAs overreacted to the deterioration of economic fundamentals after the sovereign debt crisis erupted. Distinguishing between these two explanations is difficult and certainly beyond the scope of this paper. Nevertheless, the fact that this divergence persists after 2010 suggests that it is driven by the debt restructuring rather than by an overreaction of CRAs to the deterioration of economic fundamentals after the eruption of the sovereign debt crisis.

4.2 THE DRIVERS OF SOVEREIGN RATING CHANGES FOR GREECE, 2006-2018

The Greek sovereign credit rating stood firmly within the investment grade category from the late 1990s, i.e. before the country's accession to the European Monetary Union, until the global financial crisis, when a downgrade cycle began for several euro area members.[21] This downward revision of the credit profiles of euro area countries impaired the conditions of refinancing their debt in the

19 Our findings are in line with those reported in Lennkh and Moshammer (2018) for Greece.
20 In March 2012, Greece restructured EUR 205 billion of public debt (165% of Greek GDP). Private investors suffered a 53% haircut on the face value of their Greek bond holdings.
21 Brůha et al. (2017) attribute this wave of downgrades following the global financial crisis to a structural break that led to greater importance of the quantitative stage and less optimism in the judgmental stage.

Chart 3 Changes in the Greek sovereign rating parameters



Note: The chart shows the changes in the contribution of each parameter of the quantitative component of Greece's sovereign credit rating. Contributions are computed as the product of the change of the variables and their estimated coefficients.

bond market and marked the beginning of the euro area debt crisis.

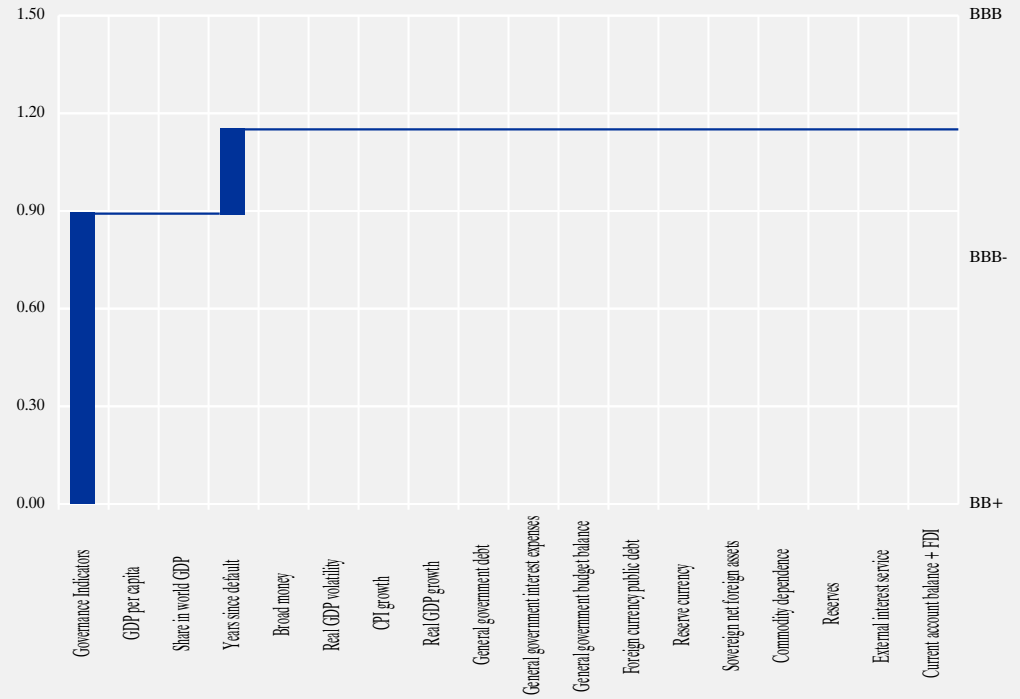
The downgrades of the Greek sovereign credit rating had a prominent role in this regard. This is because the Greek State was the first among euro area countries to lose its investment grade status. As shown by El-Shagi and von Schweinitz (2018), such downgrades to the sub-investment grade status can lead to a persistent increase in the cost of funding that could jeopardise public debt sustainability. This rise in the cost of funding, as well as the resulting reduction of financial flows (e.g. those reflected in the portfolio holdings of the international investment position) may result in an accentuation of the downturn of the economic cycle, thus creating adverse feedback loops between credit ratings and economic fundamentals.[22]

In the case of Greece, as shown in Chart 2, the initial downgrades during and immediately after the global financial crisis were largely related to the deterioration of the economy's fundamentals. In particular, the deterioration of the estimated score between end-2008 and end-2010 largely explains the loss of the investment grade status for Greece; over this period, the estimated score declines by 3.5 points, which is equivalent to a downgrade of four notches. Still, this figure, though informative, does not provide an answer to the question which one of the many adverse developments in the period from 2008 and up to 2010 had a greater contribution to the loss of the investment grade status.

In order to get a better understanding of the underlying drivers of ratings downgrades and

22 See among others Gibson et al. (2017) and Amato and Furfine (2004).

Chart 4 Impact on Greece's score due to improvements in institutional factors



Source: Authors' calculations based on the estimated scorecard.
Note: The impact is measured in score units, which are associated to ratings based on the mapping provided in Table 3; in particular, one score unit represents a rating change of one notch, while a positive sign in the score units indicates upgrades and a negative sign downgrades.

upgrades, we calculate the contributions of the underlying variables across specific sub-periods of the sample. We separate the sample in three sub-periods: from 2009 to 2011, 2012, and from 2013 to 2018. Separating the sample in three sub-samples rather than two (e.g. 2009 to 2012 and 2012 to 2018) allows to isolate the effect of the debt restructuring of 2012 on the rating from the effect of fundamentals. Chart 3 illustrates the contributions to Greece's sovereign rating score of each group of fundamentals.

The chart shows that the factors contributing to the downgrades over the 2009-2011 period are different from the ones driving the upgrades during the 2013-2018 period. More specifically, the external and fiscal imbalances combined have contributed to a reduction in Greece's sovereign rating score by around -2.4 (which is equivalent to a downgrade of three notches) vis-à-vis -1.5 score units, due to the deterioration of macroeconomic (mainly) and institutional (secondarily) factors. The development of the scores in the institutional factors category in 2012 mainly reflects the debt restructuring, as this category includes the variable "time since default". Finally, the upgrades observed over the 2013-2018 period are primarily attributed to the improvement of the institutional factors, which have added 1.82 score unit and, secondarily, to the improvement in the macroeconomic environment (+1.02 score unit), with the external and fiscal factors adding 0.52 and 0.42 unit, respectively.

The improvement of the score of institutional factors after 2012 reflects to some extent the increasing distance from the time of debt

restructuring. More importantly though, it reflects improved governance, as suggested by the rise of Greece's ranking on the "political stability and absence of violence" sub-index of the World Bank's governance indicators. Nevertheless, there is room for further improvement, if we compare Greece's ranking in 2018 on all individual governance indicators with its position before the crisis.

4.3 HOW CAN GREECE BE UPGRADED TO THE INVESTMENT GRADE?

In the present section, we report the results of a simulation analysis of potential developments, with the aim to inform how the Greek sovereign credit rating can be upgraded to the investment grade.[23] The simulations assume (a) that Greece's institutional score improves, which positions the country on the basis of the World Bank's governance indicators to its historical high observed in the early 2000s, and (b) that one more year passes without any credit event. All other variables remain at the levels assumed by the CRAs in their most recent updates.[24]

Chart 4 presents the results of this simulation exercise. The results indicate that, all else equal, the improvement in governance to 2001 levels along with one more year passing without a credit event would improve Greece's score enough to contribute to an upgrade of its rating to investment grade (i.e. equal to or above BBB-), provided that the adjustment at the second stage remains at the present level. This highlights the importance of the institutional environment for the sovereign credit rating of the Greek economy and, as a consequence, for entities of both the public and the private sector, whose cost and opportunities of funding are associated with country risk.

5 CONCLUDING REMARKS

We estimate the quantitative component of sovereign credit ratings following methodologies of the three major Credit Rating Agencies. We then use the model to replicate Greece's sovereign credit ratings over the 2006-2018 period. We show that Greek sovereign ratings over this period have largely followed the economy's fundamentals. However, we find that, after 2010, Greece's actual rating drops two to three notches below the estimated score, which measures the effect of fundamentals on the rating. This divergence is due to the judgmental component of ratings, which, according to our interpretation, largely captures the effect of the Greek debt restructuring in March 2012.

At present, the Greek economy has several advantages and few disadvantages, compared with economies belonging to the same category (BB). On the positive side, Greece outperforms its BB peers due to the strength of its institutions, the developed status of its economy, the strength of the monetary regime and its high income per capita. On the negative side, Greece lags behind its past performance in terms of quality of governance, which constitutes one of the most important rating factors for sovereign entities. In fact, our simulations suggest that improving the quality of governance to pre-crisis levels is a necessary condition for an upgrade of the Greek sovereign credit rating to investment grade.

23 In order to regain the investment grade status, Greece has to be upgraded by two notches by Fitch, three notches by Standard and Poor's and four notches by Moody's.

24 See the rating action reports by Fitch (24 July 2020), Moody's (10 July 2020) and S&P (24 April 2020).

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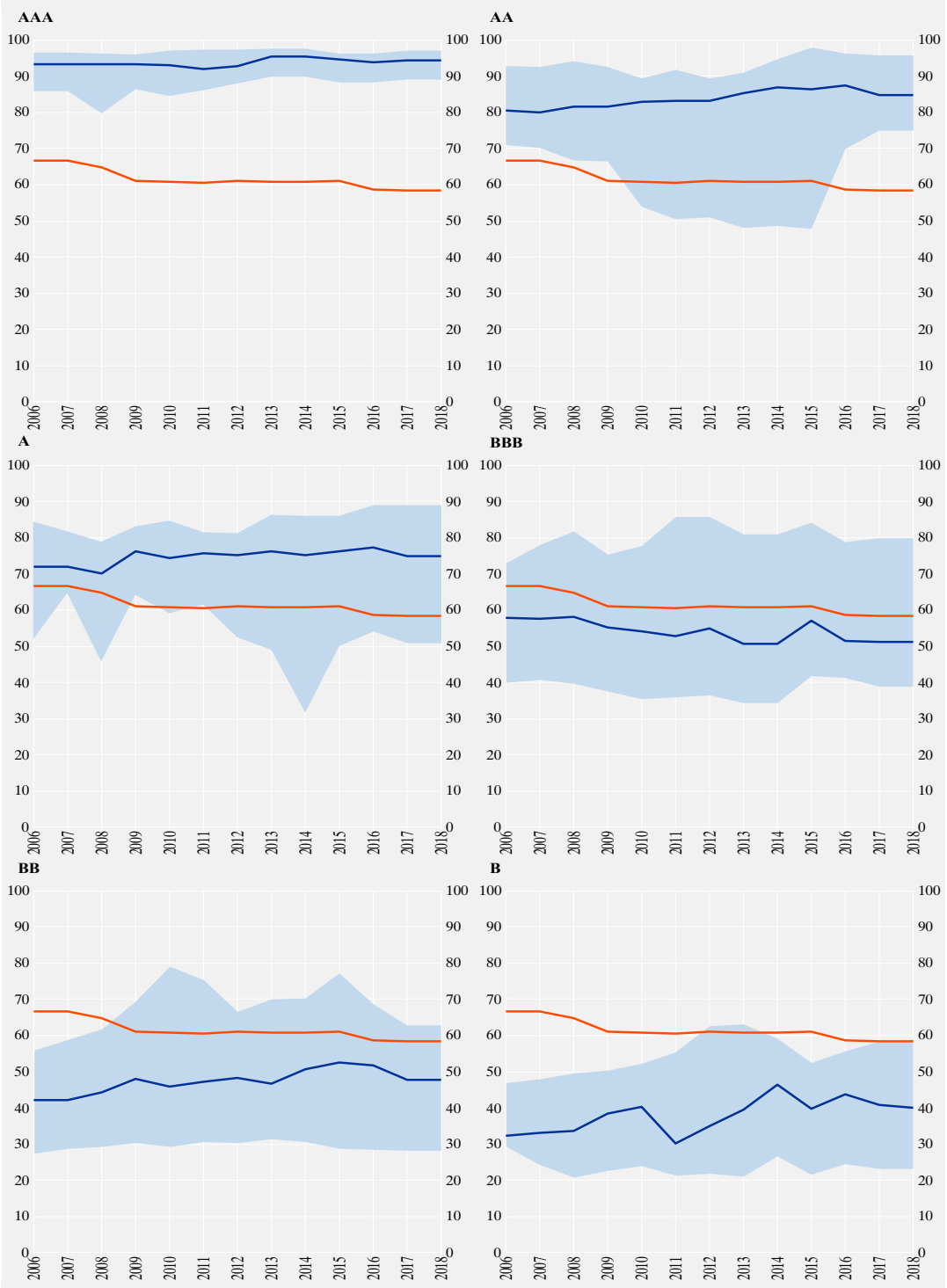
APPENDIX

Chart A1 Governance indicators

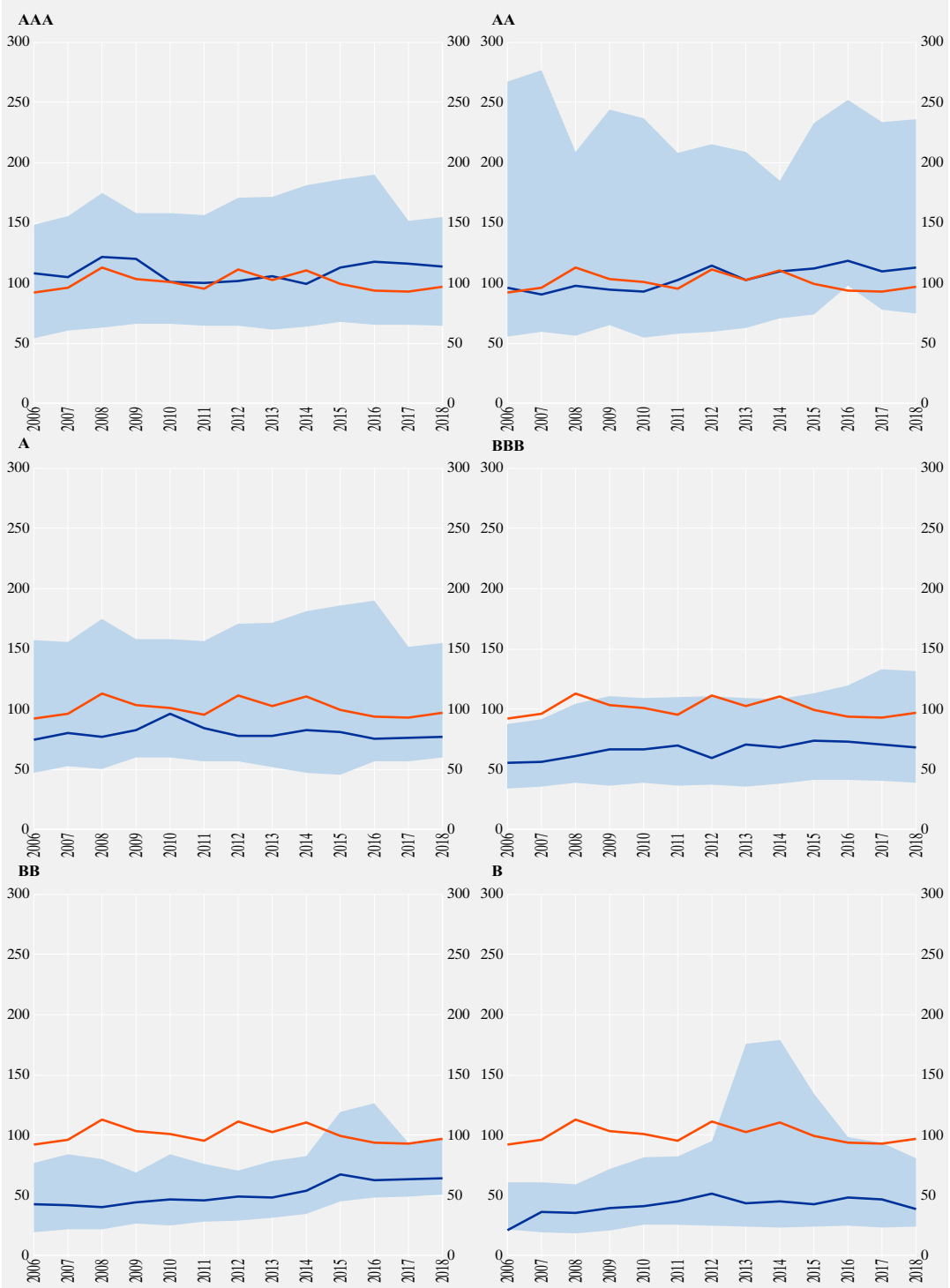
(percentile rank)



Note: The panels illustrate the value of the factor "governance indicators" for Greece (orange line), as well as the median (blue line) and the interquantile range (10% and 90%: light blue area) of each rating category. Rating categories are shown in the headings of individual panels; thus, apart from the value of this factor for Greece, the top left panel shows the median and the interquantile range for AAA-rated sovereigns, the top right panel for AA-rated sovereigns, the second-row left panel for A-rated sovereigns, and so on.

Chart A2 Broad money

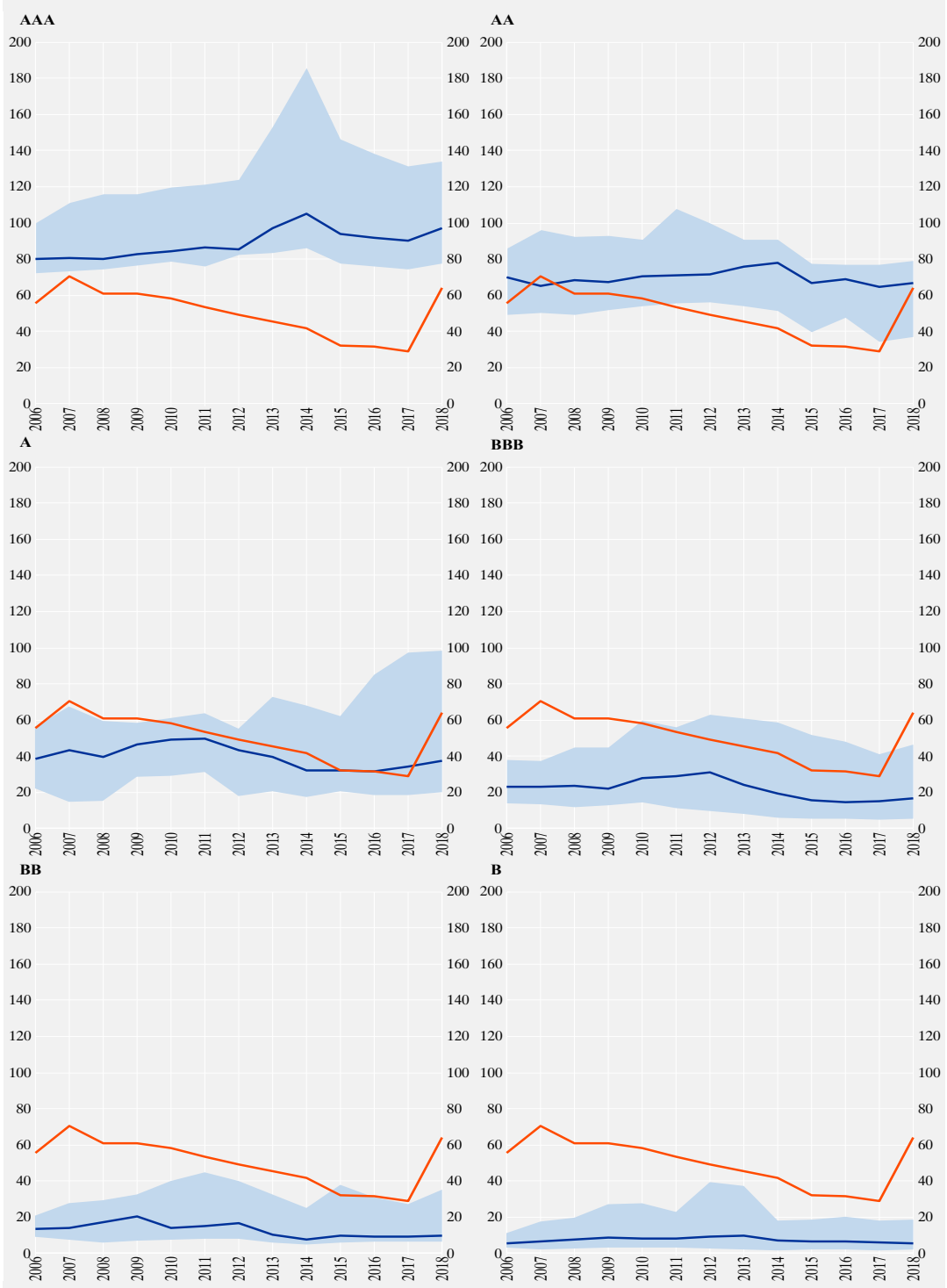
(% of GDP)



Note: The panels illustrate the value of the factor "broad money" for Greece (orange line), as well as the median (blue line) and the interquantile range (10% and 90%: light blue area) of each rating category. Rating categories are shown in the headings of individual panels; thus, apart from the value of this factor for Greece, the top left panel shows the median and the interquantile range for AAA-rated sovereigns, the top right panel for AA-rated sovereigns, the second-row left panel for A-rated sovereigns, and so on.

Chart A3 GDP per capita

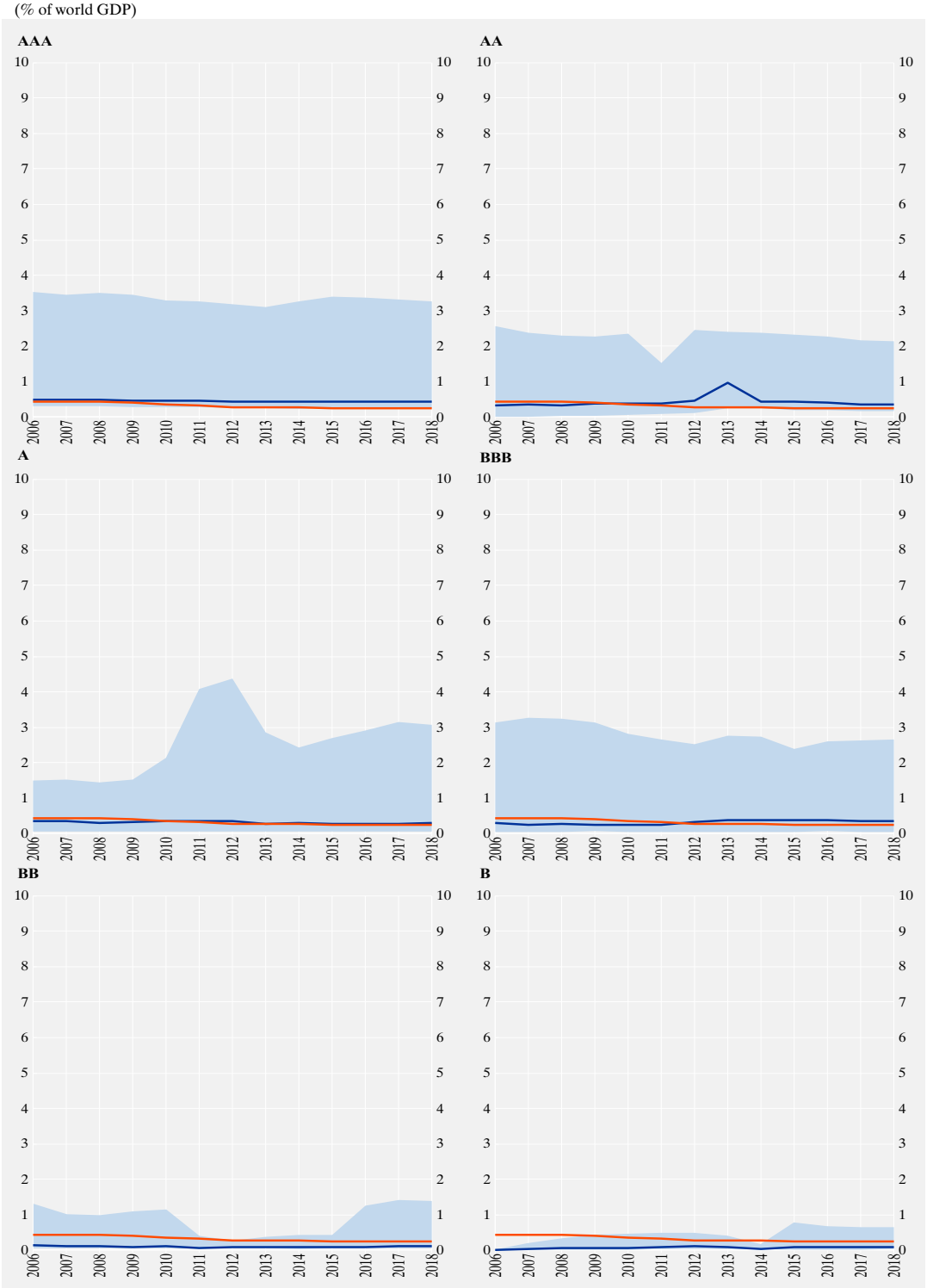
(% of US GDP per capita)



Note: The panels illustrate the value of the factor "GDP per capita" for Greece (orange line), as well as the median (blue line) and the interquantile range (10% and 90%: light blue area) of each rating category. Rating categories are shown in the headings of individual panels; thus, apart from the value of this factor for Greece, the top left panel shows the median and the interquantile range for AAA-rated sovereigns, the top right panel for AA-rated sovereigns, the second-row left panel for A-rated sovereigns, and so on.

Chart A4 Share in world GDP

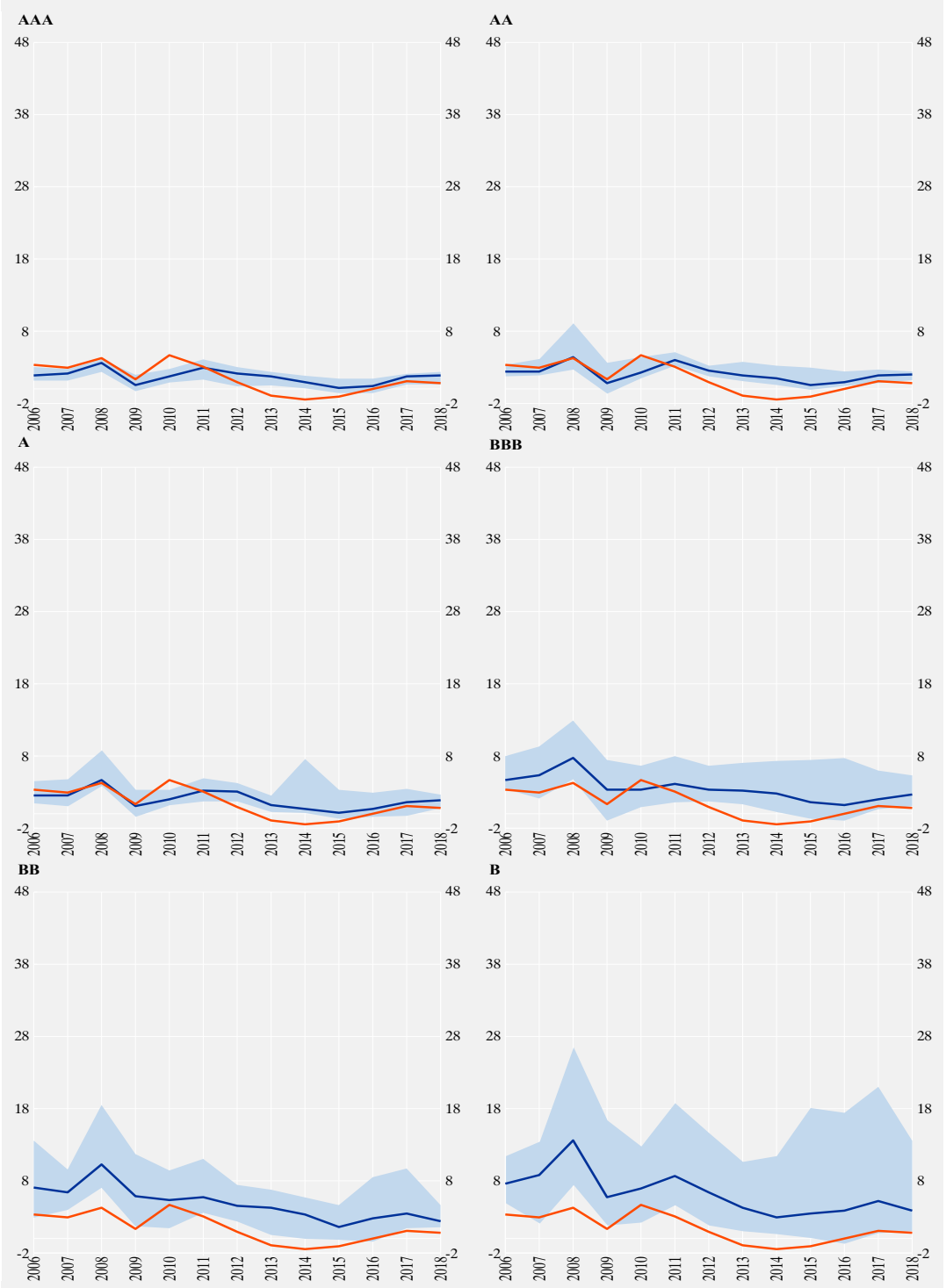
(% of world GDP)



Note: The panels illustrate the value of the factor "share in world GDP" for Greece (orange line), as well as the median (blue line) and the interquantile range (10% and 90%: light blue area) of each rating category. Rating categories are shown in the headings of individual panels; thus, apart from the value of this factor for Greece, the top left panel shows the median and the interquantile range for AAA-rated sovereigns, the top right panel for AA-rated sovereigns, the second-row left panel for A-rated sovereigns, and so on.

Chart A5 Inflation rate

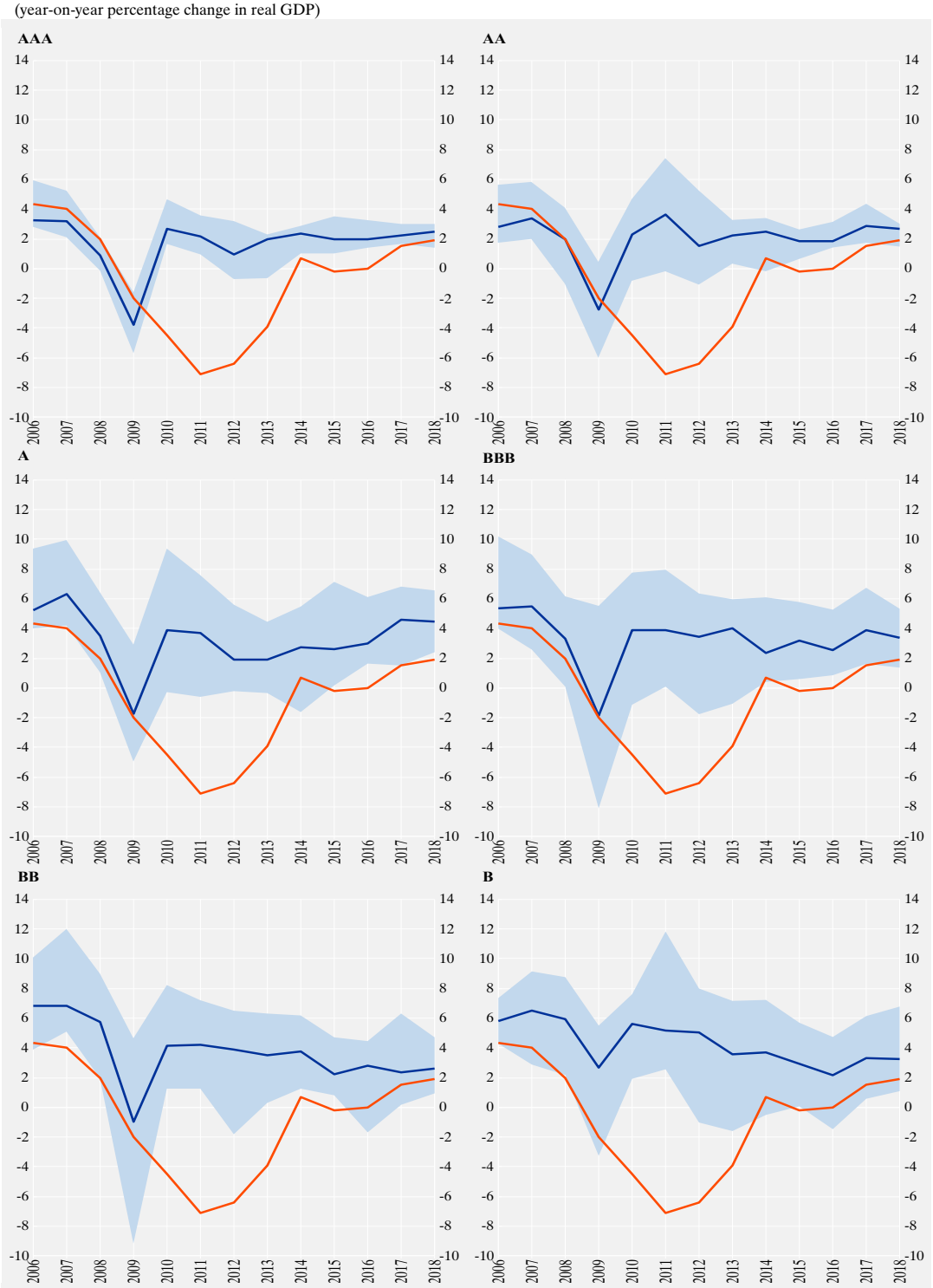
(annual rate of change in CPI)



Note: The panels illustrate the value of the factor "inflation rate" for Greece (orange line), as well as the median (blue line) and the interquantile range (10% and 90%: light blue area) of each rating category. Rating categories are shown in the headings of individual panels; thus, apart from the value of this factor for Greece, the top left panel shows the median and the interquantile range for AAA-rated sovereigns, the top right panel for AA-rated sovereigns, the second-row left panel for A-rated sovereigns, and so on.

Chart A6 Real GDP growth

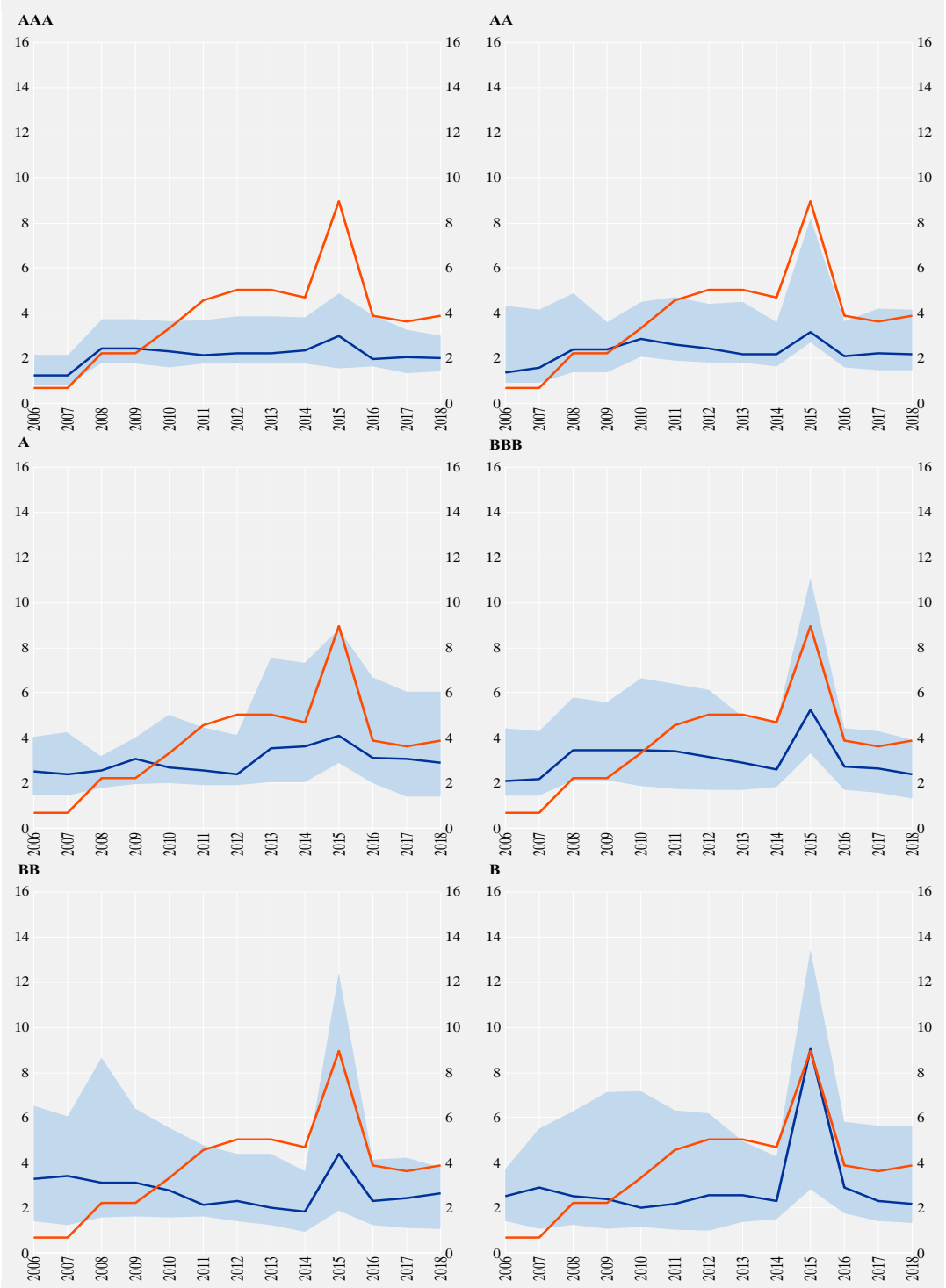
(year-on-year percentage change in real GDP)



Note: The panels illustrate the value of the factor "real GDP growth" for Greece (orange line), as well as the median (blue line) and the interquantile range (10% and 90%: light blue area) of each rating category. Rating categories are shown in the headings of individual panels; thus, apart from the value of this factor for Greece, the top left panel shows the median and the interquantile range for AAA-rated sovereigns, the top right panel AA-rated sovereigns, the second-row left panel for A-rated sovereigns, and so on.

Chart A7 GDP volatility

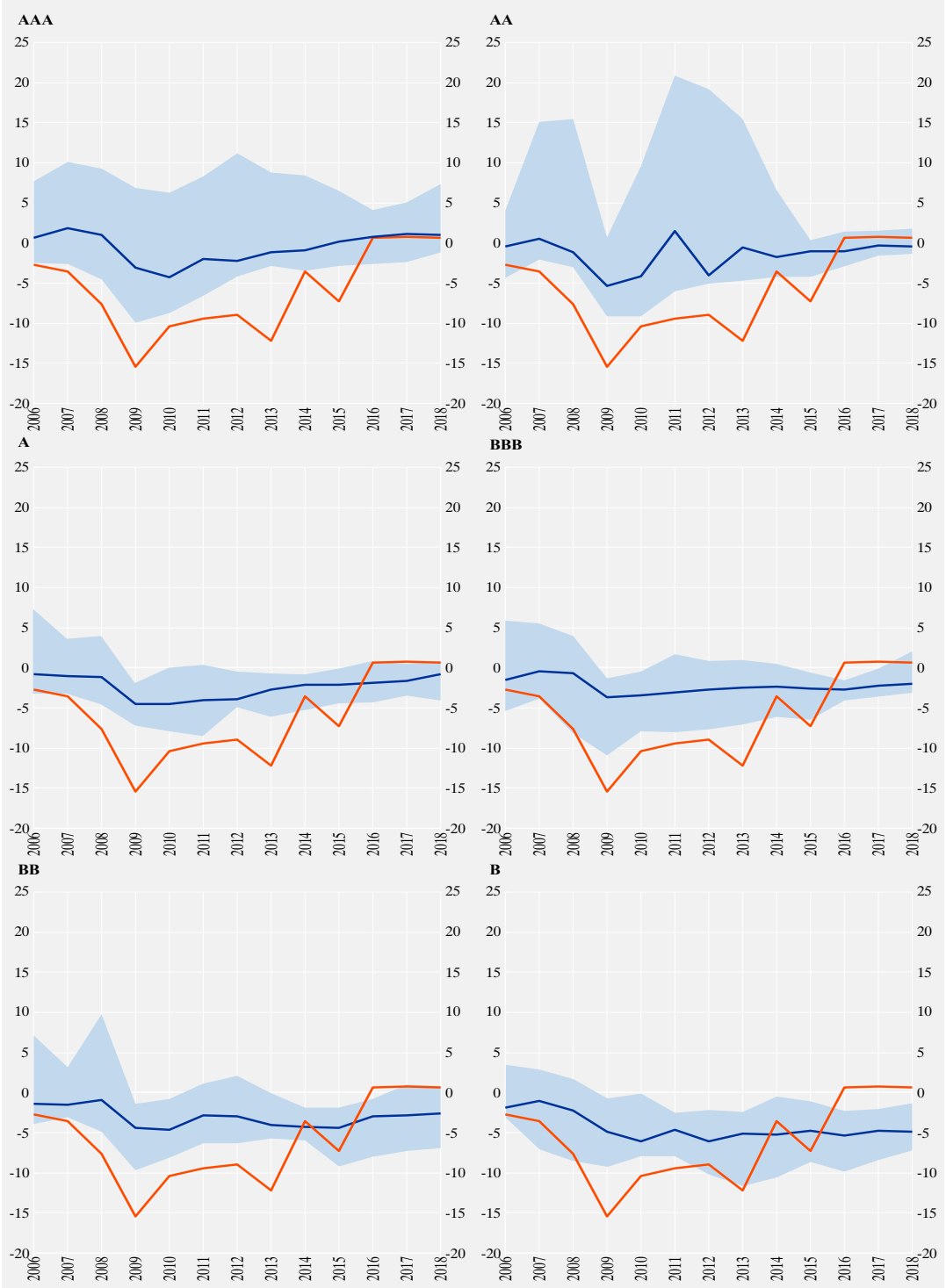
(10-year standard deviation in real GDP growth rates)



Note: The panels illustrate the value of the factor "GDP volatility" for Greece (orange line), as well as the median (blue line) and the interquantile range (10% and 90%: light blue area) of each rating category. Rating categories are shown in the headings of individual panels; thus, apart from the value of this factor for Greece, the top left panel shows the median and the interquantile range for AAA-rated sovereigns, the top right panel for AA-rated sovereigns, the second-row left panel for A-rated sovereigns, and so on.

Chart A8 General government budget balance

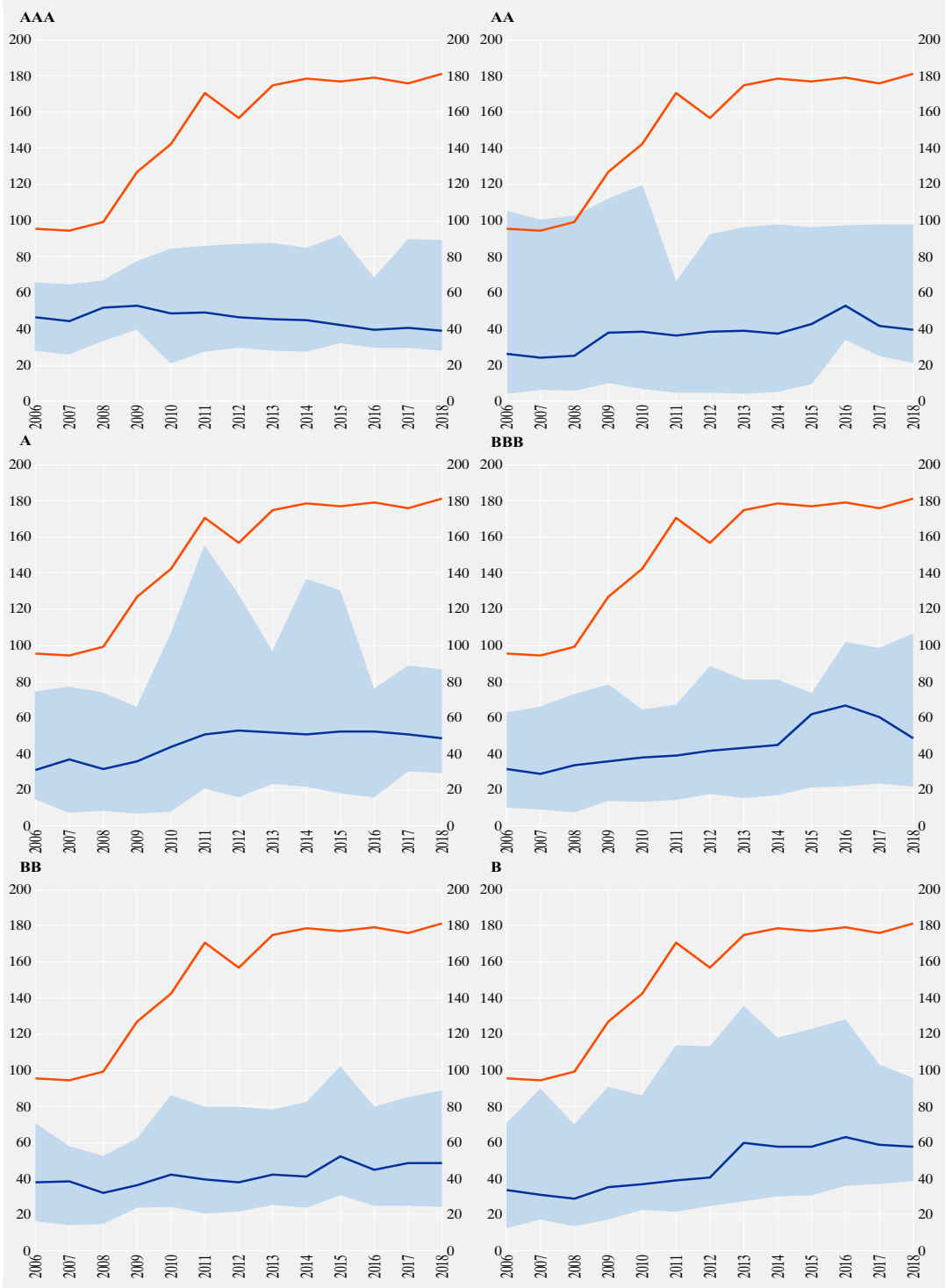
(% of GDP, + surplus / - deficit)



Note: The panels illustrate the value of the factor "general government budget balance" for Greece (orange line), as well as the median (blue line) and the interquantile range (10% and 90%: light blue area) of each rating category. Rating categories are shown in the headings of individual panels; thus, apart from the value of this factor for Greece, the top left panel shows the median and the interquantile range for AAA-rated sovereigns, the top right panel for AA-rated sovereigns, the second-row left panel for A-rated sovereigns, and so on.

Chart A9 General government debt

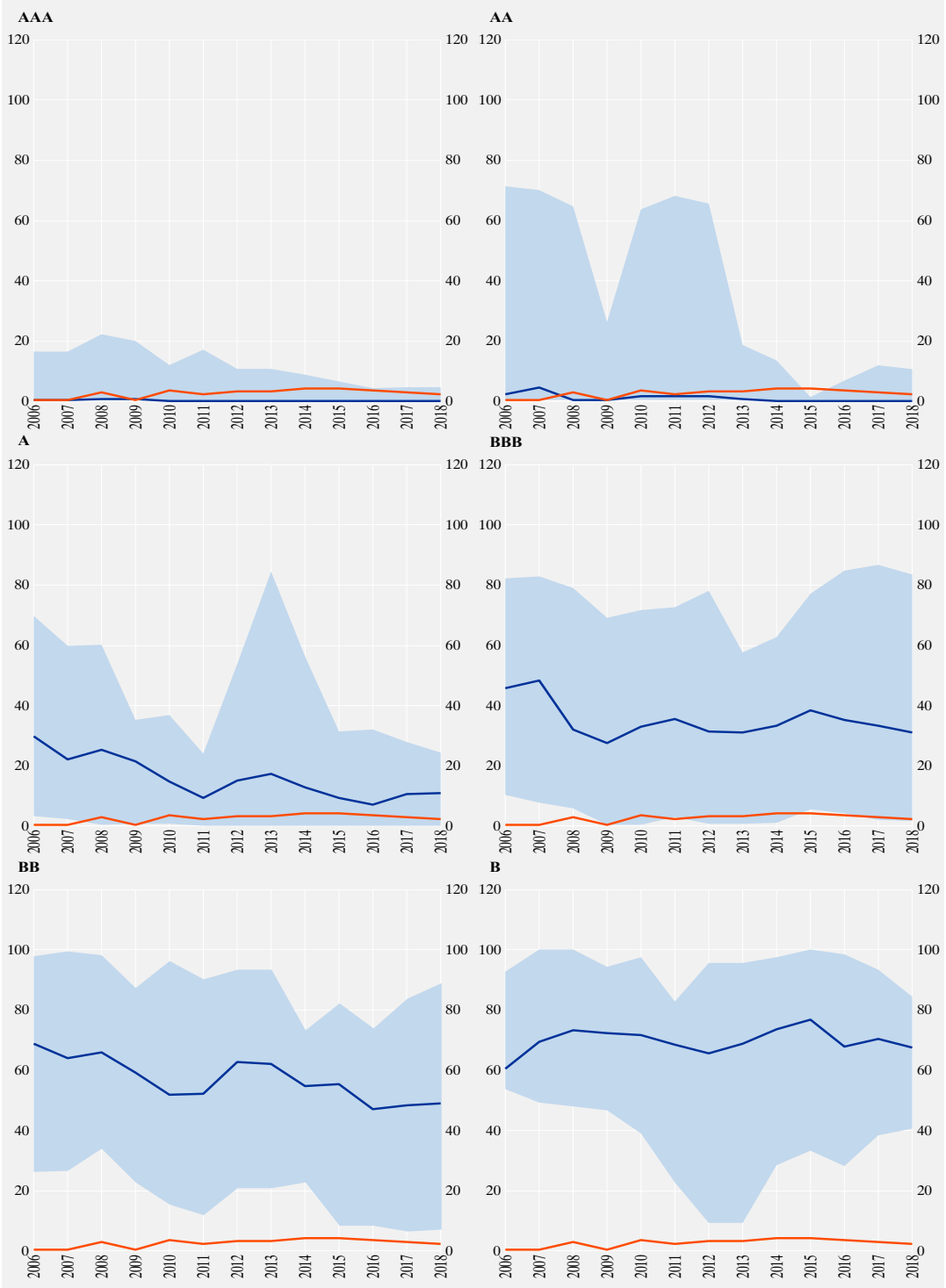
(% of GDP)



Note: The panels illustrate the value of the factor "general government debt" for Greece (orange line), as well as the median (blue line) and the interquantile range (10% and 90%: light blue area) of each rating category. Rating categories are shown in the headings of individual panels; thus, apart from the value of this factor for Greece, the top left panel shows the median and the interquantile range for AAA-rated sovereigns, the top right panel for AA-rated sovereigns, the second-row left panel for A-rated sovereigns, and so on.

Chart A10 Public debt denominated in foreign currency

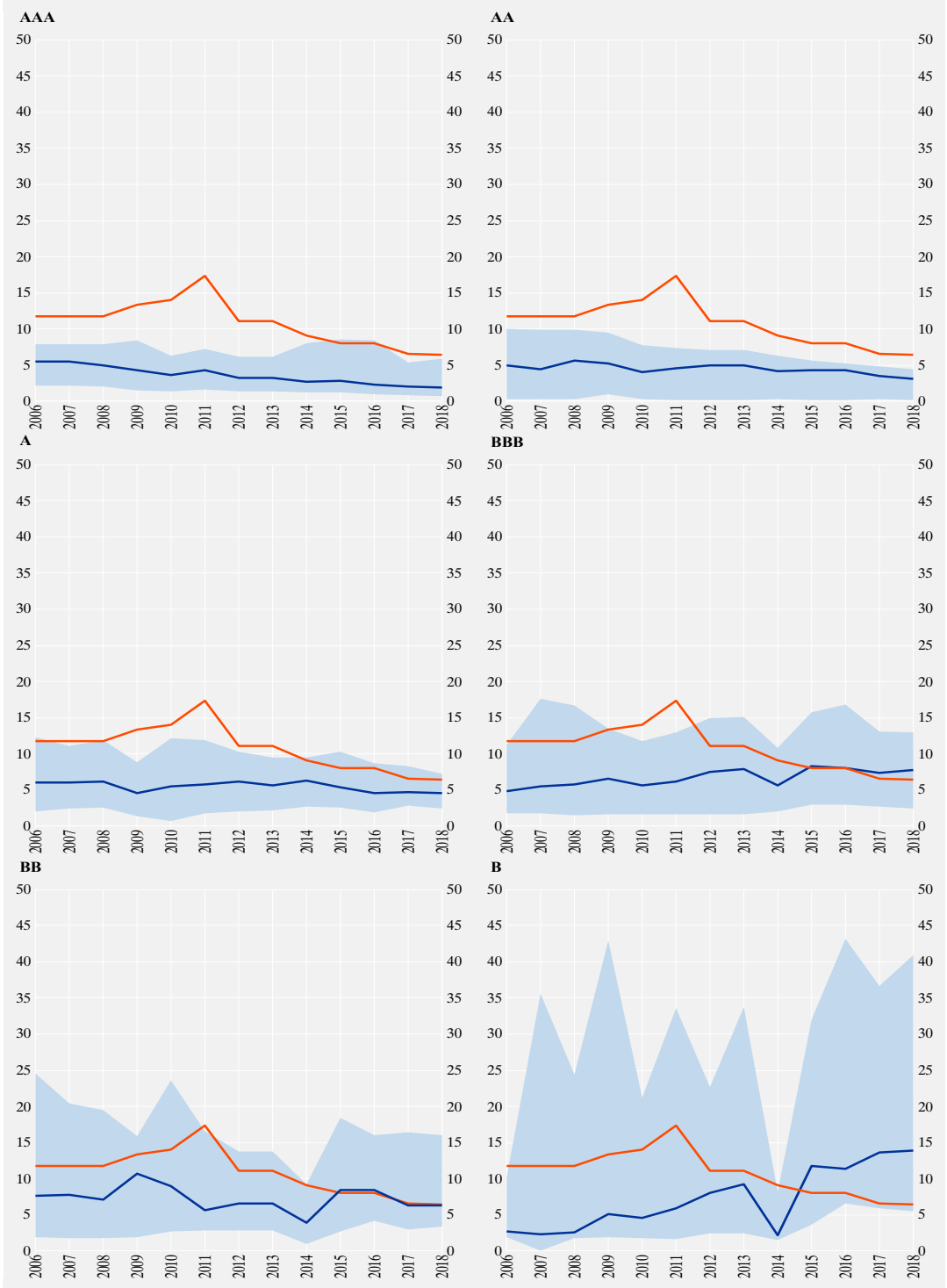
(% of gross general government debt)



Note: The panels illustrate the value of the factor "public debt denominated in foreign currency" for Greece (orange line), the median (blue line) and the interquantile range (10% and 90%: light blue area) of each rating category. Rating categories are shown in the headings of individual panels; thus, apart from the value of this factor for Greece, the top left panel shows the median and the interquantile range for AAA-rated sovereigns, the top right panel for AA-rated sovereigns, the second-row left panel for A-rated sovereigns, and so on.

Chart A11 General government interest expenses

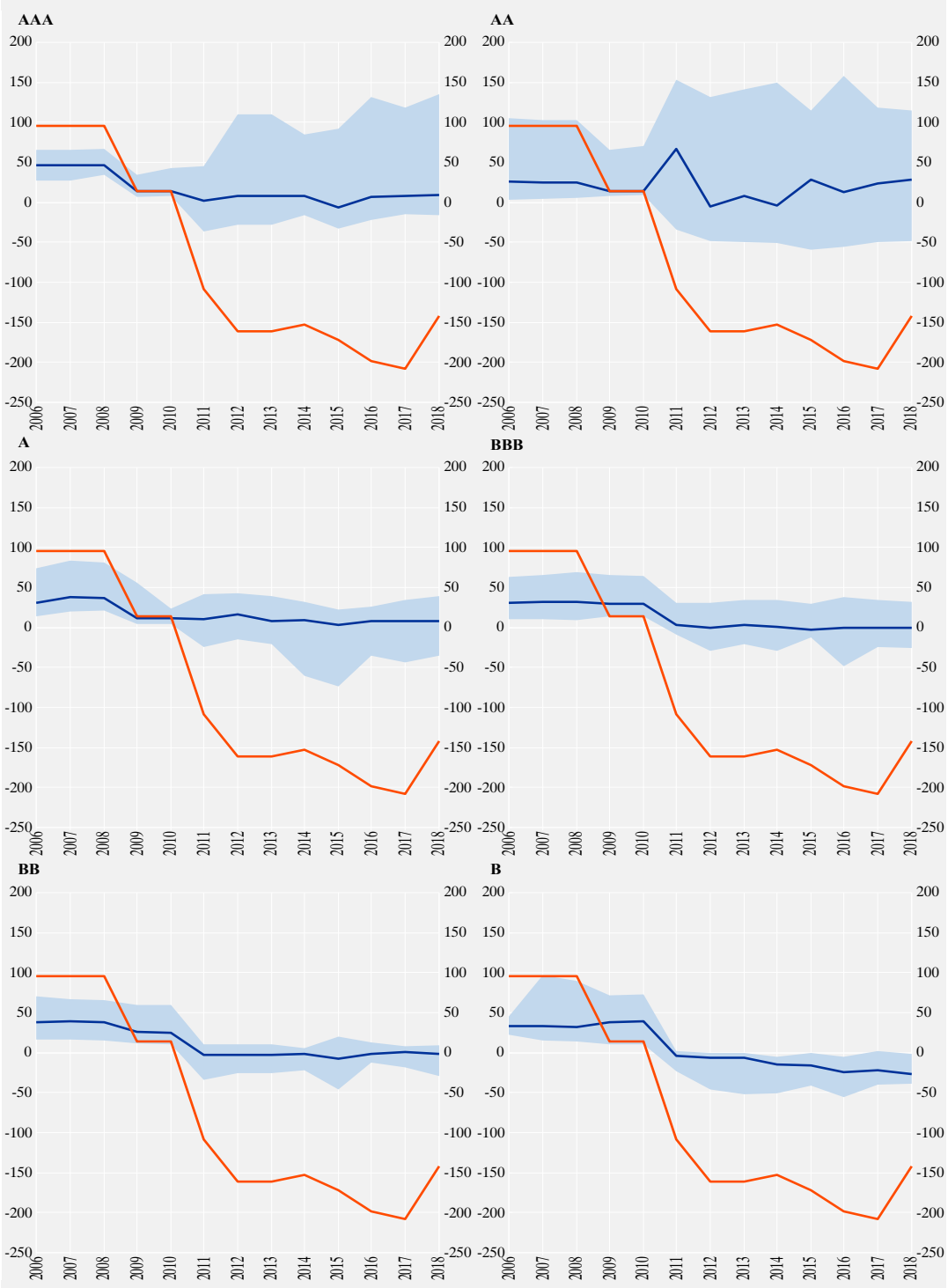
(% of revenues)



Note: The panels illustrate the value of the factor "general government interest expenses" for Greece (orange line), as well as the median (blue line) and the interquantile range (10% and 90%: light blue area) of each rating category. Rating categories are shown in the headings of individual panels; thus, apart from the value of this factor for Greece, the top left panel shows the median and the interquantile range for AAA-rated sovereigns, the top right panel for AA-rated sovereigns, the second-row left panel for A-rated sovereigns, and so on.

Chart A12 Sovereign net foreign assets

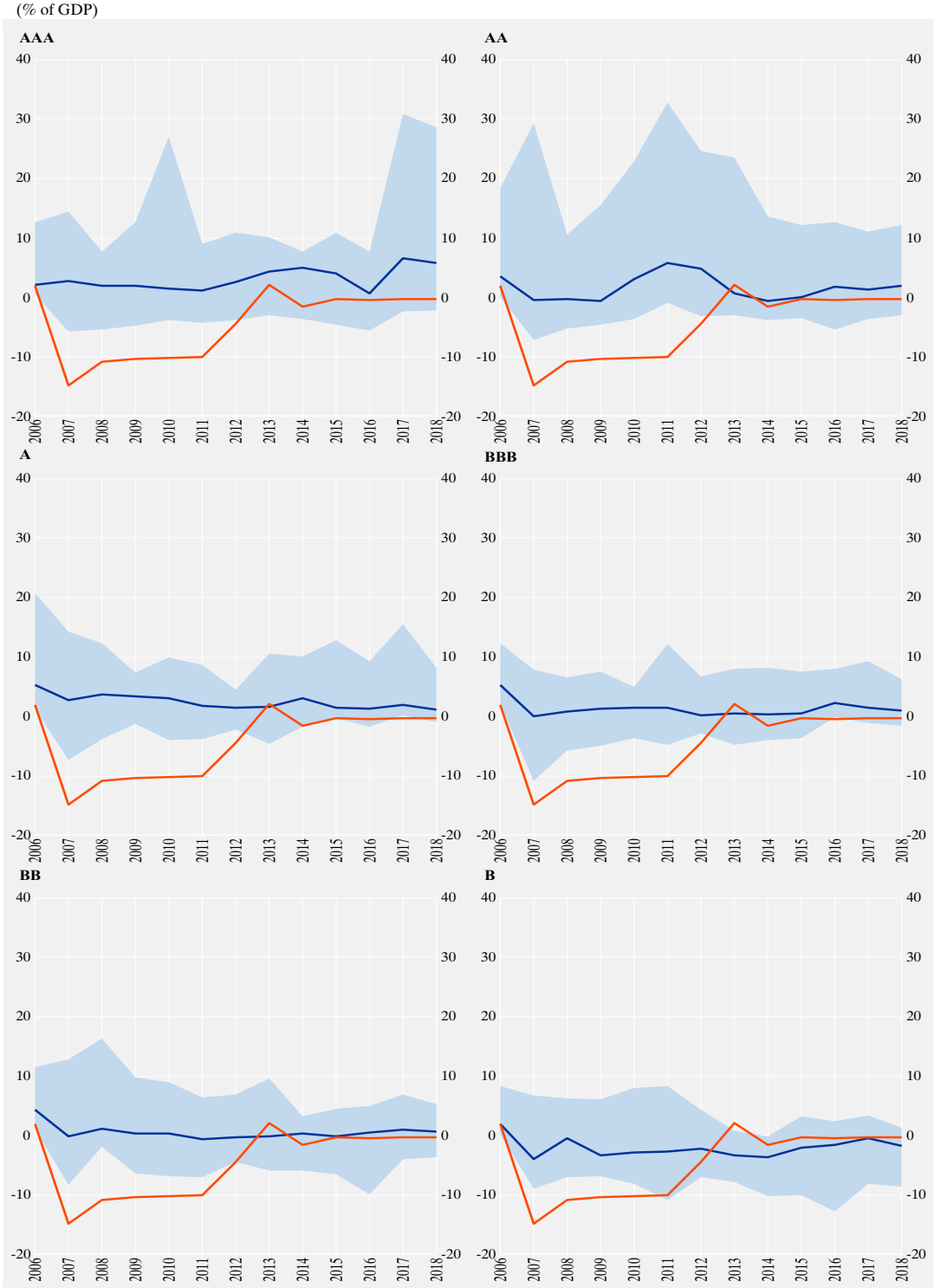
(% of GDP)



Note: The panels illustrate the value of the factor "sovereign net foreign assets" for Greece (orange line), as well as the median (blue line) and the interquantile range (10% and 90%: light blue area) of each rating category. Rating categories are shown in the headings of individual panels; thus, apart from the value of this factor for Greece, the top left panel shows the median and the interquantile range for AAA-rated sovereigns, the top right panel for AA-rated sovereigns, the second-row left panel for A-rated sovereigns, and so on.

Chart A13 Current account balance and foreign direct investment

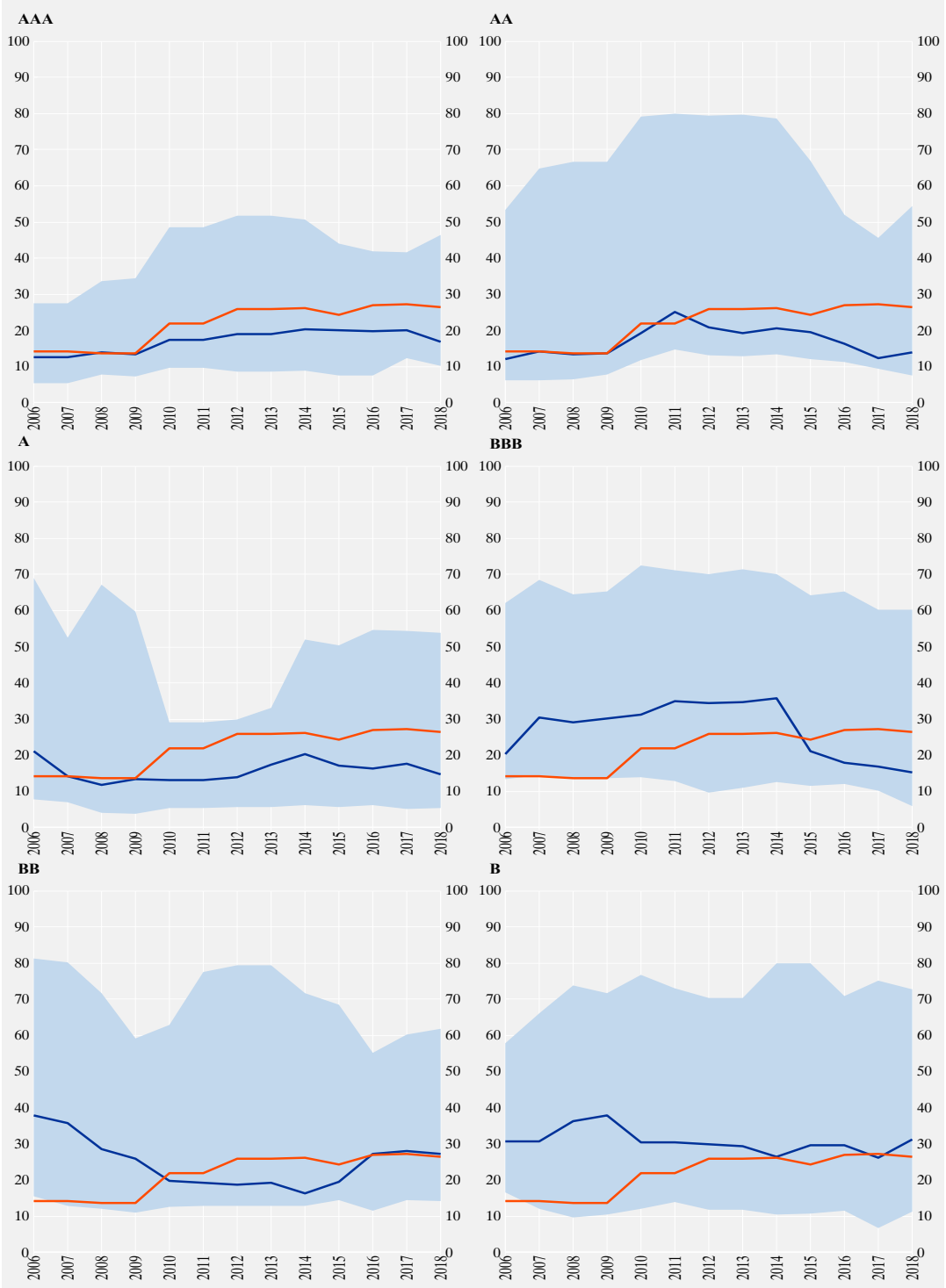
(% of GDP)



Note: The panels illustrate the value of the factor "current account balance and FDI" for Greece (orange line), as well as the median (blue line) and the interquantile range (10% and 90%: light blue area) of each rating category. Rating categories are shown in the headings of individual panels; thus, apart from the value of this factor for Greece, the top left panel shows the median and the interquantile range for AAA-rated sovereigns, the top right panel for AA-rated sovereigns, the second-row left panel for A-rated sovereigns, and so on.

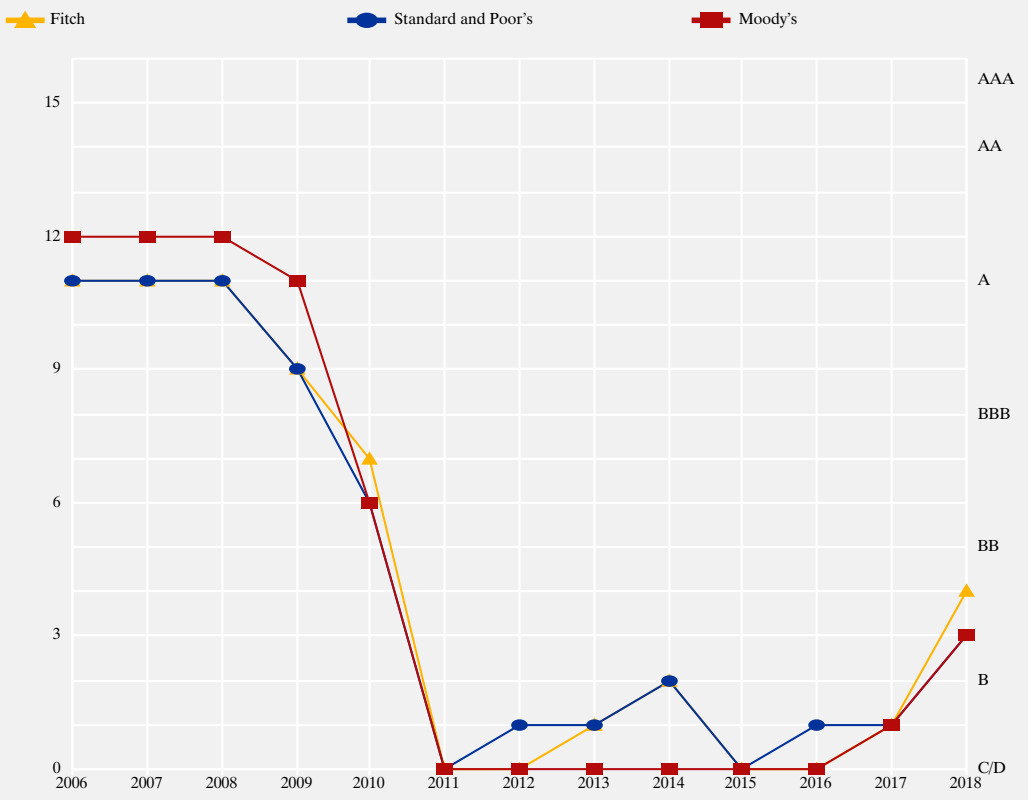
Chart A14 Commodity dependence

(% of GDP)



Note: The panels illustrate the value of the factor "commodity dependence" for Greece (orange line), as well as the median (blue line) and the interquantile range (10% and 90%: light blue area) of each rating category. Rating categories are shown in the headings of individual panels; thus, apart from the value of this factor for Greece, the top left panel shows the median and the interquantile range for AAA-rated sovereigns, the top right panel for AA-rated sovereigns, the second-row left panel for A-rated sovereigns, and so on.

Chart A15 Greece's sovereign credit rating from individual CRAs



Note: The chart shows the sovereign credit rating assigned to Greece by Fitch (marked by orange triangles), Moody's (marked by brown squares) and Standard and Poor's (marked by blue circles) for the period 2006-2018. Each mark is the rating assigned by each of the three CRAs at the end of the respective year; ratings are noted in notches and shown on the left-hand scale in numerical and on the right-hand scale in alphanumeric form.

THE CURRENT ACCOUNT ADJUSTMENT IN GREECE DURING THE CRISIS: CYCLICAL OR STRUCTURAL?

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ABSTRACT

The substantial narrowing of the Greek current account deficit —by more than 13 percentage points of GDP— constitutes a significant part of the overall adjustment of the economy in the 2008-2019 period. A major issue, however, is related to whether the factors driving this external correction are temporary, due mostly to the economic cycle, or structural, in which case they are expected to be sustained over the medium term. In this paper we evaluate the degree to which cyclical versus structural developments have driven the pattern of correction of the country's external imbalance, as this is essential in assessing its evolution going forward. Our analysis shows that the current account adjustment has in a considerable part been driven by structural factors, which according to our baseline scenario account for 60% of the overall adjustment. Therefore, most of the correction is of a permanent nature, which means that the relatively high deficits of the pre-crisis period are not expected to re-emerge any time soon. Our results are robust to various income elasticities of trade; the non-cyclical component ranges from 47% to 74% of the current account deficit correction.

Keywords: cyclically adjusted current account; macroeconomic imbalances; output gap; current account; business fluctuations

JEL classification: F32; F40; E32

Η ΠΡΟΣΑΡΜΟΓΗ ΤΟΥ ΕΛΛΕΙΜΜΑΤΟΣ ΤΟΥ ΙΣΟΖΥΓΙΟΥ ΤΡΕΧΟΥΣΩΝ ΣΥΝΑΛΛΑΓΩΝ ΤΗΣ ΕΛΛΑΔΟΣ ΚΑΤΑ ΤΗ ΔΙΑΡΚΕΙΑ ΤΗΣ ΚΡΙΣΗΣ: ΚΥΚΛΙΚΗ Ή ΔΙΑΡΘΡΩΤΙΚΗ;

Κωνσταντίνα Μπακινέζου
Διεύθυνση Οικονομικής Ανάλυσης και Μελετών

Στέλιος Παναγιώτου
Διεύθυνση Οικονομικής Ανάλυσης και Μελετών

Χρήστος Παπάζογλου
Διεύθυνση Οικονομικής Ανάλυσης και Μελετών
και Πάντειο Πανεπιστήμιο, Τμήμα Διεθνών, Ευρωπαϊκών και Περιφερειακών Σπουδών

ΠΕΡΙΛΗΨΗ

Η σημαντική μείωση του ελλείμματος του ισοζυγίου τρεχουσών συναλλαγών της Ελλάδος —πάνω από 13 ποσοστιαίες μονάδες του ΑΕΠ— αποτελεί κεντρικό παράγοντα της συνολικής προσαρμογής της οικονομίας την περίοδο 2008-2019. Ένα μείζον ερώτημα, ωστόσο, σχετίζεται με το αν οι παράγοντες που οδήγησαν σ' αυτή τη διόρθωση της εξωτερικής ανισορροπίας είναι προσωρινοί, αποτέλεσμα κυρίως του οικονομικού κύκλου, ή διαρθρωτικοί, οπότε αναμένεται να διατηρηθούν μεσοπρόθεσμα. Στο παρόν άρθρο εξετάζουμε τη σχετική σημασία των κυκλικών και των διαρθρωτικών παραγόντων που συνέβαλαν στη διόρθωση της ανισορροπίας του εξωτερικού τομέα της χώρας. Αυτό είναι απαραίτητο για την αξιολόγηση της εξέλιξης του εξωτερικού τομέα μεσοπρόθεσμα. Η ανάλυσή μας δείχνει ότι η προσαρμογή του ισοζυγίου τρεχουσών συναλλαγών οφείλεται σε μεγάλο βαθμό σε διαρθρωτικούς παράγοντες, οι οποίοι σύμφωνα με το βασικό σενάριό μας αντιστοιχούν στο 60% της συνολικής προσαρμογής. Επομένως, το μεγαλύτερο μέρος της διόρθωσης είναι μόνιμου χαρακτήρα, πράγμα που σημαίνει ότι τα σχετικά υψηλά ελλείμματα της περιόδου πριν από την κρίση δεν αναμένεται να επανεμφανιστούν σύντομα. Τα αποτελέσματά μας εξακολουθούν να ισχύουν σε διάφορες τιμές εισοδηματικής ελαστικότητας των εμπορικών συναλλαγών και η μη κυκλική συνιστώσα της προσαρμογής κυμαίνεται από 47% έως 74% της συνολικής διόρθωσης του ελλείμματος του ισοζυγίου τρεχουσών συναλλαγών.

THE CURRENT ACCOUNT ADJUSTMENT IN GREECE DURING THE CRISIS: CYCLICAL OR STRUCTURAL?[1]

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1 INTRODUCTION

The adjustment of the Greek economy in recent years is primarily linked with the significant correction of large macroeconomic imbalances generated in the run-up to the economic crisis of 2008 and includes, inter alia, a major improvement in the external sector. In particular, the reduction of the current account deficit during the crisis was indeed remarkable, since it fell from 15.1% of GDP in 2008 to 1.4% of GDP by the end of 2019 (see Chart 1). This undoubtedly constitutes a success story for the Greek economy.

An important issue —which has drawn a lot of attention recently[2]— refers to the extent to which this adjustment will be sustained over the medium term. This depends on the magnitude of the part of the external correction that can be attributed to the economic cycle, relative to the part that was the result of structural factors, which are independent of the cycle and, therefore, more permanent in nature. In particular, the cyclical part is primarily related to the large negative output gap of the post-crisis period. This in turn was the result of the large decline in domestic demand, which, through a considerable drop in imports, contributed to the reduction of the current account deficit. Moreover, the correction associated with cyclical factors is the result of the deeper recession of the Greek economy in comparison with the economies of its major trading partners, a differential that allowed imports to fall faster than exports, lowering the Greek current account deficit. The size of such cyclical adjustment is what raises concerns about the sustainability of the overall improvement in the recovery phase of the cycle. That is, as the economy recovers and the country's real GDP approaches its potential level, raising the prospect of a positive output gap in the medium term, the likelihood increases that the large external deficits of the past might re-emerge.

On the other hand, to the extent that a significant part of the current account correction can be attributed to structural factors, the achieved adjustment will be permanent. That is, structural factors are, among other things, associated with competitiveness gains as a result of productivity growth, improved fiscal positions, stronger institutions, a shift of production towards tradable sectors, financial deepening and favourable demographic changes. The evolution of these factors could be of significant importance in capturing broad medium-term trends in external imbalances. For instance, to the extent that the decline in the current account deficit is attributable to rising exports, resulting from competitiveness gains, it reflects structural changes and is expected to persist over the medium term.

Consequently, the answer to the question on whether the current account deficit will eventually return to its pre-crisis level is critically linked with the nature (cyclical or structural) of the achieved external sector correction. The aim of this paper is to investigate which part of

1 The authors would like to thank H. Balfoussia for her useful comments and invaluable insights. The views expressed are of the authors and do not necessarily reflect those of the Bank of Greece. The authors are responsible for any errors or omissions.
2 For example, see IMF (2019).

the accomplished adjustment is the result of cyclical factors and thus will fade away in the medium term and which part is due to structural factors and therefore is more likely to stay. In Section 2 we examine in more detail recent developments in the Greek current account. The methodology and data employed are explained in Section 3. The results of the analysis and their robustness check are discussed in Sections 4 and 5, respectively. Finally, the concluding remarks of the analysis are presented in Section 6.

2 DEVELOPMENTS IN THE GREEK CURRENT ACCOUNT

As pointed out, the current account deficit reached its peak of EUR 36.6 billion (15.1% of GDP) in 2008 at the outbreak of the global financial crisis and just before the collapse of world trade that followed in 2009 (see Chart 1). The lead-up to the economic crisis (i.e. 2002-2008) was characterised by low private savings, which could not meet the investment needs of the economy and, combined with extensive fiscal imbalances, led to the build-up of sizeable external imbalances.[3] In terms of the trade balance, there had been a rising goods deficit, only partially counterbalanced by the services (mainly travel and sea transport) surplus, which remained rather stable at a relatively low level. As an overall assessment, the country's entry into the Monetary Union increased domestic demand which, reinforced further by a pro-cyclical fiscal policy, pushed upwards imports and the trade deficit, while productive resources were to a great extent trapped into non-tradable sectors.

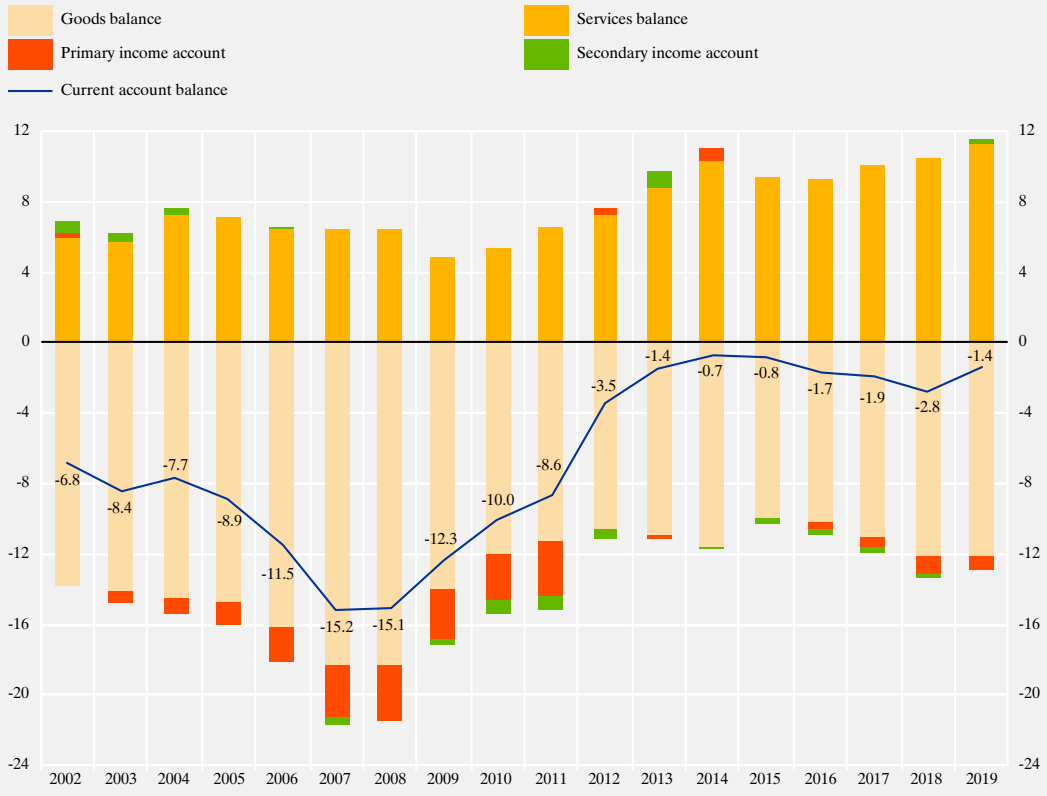
At the same time, exports of goods were rising and gaining market share, as Greek exporters managed to exploit their position in the South-east European markets,[4] compensating for the loss in cost/price competitiveness (largely due to competition from Asian countries) and for the less favourable product composition of Greek exports (which mainly consisted of low- to medium-technology products).[5] Despite that, exports remained at approximately one-third of imports and their expansion was not fast enough to outweigh the increasing goods balance deficit. It should also be noted that exports and investment (concentrated mostly in housing construction) have a considerable import content of approximately 31% and 41%, respectively.[6]

The decade after the crisis (i.e. 2009-2019) has been characterised by a substantial improvement in the Greek external balance. The current account deficit dropped by 13.7 percentage points (pp) and reached 1.4% of GDP in 2019. Most of the adjustment can be attributed to exports of goods, which increased to 17.3% of GDP from 9.1% of GDP in 2008. Shrinking domestic demand urged domestic producers to intensify their efforts to enter and expand into foreign markets. At the same time, exports of services adjusted upwards, albeit at a weaker pace due to the underperformance of sea transport and the slow recovery of tourism. Overall, since the end of 2009, exports of goods and services excluding sea transport have increased by 64% at constant prices (while exports of goods increased by almost 62% over the same period). At the same time, imports have dropped by 30% since their peak in 2008. Imports started rising again after 2016 as a response to the improvement of economic activity and the need for replacing capital equipment, which raises concerns over whether the current account improvement can be sustained if growth in all components of domestic demand and exports accelerates. However, despite the fact that imports are needed for growth, there have been some substantial structural changes in the Greek economy during this adjustment, especially on the side of exports, that could help sustain the external rebalancing achieved.

The recovery in competitiveness is complete in terms of cost and almost complete in terms of

3 See Bank of Greece (2020).
4 See Papazoglou (2007).
5 See Backinezos et al. (2019) and Athanasoglou et al. (2010).
6 See Bank of Greece (2018a).

Chart 1 Current account balance components as % of GDP



Sources: Bank of Greece, Balance of Payments Statistics, and ELSTAT, National Accounts.

price, while some substantial improvement in non-price competitiveness has also been achieved. Greek exports, particularly non-oil exports, lost their market share in the beginning of the crisis but started regaining and maintaining their position in international markets since 2016. Continuing the implementation of structural reforms in product markets and institutions will further increase competitiveness, especially non-price. In addition, while the sectoral distribution of Greek exports has not changed considerably, it has started contributing in a positive way to the expansion into foreign markets, allowing exporters to benefit from the prolonged rise in cost/price competitiveness.[7]

Domestic firms have become more export-oriented, although they went through a period of economic contraction.[8] In many sectors, the proportion of domestic output exported has increased and it is most unlikely that these exporters will retract from their positions in international markets in favour of the domestic market. Furthermore, a considerable share of Greek exports relies on products that are less elastic to foreign demand changes (such as food and pharmaceuticals which represent 26% and 9% of total non-oil exports, respectively) and therefore more resilient to foreign demand changes, as the reaction to the recent (2019) slowdown in the world economy has proven.

With regard to tourism, its performance in 2019 showed that the image of the country has improved significantly, since a considerable

7 See Backinezos et al. (2019).
8 See Bank of Greece (2017).

rise in average expenditure per trip was recorded, reflecting a shift towards higher-income travellers, in contrast with developments in past years when travel receipts were driven mainly by the large numbers of arrivals.[9] Besides, since 2002 there has been a quality improvement in the Greek-controlled fleet, which since 2011 is younger than or on a par with the world fleet. This fleet renewal was supported by the exceptionally advantageous freight markets in 2007-2008 and the availability of ship finance in that period. Moreover, Greek-controlled shipping expanded into new sectors such as the carriage of Liquefied Natural Gas that required fresh investment in technologically advanced vessels (Greek Shipping Co-operation Committee). Finally, on the back of all those changes, exports grew as a proportion of imports leading to the contraction of the goods and services balance deficit, which accounts for the bulk of the current account. Also, such changes are more structural in nature and are expected to have more permanent effects on the export performance of the Greek economy.

3 METHODOLOGY AND DATA

In the literature, there are two main streams in analysing the adjustment of the current account balance, in order to isolate the cyclically adjusted (or structural) current account. The first stream is based on the intertemporal approach of the current account and, relying on a variety of parameters such as macroeconomic variables, demographics, the financial, political and institutional environment, etc., directly estimates the structural component of the current account. It is mostly employed by international institutions through the use of country panel data.[10] The second stream calculates the cyclically adjusted trade balance indirectly after estimating the cyclical component. The estimation of the latter is based on the output gaps of home and trading partners, as well as on the income elasticities of imports and exports.[11] In our analysis, we follow the methodology employed in the second stream. Specifically, our methodology closely follows Haltmaier (2014) and is augmented with Fabiani et al. (2016). According to the IMF (2009), "the current account shows flows of goods, services, primary income, and secondary income between residents and nonresidents". Therefore, in nominal terms, it is presented as:

$$ca = x - m + bpi + bsi \quad (1)$$

where:

ca: current account balance (nominal);

x: exports of goods and services (nominal);

m: imports of goods and services (nominal);

bpi: balance of primary income (e.g. compensation of employees, dividends, interest, etc., nominal); and

bsi: balance of secondary income (e.g. personal transfers, current international assistance, etc., nominal).

Our objective is to separate the cyclical from the non-cyclical element of the current account. In our analysis, the adjustment concerns exclusively the exports and imports of goods and services, i.e. the trade balance.

We first define:

ΔX (ΔM) as the difference between the potential and the observed level of real exports (imports), i.e. the cyclical component of the exports (imports).

Then from the export side of the trade balance we have:

$$\Delta X = X^* - X \quad \text{or} \quad X^* = X + \Delta X \quad (2)$$

where:

9 See Bank of Greece (2019a).
10 See for instance the IMF's External Balance Assessment (EBA) methodology in Phillips et al. (2013).
11 See for instance Haltmaier (2014).

X^*: potential exports (real), i.e. the level of exports consistent with trading partners' potential output; and

X: observed exports (real).

Let's define as θ_X (θ_M) the elasticity of real exports (imports) with respect to the real GDP of trading partners (of the home economy).

$$\theta_X = \frac{\Delta X/X}{\Delta Y^f/Y^f} \quad (3)$$

where:

Y^f: trading partners' real GDP; and

ΔY^f: the difference between the potential real GDP (Y^{*f}) and the observed real GDP of trading partners.

Equation (3) can be rewritten as:

$$\frac{\Delta X}{X} = \theta_X \frac{\Delta Y^f}{Y^f} \quad (4)$$

Substituting equation (4) in equation (2), we get:

$$X^* = X + \Delta X = X\left(1 + \theta_X \frac{\Delta Y^f}{Y^f}\right) \quad (5)$$

The output gap is defined as:

$$y^f = \frac{Y^f - Y^{*f}}{Y^{*f}}$$

and it can be rearranged as:

$$\frac{Y^{*f}}{Y^f} = \frac{1}{1+y^f} \quad (6)$$

Rearranging the last element of equation (5) $\left(\frac{\Delta Y^f}{Y^f}\right)$ and substituting equation (6), we get:

$$\frac{\Delta Y^f}{Y^f} = -\frac{y^f}{1+y^f} \quad (7)$$

Finally, we substitute (7) into (5) and we get:

$$X^* = X + \Delta X = X\left(1 - \theta_X \frac{y^f}{1+y^f}\right) \quad (8)$$

or

$$\Delta X = -X\,\theta_X \frac{y^f}{1+y^f} \quad (9)$$

If we assume that the export prices (P_X) remain unchanged, the cyclical component of exports in nominal terms is:

$$\Delta x = -P_X\,X\,\theta_X \frac{y^f}{1+y^f} = -x\,\theta_X \frac{y^f}{1+y^f} \quad (10)$$

and the corresponding cyclically adjusted nominal exports are:

$$x^* = x + \Delta x = x\left(1 - \theta_X \frac{y^f}{1+y^f}\right) \quad (11)$$

Accordingly, the equations for nominal imports are as follows:

Cyclical component of imports in nominal terms:

$$\Delta m = -P_M\,M\,\theta_M \frac{y}{1+y} = -m\,\theta_M \frac{y}{1+y} \quad (12)$$

Cyclically adjusted nominal imports:

$$m^* = m + \Delta m = m\left(1 - \theta_M \frac{y}{1+y}\right) \quad (13)$$

Therefore, the cyclically adjusted nominal trade balance is given by:

$$\begin{aligned} tb^* &= x\left(1 - \theta_X \frac{y^f}{1+y^f}\right) - m\left(1 - \theta_M \frac{y}{1+y}\right) \\ &= x - m - x\,\theta_X \frac{y^f}{1+y^f} + m\,\theta_M \frac{y}{1+y} \\ &= tb - x\,\theta_X \frac{y^f}{1+y^f} + m\,\theta_M \frac{y}{1+y} \end{aligned} \quad (14)[12]$$

It follows from equation (1) that the cyclically adjusted current account (in nominal terms) will be:

$ca^* = tb^* + bpi + bsi$ or

$$ca^* = ca - x\,\theta_X \frac{y^f}{1+y^f} + m\,\theta_M \frac{y}{1+y} \quad (15)$$

Finally, the current account as a percentage of nominal GDP (Y_{nom}) is:

$$\frac{ca^*}{Y_{nom}} = \frac{ca}{Y_{nom}} - \frac{x}{Y_{nom}}\theta_X \frac{y^f}{1+y^f} + \frac{m}{Y_{nom}}\,\theta_M \frac{y}{1+y} \quad (16)$$

12 In the special case that $\theta_X = \theta_M = \theta$, then $tb^* = tb - \theta\left(x \frac{y^f}{1+y^f} - m \frac{y}{1+y}\right)$.

Therefore, the cyclically adjusted current account balance (as a percentage of GDP) results from the difference between the actual balance and the cyclical component. The cyclical component, in turn, depends on the share of nominal exports and imports in GDP, the income elasticities of exports and imports and finally the output gaps of the home economy and of its trading partners.

Thus, in order to isolate the cyclical part of the adjustment, two elements of information are required. The first is related to the intensity of the economic cycle in the home economy and its major trading partners, which is measured by the magnitude of their output gaps. The second concerns the sensitivity of the current account balance to changes in the output gap, which relates to the export and import elasticity of GDP of the trading partners and the home country, respectively.

The impact of the economic cycle on the external sector is primarily reflected in its impact on the trade balance, which is the main part of the current account balance. Changes in the other two parts of the current account (primary and secondary income balances) are considered to be structural in nature.[13]

In our research, we do not estimate the income elasticities of export and imports; we rather employ the elasticities estimated in other research work. In our baseline scenario, we employ an elasticity of 1.5 for both exports and imports with respect to income, which reflects the European Commission's approach as described in Salto and Turrini (2010). We also need to assume home imports and exports as isoelastic to home and foreign GDP, respectively. This means that they are exogenously given constant long-run elasticities, θ_X and θ_M (Fabiani et al. 2016; Amador and Silva 2019).

The robustness of our results is confirmed by a sensitivity analysis based on a wide range of elasticities from 1.0 to 2.0. This approach allows us to identify the potential discrepancies among research work that employed different import and export income elasticities. Finally, as trade elasticities differ over time (let alone among countries), our sensitivity analysis allows us to better assess the cyclical and non-cyclical adjustment of the Greek current account deficit.

For the current account components, the Bank of Greece Balance of Payments data for the period 2002-2019 were used. Greece's output gap, as estimated by the Bank of Greece, was employed in our analysis (Bank of Greece 2018b and 2019b), while trading partners' output gap is the trade-weighted output gap of the main trading partners, as provided by AMECO and the IMF's *World Economic Outlook*, and using the ECB's trade shares (see Appendix A).

4 ANALYSIS AND RESULTS

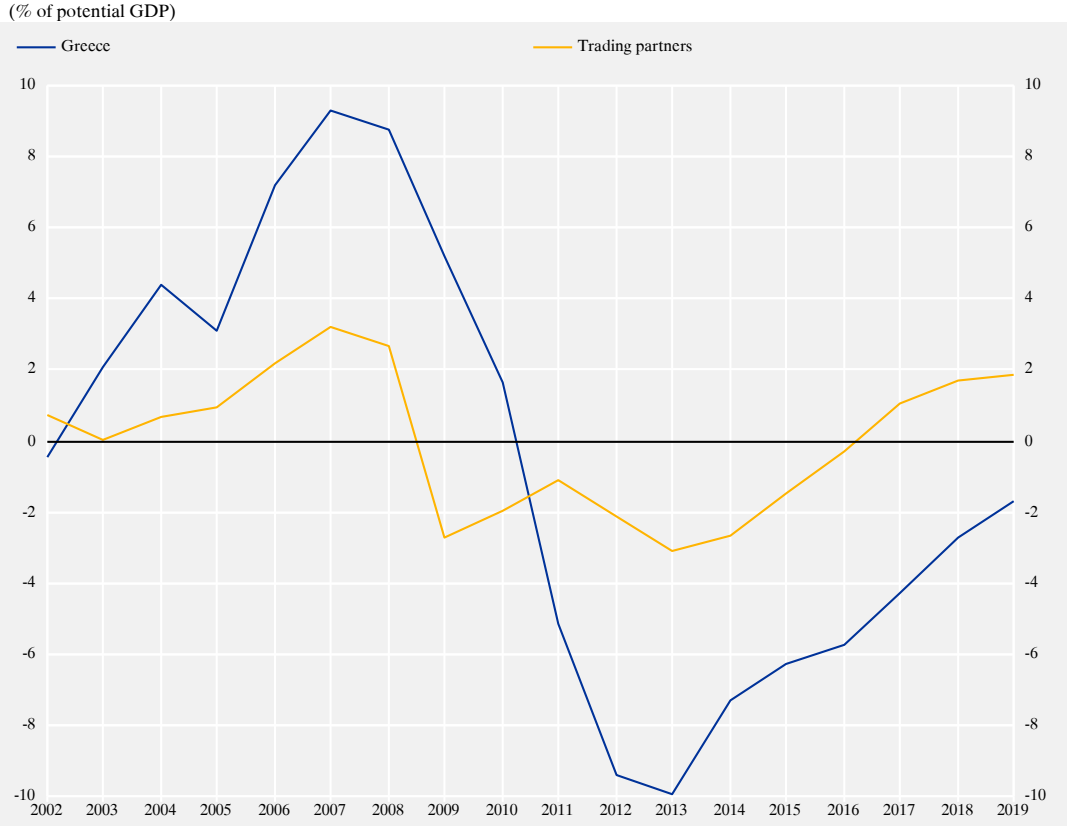
In the period 2003-2010, Greece had a positive output gap, which indicated that actual imports in that period were above the level that corresponds to potential output. Starting from 2011, Greece moved into a negative output gap —as a result of the Greek economic crisis— which peaked in 2013; thereafter, the output gap has been following a gradually narrowing trend (see Chart 2). Thus, imports have been below the level that corresponds to potential output.

Turning to Greece's main trading partners, the magnitude of their trade-weighted output gap is significantly smaller, compared with Greece. This reflects, on the one hand, the magnitude of the Greek recession and, on the other hand, the fact that trading partners' output gap is calculated as the weighted average of 32 countries that may stand at different points in their economic cycles. Overall, for the period 2009-2016, trading partners were —on average— faced by a mildly negative output gap, partly

13 After all, most of these categories include, on the one hand, receipts, in particular inflows from EU structural funds, and, on the other hand, outflows, primarily interest payments to the support mechanism for servicing public debt. Therefore, they are not linked with the economic cycle, as they are structural in nature.

Chart 2 Output gap: Greece and trading partners

(% of potential GDP)



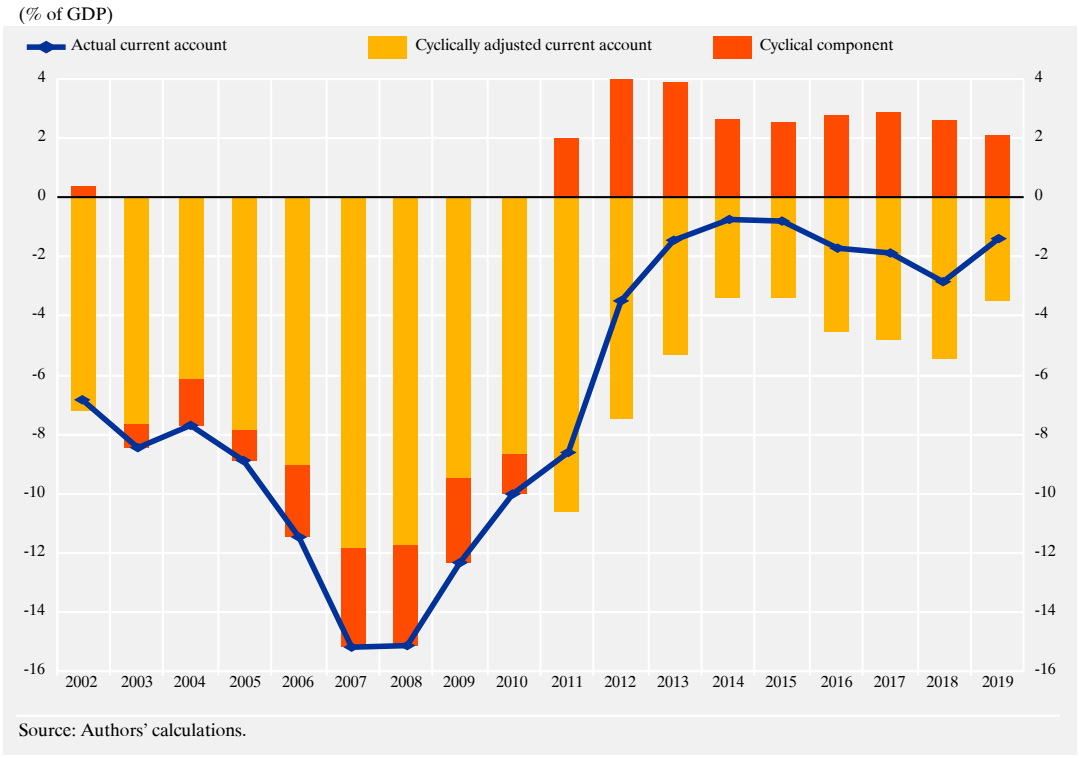
Sources: Greece: Bank of Greece; trading partners: authors' calculations based on ECB, AMECO and IMF WEO data.

reflecting the global financial crisis and the euro area sovereign crisis (see Chart 2). Therefore, Greek exports were below the level that is consistent with the potential output of trading partners in that period.

As discussed in Section 2, the actual current account deficit kept increasing from 2005 until 2008, as both the cyclical and the non-cyclical components of the trade balance were deteriorating; the former due to the positive output gaps in Greece and in its trading partners. Over the same period, the balance of primary and secondary income (bpi+bsi) was in deficit and widening, before stabilising at around -3.3% of GDP in 2007. From 2009 onwards, the current account deficit is on a downward trajectory and stabilised at around 2% of GDP —on average— in the 2016-2019 period. In the first years of the Greek economic crisis (2011-2012), the actual current account adjustment was mainly driven by the cyclical component (i.e. Greece's and its trading partners' output gaps) and secondarily by the balance of primary and secondary income. In the years that followed (2013-2015), the non-cyclical component of the trade balance came into play and supported a further adjustment in the actual current account. In the 2016-2019 period, the cyclically-adjusted trade balance hovered around -3.7% of GDP and the respective current account stood at -4.5% of GDP. The cyclical component gradually decreased and remained —on average— at 2.6% of GDP.

The highest current account deficit was recorded in 2008, amounting to EUR 36.6 billion, i.e. 15.1% of GDP (see Chart 1). The

Chart 3 Cyclically adjusted current account (2002-2019)



Source: Authors' calculations.

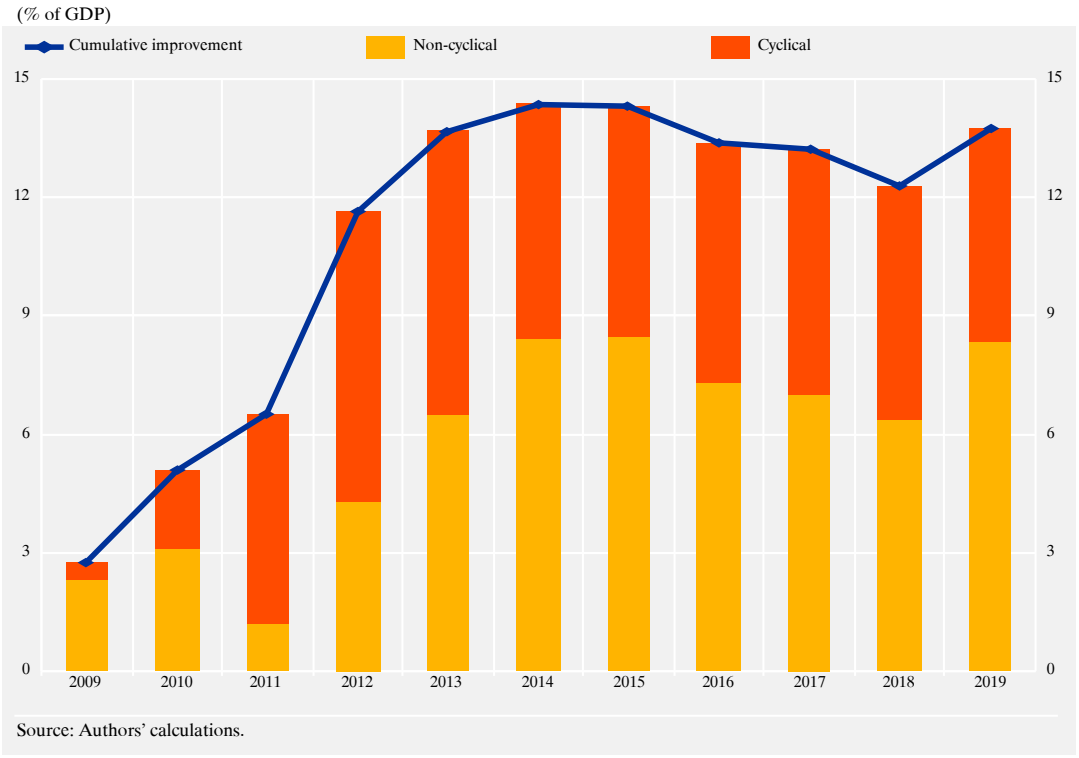
cyclical part of this deficit was 3.3% of GDP, with the consequent cyclically adjusted deficit of the current account reaching 11.8% of GDP (see Chart 3). In 2019, the current account deficit fell to 1.4% of GDP, recording an improvement of 13.7 pp of GDP since 2008. Of this improvement, 5.4 pp of GDP is attributed to cyclical factors and 8.3 pp to structural factors (see Chart 4). Therefore, 60% of the current account deficit correction can be attributed to structural factors, and the remaining 40% to cyclical factors (trading partners' and Greece's output gap). In greater detail, the improvement in the trade balance (goods and services) was 10.9 pp of GDP, almost equally distributed between the cyclical and the non-cyclical component. The improvement in the primary and secondary income balance, which by definition is structural, amounted to 2.8 pp of GDP.[14]

At this point, it would be useful to see how our results compare with the corresponding ones of previous studies. First, Tressel and Wang (2014) estimated the current account adjustment decomposition for the 2007-2012 period for a number of euro area countries. In the case of Greece, cyclical factors (including output gap, financial conditions and commodity terms of trade) were estimated to have contributed 50% of the actual current account reversal during the above mentioned period.

The ECB (2014) estimated that, in the case of Greece, more than 50% of the current account adjustment in the 2008-2012 period was explained by cyclical factors. This outcome was based on the estimated output gaps by the IMF, the European Commission (EC) and the OECD and followed the first stream methodology described briefly in Section 3. Without prejudice to data revision (both current account and output gap) since 2014, the ECB's

14 Even if the EU's AMECO database estimates for Greece's output gap are applied, the results are not significantly different (36% cyclical and 64% structural).

Chart 4 Cumulative correction of the current account since 2008



Source: Authors' calculations.

conclusion is in line with our analysis, which indicates that more than 60% of the cumulative adjustment could be attributed to cyclical factors in that period. The EC (2015) also supports that in the initial phase of the adjustment in the deficit countries, the current account deficit contraction was associated with reduced imports on the back of weakened domestic demand.

More recently, the IMF (2019) attempted to decompose the Greek current account adjustment into cyclical and structural factors by using the first stream methodology and utilising —to some extent— the IMF's EBA methodology. They considered as cyclical the output gap, the commodity terms of trade, the credit-to-GDP gaps and volatility (proxied by the VIX index), while structural factors included variables such as the cyclically adjusted fiscal balance, real unit labour cost (ULC), measures of the institutional and political environment, etc. They concluded that the largest part of the deterioration in the current account between 2004 and 2008 was structural. For the 2008-2018 period, about 75% of Greece's current account correction was attributed to cyclical factors and the remaining 25% to structural factors and policies.

Our analysis, though, indicates that more than 50% of the cumulative adjustment for the 2008-2018 period can be attributed to non-cyclical factors. This discrepancy, apart from methodological differences, may partly reflect data revisions, both of current account data and of output gaps. It should also be noted that in Cubeddu et al. (2019) regarding the EBA 2018 update, the credit gap (i.e. the credit-to-GDP gap) is considered a policy variable rather than a cyclical factor as in the abovementioned research. Had the credit-to-GDP gap been included in the structural factors, the breakdown would have been different and definitely in favour of the structural adjustment.

Sensitvity analysis with respect to income elasticity of exports and imports

(cumulative share of cyclical and non-cyclical adjustment in the current account deficit, 2008-2019)

Income elasticity of imports (θ_M)	Income elasticity of exports (θ_X)					
	1.0		1.5		2.0	
	cyclical	non-cyclical	cyclical	non-cyclical	cyclical	non-cyclical
1.0	26	74	27	73	27	73
1.5	39	61	**40**	**60**	40	60
2.0	52	48	52	48	53	47

Source: Authors' calculations.

5 SENSITIVITY ANALYSIS

In order to investigate the sensitivity of the results to the income elasticities of imports and exports, the current account balance adjustment was calculated for a range of elasticities (1.0-2.0) around the central value (1.5). The values of the elasticities are in line with a number of previous research endeavours (see Appendix B). The effect of the income elasticity of imports is greater than that of exports. Structural factors may account for 47%-74% of the current account deficit correction, depending on the elasticities used (see the table above).

Overall, as regards the trade balance, much of the improvement came from the significant recovery in exports, particularly after 2012, which, coupled with the almost zero output gap of trading partners' economies after 2016, was purely structural in nature.[15] On the other hand, the decline in imports was primarily cyclical, as a result of the decline in domestic demand and the emergence of a large negative output gap. However, to the extent that the prolonged recession also contributed to a decline in potential output, it helped reduce the cyclical portion of the overall adjustment. Finally, given the high import content of exports, the increase in exports also contributed to a rise in the structural share of imports.[16] More generally, the structural changes that took place in recent years in the Greek economy and the consequent shift, albeit gradual, towards a more extroverted growth model appear to be reflected in the significant structural adjustment of the current account balance.[17]

6 CONCLUSIONS

Greece's external imbalances widened persistently in the lead-up to the 2008 financial crisis and have narrowed considerably afterwards, as the economy went through a major recession. The assessment of the relative importance of structural and cyclical factors in explaining the correction of current account balances is key in evaluating the future development of the external sector. In this paper we assessed the relative significance of structural and cyclical factors behind the considerable reduction of the Greek current account deficit and the analysis relied primarily on the methodology used by Haltmaier (2014). In particular, the cyclical part of the adjustment was estimated using alternative income elasticities of both imports and exports in line with the literature, while the structural part was calculated indirectly as the difference between the overall actual balance and the cyclical part.

Our analysis shows that the current account adjustment has in a considerable part been

15 See for instance Bardaka and Papazoglou (2019) and Backinezos et al. (2019).
16 For the participation of Greece in global value chains, see for instance Gibson et al. (2019).
17 According to Bank of Greece estimates, over the 2010-2017 period (data availability), the volume of tradable goods and services recorded a cumulative increase of 14%, compared with non-tradables.

driven by structural factors, which account for 60% of the overall adjustment according to our baseline scenario. Therefore, most of the correction is of a permanent nature, which means that the relatively high deficits of the pre-crisis period are not expected to re-emerge any time soon. Our results are robust as they largely hold under alternative hypotheses regarding the income elasticities of exports and imports. That is, even though the deep recession that the country experienced has indeed contributed to the correction of the external imbalance, most of the adjustment was structural, reflecting a gradual shift in Greece' s growth model. This has manifested itself to a significant extent in the fact that the country is turning into a more open economy as a result of its enhanced export performance.

However, given the fact that a significant part of the adjustment came from cyclical factors and the high negative size of net international investment position, the above conclusions should not lead to complacency. On the contrary, persistent structural reforms aimed at enhancing the overall competitiveness of the Greek economy and shifting production towards tradable goods and services should remain among the main economic policy priorities. That is, targeted policy initiatives must be at the centre of the reform effort, as they are essential in sustaining the reduction of external imbalances over the medium term.

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APPENDIX A
CONSTRUCTION OF TRADE-WEIGHTED TRADING PARTNERS' GDP AND POTENTIAL GDP

Trading partners' GDP (potential GDP) was constructed as their trade-weighted GDP (potential GDP). We have used the export trade weights of Greece's main trading partners in manufactured goods, as defined in Sections 5 to 8 of the Standard International Trade Classification (SITC 5-8), i.e. excluding trade in services, agricultural products, raw materials and energy products. As data were available up until 2015, for the 2016-2019 period the trade weights refer to the last available observation (i.e. 2013-2015 period level). The trade weights, as calculated by the ECB, are based on bilateral data on trade in manufactured goods for the periods 1995-97, 1998-2000, 2001-03, 2004-06, 2007-09, 2010-12 and 2013-15, the last update having been made in 2017. The export trade weights were retrieved from the ECB Statistical Data Warehouse (key: WTS.A.GR.xx.Z0Z.X0.X.MAN.F). The aggregated trade share of the 32 countries used amounts to approximately 70% of Greek exports of manufactured goods (see Table A1). The selection of these countries was also driven by the availability of potential output data in AMECO or the IMF's WEO. The methodology for the construction of the geometric weighted average of trading partners' GDP and potential GDP is similar to the one of the export demand index in Hubrich and Karlsson (2010).

GDP data were retrieved from the Eurostat website. AMECO potential GDP data (updated on 6 May 2020) were used, except for Australia, Canada, Japan and Norway. For these four countries, the IMF's October 2019 World Economic Outlook database was used, as the respective data were not available in AMECO. It should be noted that the April 2020 WEO database does not include potential output data, due to the high level of uncertainty in current global economic conditions.

Finally, trading partners' GDP and potential GDP, reflecting foreign demand and potential foreign demand, respectively, were chain-linked so as to avoid any changes stemming from the variation of the trade weights across periods (i.e. 1995-97, 1998-2000, 2001-03, 2004-06, 2007-09, 2010-12 and 2013-15).

Table A1 Trading partners

Euro area	EU – non-euro area	Non-EU
Austria	Bulgaria	Australia
Belgium	Croatia	Canada
Cyprus	Czechia	Japan
Estonia	Denmark	Norway
Finland	Hungary	United Kingdom
France	Poland	United States
Germany	Romania	
Ireland	Sweden	
Italy		
Latvia		
Lithuania		
Luxembourg		
Malta		
Netherlands		
Portugal		
Slovakia		
Slovenia		
Spain		

APPENDIX B
LONG-RUN ESTIMATIONS FOR INCOME ELASTICITIES OF EXPORTS AND IMPORTS

Table B1 Exports

Researcher	Foreign income elasticity	Estimation period	Dependent variable	Foreign income
Senhadji and Montenegro (1999)	2.81 (OLS and Phillips-Hansen's Fully Modified)	1960-1993	Real exports of goods and non-factor services	Weighted average of trading partners' GDP minus exports
Caporale and Chui (1999)	2.38 (DOLS); 2.10 (ARDL)	1960-1992 (annual data)	Export volumes of goods and services	Export shares-weighted GDP
Pain et al. (2005)	A unit income elasticity imposed	1982-2002 (quarterly data)	Export volumes of goods and services	Export market share (market share-weighted sum of partner countries' imports)
Sideris and Zonzilos (2005)	1.00 (supported by data)	1980:q1-2000:q4 (quarterly data)	Export volumes of goods and services	Weighted average of import volumes of main trading partners
Algieri (2014)	1.81 (range: 1.41-2.46)[1] (VECM)	1980:q1-2012:q3 (quarterly data)	Real exports of goods and services	– Corrected world GDP: real world GDP in USD adjusted for PPP – Foreign demand: weighted average of import volumes of main trading partners
Morin and Schwellnus (2014)	1.00 (imposed, but supported by data)	1992:q2-2012:q2 (quarterly data)	Export volumes of goods and services	Export market share (market share-weighted sum of partner countries' imports)
Christodoulopoulou and Tkačevs (2016)	0.91 (range: 0.43-1.45)[2] 0.93 (range: 0.87-0.98)[2]	2000:q1-2013:q1 (quarterly data)	Export volumes of goods Export volumes of services	Geometric weighted average of trading partners' imports
Bragoudakis et al. (2016)	0.83 (Engle-Granger cointegration)	1980-2015 (annual data)	Export volumes of goods and services	Weighted average of import volumes of main trading partners
Bardaka (2017)	1.60 (Johansen cointegration)	2002-2017 (quarterly data)	Export volumes of goods and services	Trade share-weighted partner countries' GDP

1 The figure refers to the average estimated long-run elasticity of three alternative models. The foreign income elasticity was estimated at 2.46 when corrected world GDP was used and at 1.56 and 1.41 when foreign demand was used.
2 The figure refers to the average estimated long-run elasticities of a model with different Harmonised Competitiveness Indicators (HCI) based on CPI, CPI for Services, PPI, ULCM, ULCT and GDP deflators. Significant at the 1% and 5% level.

Table B2 Imports

Researcher	Domestic income elasticity	Estimation period	Dependent variable	Domestic income
Caporale and Chui (1999)	1.32 (DOLS); 1.58 (ARDL)	1960-1992 (annual data)	Import volumes of goods and services	Real GDP
Pain et al. (2005)	A unit income elasticity imposed	1982-2002 (quarterly data)	Import volumes of goods and services	Components of domestic demand
Sideris and Zonzilos (2005)	1.00 (imposed)	1980:q1-2000:q4 (quarterly data)	Import volumes of goods and services	Weighted sum of the import content of the domestic demand components
Morin and Schwellnus (2014)	1.62[1]	1992:q2-2012:q2 (quarterly data)	Import volumes of goods and services	Components of domestic demand
Christodoulopoulou and Tkačevs (2016)	1.56 (range: 1.47-1.68)[2] 0.22 (range: -0.07-0.57)[3]	2000:q-2013:q1 (quarterly data)	Import volumes of goods Import volumes of services	Private consumption + gross capital formation + government consumption
Bragoudakis et al. (2016)	1.0 (restricted); 1.23 (unrestricted) (Engle-Granger cointegration)	1980-2015 (annual data)	Import volumes of goods and services	Weighted sum of the import content of the domestic demand components
Bardaka (2017)	1.41 (Johansen cointegration)	2002-2017 (quarterly data)	Import volumes of goods and services	Real GDP

1 Based on the estimated impulse response for import volume generated by a 1% increase in total expenditure after 70 quarters (see Table A.7 therein).
2 The figure refers to the average estimated long-run elasticity of a model with different Harmonised Competitiveness Indicators (HCI) based on CPI, CPI for Services, PPI, ULCM, ULCT and GDP deflators. Significant at the 1% level.
3 The figure refers to the average estimated long-run elasticity of a model with different Harmonised Competitiveness Indicators (HCI) based on CPI, CPI for Services, ULCT and GDP deflators. Not significant at the 10% level.

D-EURO: ISSUING THE DIGITAL TRUST

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ABSTRACT

Since 2008 new schemes such as digital currencies have emerged in limited forms. Currently, digital technologies enjoy a widespread use in the area of payments and, as a result, central banks have started contemplating the costs and benefits of issuing a digital currency for broad use in payments and settlements. This paper defines Central Bank Digital Currency (CBDC) and classifies it alongside existing forms of money. Further, it highlights the properties that such a currency should have, and analyses the main motivations behind the potential issuance of an account-based retail CBDC (called here the "d-euro"). We argue that the latter should involve a public-private partnership whose effectiveness will be enhanced by the establishment of separate and distinct roles. This paper briefly discusses legal considerations, monetary policy implications and financial stability issues arising from d-euro. In doing so, it further analyses d-euro's underlying principles, which would at the same time constitute its key benefits. We provide a general framework and propose the technical design of our so called "two-dot model". Issues concerning parity, supply limits and anonymity are dealt with. The proposed technical design seems an effective and workable solution that boosts the autonomy and resilience of the European payment systems. Finally, we argue that the initial introduction of d-euro as a retail payment medium may establish it as the new cash of a digitalised ecosystem, reflecting a new digital trust issued by central banks.

Keywords: CBDC; d-euro; money; Dedicated Digital Account; TIPS

JEL classification: E58; G21; O33

D-EURO: ΕΚΔΙΔΟΝΤΑΣ ΤΗΝ ΨΗΦΙΑΚΗ ΠΙΣΤΗ

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ΠΕΡΙΛΗΨΗ

Από το 2008 περίπου τα ψηφιακά νομίσματα έχουν εμφανιστεί με διάφορες μορφές. Σήμερα, καθώς οι ψηφιακές τεχνολογίες χρησιμοποιούνται ευρέως στο χώρο των πληρωμών, οι κεντρικές τράπεζες έχουν αρχίσει να μελετούν τα κόστη και τα οφέλη της έκδοσης ενός ψηφιακού νομίσματος με ευρεία χρήση στις πληρωμές και το διακανονισμό. Το παρόν άρθρο δίνει τον ορισμό ενός τέτοιου ψηφιακού νομίσματος κεντρικής τράπεζας (CBDC) και το ταξινομεί σε σχέση με τις υπάρχουσες μορφές χρήματος. Στη συνέχεια, διευκρινίζει τις ιδιότητες που πρέπει να διαθέτει και εξηγεί τα κύρια αίτια για τη δυνητική έκδοση ενός CBDC το οποίο προτείνεται να βασίζεται σε τραπεζικό λογαριασμό (και θα ονομάζεται d-euro). Η προσπάθεια αυτή απαιτεί τη σύμπραξη δημόσιου και ιδιωτικού τομέα, η αποτελεσματικότητα της οποίας θα ενισχυθεί από τον καθορισμό διακριτών ρόλων για τον κάθε τομέα. Το άρθρο παρουσιάζει συνοπτικά τους σχετικούς νομικούς προβληματισμούς, καθώς και τις δυνητικές επιπτώσεις μιας ενδεχόμενης έκδοσης του d-euro σε θέματα χρηματοπιστωτικής σταθερότητας και νομισματικής πολιτικής. Επίσης, αναλύονται οι βασικές αρχές του νομίσματος, οι οποίες συγχρόνως θα αποτελούν τα βασικά του πλεονεκτήματα. Προτάσσεται ένα γενικό πλαίσιο λειτουργίας που συνοδεύεται από το τεχνικό σχέδιο του αποκαλούμενου "μοντέλου δύο σημείων". Στη συνέχεια, επεξηγούνται θέματα σχετικά με την ισοτιμία, την προσφορά χρήματος και την ανωνυμία. Ο προτεινόμενος τεχνικός σχεδιασμός κρίνεται ως μια κατάλληλη και εφαρμόσιμη λύση, ικανή να ενισχύσει την αυτονομία και την ανθεκτικότητα των ευρωπαϊκών συστημάτων πληρωμών. Τέλος, υποστηρίζεται ότι μια ενδεχόμενη αρχική υιοθέτηση του d-euro ως μέσου πληρωμών λιανικής θα μπορούσε να οδηγήσει στην καθιέρωσή του ως της νέας μορφής μετρητών ενός ψηφιακού οικοσυστήματος, αντανακλώντας μια νέα ψηφιακή πίστη προερχόμενη από τις κεντρικές τράπεζες.

D-EURO: ISSUING THE DIGITAL TRUST

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1 INTRODUCTION

A few years ago one frequently heard that the use of physical cash would eventually decline (Cœuré 2018). A decade ago one read lines suggesting that "we have proposed a system for electronic transactions without relying on trust" (Nakamoto 2008, p. 8). Nowadays, it is common to see someone pay at a supermarket by swiping a card or by waving their mobile phone, irrespective of the currency or the amount to be paid. In the near future, one may decide to pay for a pizza by using stablecoins, i.e. cryptoassets[1] with value stabilising characteristics. Such assets, mainly used through widespread social messaging apps, could make payments cheaper and faster. However, they have to overcome regulatory and supervisory challenges at the international policy level, especially regarding risks to financial stability and monetary sovereignty, data protection and compliance with anti-money laundering and counter-terrorism financing rules (G7 Working Group on Stablecoins 2019; European Central Bank 2019c; FATF 2020).

This paper does not intend to rake over the coals of the stablecoins issue once more. It simply uses this new type of cryptocurrency, which applies stabilisation mechanisms in order to minimise price volatility, as an introductory point of my discourse about digital currencies (see for example Bullmann et al. 2019). It is a starting point for central banks in their efforts to use new technologies in order to enhance the efficiency and resilience of the payments landscape by issuing to the public an instant, safe, cheap, and potentially semi-anonymous digital currency, i.e. a retail Central Bank Digital Currency (CBDC)[2].

We start by mentioning a set of truisms. Digital currencies have existed for a number of decades. David Chaum (1983), who is widely recognised as the inventor of digital cash, introduced the cryptographic primitive of a blind signature that could prevent double spending. In 2008, Bitcoin was the first cryptocurrency that used permissioned blockchain protocols, relying heavily on cryptography, thus accomplishing nearly anonymous transactions through decentralised means. The key innovation in this regard is the introduction of a "distributed ledger", which allows a digital currency to be used in a decentralised payment system (Böhme et al. 2015; Narayanan et al. 2017). A common feature of developed economies has been the wide variety of ways in which payments are made as well as the many forms of money used. There is also a wide range of economic agents whose liabilities can function as money. The most prominent issuers of money are central banks, which provide central bank money in the form of both banknotes and liquidity through the financial system, and commercial banks, which generally issue private money (commercial bank money) in the form of deposits (Bank for International Settlements 2003; Kokkola 2010). Contrary to the various decentralised forms of assets, central banks also offer a form of digital currency to certain institutions, the so-called reserve balances, i.e. deposits held with the central bank (Friedman 2000; Agarwal and Kimball 2019). On the other side, commercial banks offer to the public deposits that can be converted to cash (legal tender) through withdrawal (Middleton and Sinha 2019).

In this context, the European Central Bank (ECB) does recognise that, in today's continuously changing payments ecosystem, great attention should be given to the front-end of European retail payments systems, and in par-

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1 See Chimienti et al. 2019 and European Central Bank 2019a.

2 CBDC or d-euro are here used interchangeably.

ticular to the point-of-sale and online payment solutions (Cœuré 2019c). The necessity for a retail payments strategy has been the result of three main reasons. The first relates to the strategic autonomy and resilience of the European payments system, both of which underpin the euro's international role (Cœuré 2019c). The second is the rapid technological transformation that has occurred in peoples' lives. The third focuses on the public criticism to the role of central banks due to their handling of the recent financial crisis (Cœuré 2019b). This comes in contrast to the fact that they stand as a pillar of stability of the financial system and ensure the smooth and secure functioning of the European payments markets. Thus, by weighing the costs and benefits, central banks have to reassess and redefine their role in the payments ecosystem (Habermeier et al. 2018; Cœuré 2019b).

These issues are explored in more detail in the rest of the paper, which examines the prospects of a retail account-based CBDC and is divided into four sections. Section 2 investigates the taxonomy of money, the digital currency ecosystem and the main properties that a retail account-based CBDC has to fulfil. Section 3 describes the main motivations for issuing an account-based CBDC as well as the existing central bank policies, and focuses on the possible implications of such policies. In the light of this analysis, Section 4 simulates the issuance of an account-based CBDC in the current Eurosystem's payments environment. Finally, Section 5 provides some concluding remarks.

2 CBDC AND THE TAXONOMY OF MONEY

What will the money of the future look like? Today, one pays for a croissant at the corner bakery by using either physical cash (banknotes and/or coins) or an electronic means of payment at the point of interaction (POI). Regardless of the price of the good or the currency used to pay for it, an electronic payment is usually performed by initiating a credit transfer or a card payment. In the former case, one initiates the transaction by giving an order to irrevocably debit one's payment account whereas, in the latter, one uses a payment card with a debit, credit or delayed debit function at the POI. However, one could pay for the good just by waving a mobile phone or a wearable to the terminal using near-field communication (NFC) or augmented reality (AR) technology, scanning a quick response (QR) code or receiving a request to pay (RtP) and accepting the payment. What ten years ago was considered science fiction is today's reality. The digitalisation of payments has coincided with the dematerialisation of financial assets. Nowadays, the digital penetration in the retail payments arena is such that, for example, payments are regularly initiated through mobile apps.

Indeed, digitalisation in the payments ecosystem has been widespread and profound. In the front-end retail sector, numerous and fancy solutions are available to the customer who wishes to initiate a payment. At the back-end, Distributed Ledger Technologies (DLTs), the best known of which is blockchain, promise greater resilience, immutability, transaction privacy, as well as higher speed and scalability (Gandal and Halaburda 2014; Robleh et al. 2014; Middleton and Sinha 2019; Fleuret and Lyons 2020). Nevertheless, DLT, although highly promising, is not mature enough to replace the traditional account-based Real Time Gross Settlement System (RTGS)[3] (Kahn and Roberds 2009), which forms the central bank's basic tool in order to implement monetary policy and ensure financial stability (Kokkola 2010). In addition, DLT, although resilient to malicious incidents and able to confront single point of failure issues, is currently using consensus protocols[4]. Consequently, it

3 In Europe TARGET2, the RTGS owned and operated by the Eurosystem, is the system that settles payments related to the Eurosystem's transactions, as well as to bank-to-bank and commercial transactions.

4 The author's proposal, presented at the 1st EUROchain Hackathon, for issuing retail account-based CBDC by using permissioned DLT, uses central bank blind signature to verify the transactions in order to prevent double spending.

does not fully comply with the legal and regulatory notion of ultimate finality, as required in the payment chain of a credit transfer, and also suffers from interoperability and accountability issues among the different DLT networks[5] (Tobias and Mancini-Griffoli 2019; Middleton and Sinha 2019; Ward and Rochemont 2019). Irrespective of this argumentation and regardless of the technology used at the back-end of a payment system, the question remains: What will the money of the future be like?

A number of fiat, digital currencies and payment solutions, including EUR, USD, JPY, Bitcoin, Libra, Alipay, and Apple Pay, compete to dominate our physical or digital wallet[6] (Tobias and Mancini-Griffoli 2019). Normally, questions are raised about the autonomy, trust, and habits of our everyday payment transactions. However, surprising as it may sound, what is money? Money is fundamental to the operation of a modern economy and, strictly speaking, must serve three basic and not mutually exclusive functions as: a unit of account, a medium of exchange, and a store of value (Quinn and Roberds 2014; McLeay et al. 2014; Bjerg et al. 2018). A unit of account refers to a standard numerical monetary unit of measurement of price or cost of goods and services, for example EUR 100 to buy and EUR 10 to rent a bicycle, respectively. In order to successfully fulfil the aforementioned attributes, money must exhibit a stable price[7]. The Eurosystem, by targeting inflation, enhances trust between the various economic agents and helps them take rational economic decisions. As a medium of exchange, money is universally accepted as payment for goods and services. As a successor of the barter system, it provides the most efficient, secure and universally available means of exchange. Finally, as a store of value, money has to be able to be securely stored and, when subsequently retrieved, to retain a stable level of purchasing power. Moreover, apart from the codification of money, some simple financial concepts should be presented prior to the analysis of the retail account-based CBDC. The reason is that "sound conclusions are sometimes supported by erroneous arguments, and the error is compounded when a sound conclusion is declared to be mistaken on the ground that the argument for it is mistaken" (Nagel 1963, p. 211).

Currency[8] is in fact money in circulation denominated in an existing unit of account, i.e. euro banknotes and coins, which serves as a medium of exchange (Kiyotaki and Wright 1989; Yang 2007; Brunnermeier and James 2019; Engert and Fung 2020). Thus, currency does fulfil the three basic functions of money. A further examination distinguishes between two main types of money according to who the issuer is, i.e. central banks (monetary base) or commercial banks (bank deposits). Cash is issued by central banks and remains the most widespread means of retail payment (Cruijsen van der et al. 2015; Bech et al. 2018) in the euro area[9] (Esselink and Hernández 2017). The main reason for holding and using cash in our everyday transactions is trust. People trust the central bank's promise that a banknote retains its face value, i.e. that it would be accepted by others at its face value[10], for example that a EUR 5 banknote buys EUR 5 worth of goods (Allen and Dent 2010). A second reason for using cash as a means of payment is because it constitutes fiat money by having legal tender status[11]. Fiat money has the unique property of being issued and accepted by a higher authority (the government) as a means of payment for salaries and taxes.[12]

5 DLT is currently falling short in scalability, energy efficiency, and payment finality (He et al. 2017).
6 For narrow finance solutions, see Pennacchi (2012) and Mancini-Griffoli et al. (2018).
7 Price stability is actually the primary objective of the ECB, which is clearly established in the Treaty on the Functioning of the European Union (2012, Article 2).
8 Deriving from the Latin word "currens" meaning: "in circulation".
9 Esselink and Hernández (2017, p. 19) argue that across the euro area in 2016, on average, 78.8% of all POI transactions were carried out using cash.
10 Greek drachmas bore the inscription "ΠΛΗΡΩΤΕΕΣ ΜΕ ΤΗΝ ΕΜΦΑΝΙΣΗ" meaning: "to be paid on demand".
11 On 1 January 2002, the euro became the sole legal tender throughout the euro area, as the then President of the ECB, Dr. Willem F. Duisenberg, declared.
12 Usually, people erroneously believe that paying by cash at a shop, the merchant is obliged to accept it because it is legal tender. This is not true. Only central banks do accept cash. Legal tender means that if we pay a debt with euro banknotes, then the creditor cannot sue us for failing to repay.

What does actually make cash such a popular means of payment in everyday transactions? In any case, taxonomy and terminology are unrelated to habits and daily economic behaviour. Cash is the most popular instrument for retail payments because it offers a real attractive advantage to users (Klee 2008; Arango et al. 2015; Wakamori and Welte 2017). A cash transaction offers full anonymity which, combined with convenience, is indeed a crucial benefit when using cash. Furthermore, cash has a number of additional benefits. It offers the capability to transact in real time, 24/7/365, irrespective of payment systems, intermediaries and infrastructures. In addition, it provides immediate and final settlement, with no single point of failure, and no settlement and cyber risk as both transacting parties are physically present (Weber 2015; Grym et al. 2017; Masciandaro 2018; Middleton and Lund 2018; Middleton and Sinha 2019; Tobias and Mancini-Griffoli 2019). Finally, it is possible for a person to negotiate a lower price when paying for goods and services in cash, also avoiding possible extra credit card surcharges (Rogoff 2014; Wakamori and Welte 2017).

However, cash can be used mainly for proximity payments, resulting in additional costs when a person wishes e.g. to send money to relatives and friends who live far away. Moreover, its use is limited to low value transactions (Wakamori and Welte 2017), it is expensive to store and handle, as well as heavy and bulky in large amounts, and costly to count and process. Additionally, it is vulnerable to theft and susceptible to counterfeit (Middleton and Sinha 2019). In financial terms, cash holders do not enjoy interest or dividend returns, as stored cash cannot be used for investment purposes. Regarding some current trends, cash is facing decreasing acceptance, mainly in Scandinavian countries, as well as restrictions on the maximum value of cash transactions set by many governments.[13] Finally, cash has a reputational cost, as it is widely used in the shadow economy and remains a facilitating medium of criminal activities such as money laundering, terrorist financing and the financing of the proliferation of weapons of mass destruction (Rogoff 2014; Wright et al. 2017).

It is important to understand that cash is a physical means of payment that does not require the existence of payment accounts to initiate a payment. Additionally, banknotes in circulation are part of central banks' balance sheet liabilities. Thus, if one wants to pay in central bank money, one has to pay by using cash. In other words, including central bank trust in payments means using cash stored in wallets or withdrawn from an ATM (thus reducing a commercial bank's account balance). In any case, the majority of money in the economy appears on the liability side of commercial banks' balance sheets, since it is kept in commercial banks' deposits which potentially can be converted into legal tender and hence central bank liability (Kokkola 2010). However, commercial banks do settle interbank, customer, and securities[14] related payments, as well as monetary policy operations in central bank money, i.e. money in an account held with a central bank[15].

Currently, commercial banks' deposits form the majority of monetary circulation in developed economies and can be safely kept in accounts, converted into legal tender, or used in various transactions (Bossone 2001; Kokkola 2010). The latter include credit transfers, instant credit transfers, card payments, and direct debits, i.e. the main instruments used in the euro area to initiate electronic payments (e-payments) from payment accounts. Irrespective of the user penetration and growth of said instruments, at the local or the European level[16], it should be noted that an e-payment transaction is not

13 In Greece the maximum amount of using cash in payment transactions is restricted to EUR 500. Usually, such restrictions are placed as measures against tax fraud and AML since the feature of anonymity encourages persons to conduct transactions in cash.

14 In Europe, securities transactions are conducted in central bank money. TARGET2-Securities (T2S) settles the transaction on a delivery-versus-payment (DvP) basis, i.e. money and securities change hands simultaneously.

15 The reserves are actually sight deposits held with the national central banks (NCBs) by credit institutions in order to settle payments, and meet the minimum reserve requirements and the deposit facility. Regarding allocating reserves to the general public, see Brunnermeier and Niepelt (2019) and Niepelt (2019).

16 Payment cards have overtaken credit transfers as the most widely used cashless payment instrument in the euro area.

anonymous but traceable. However, the crucial benefit of an e-payment, besides the obvious user convenience it offers, consists in its scalability since it is used both for retail and larger value payments. An e-payment serves not only proximity payments at the POI, like cash, but also e-commerce transactions. Additionally, an e-payment also offers 24/7/365 transacting capability and, in the case of the instant credit transfer, real time availability of funds to the payee[17] (Mancini-Griffoli et al. 2018).

One may argue that the initiation of an e-payment simultaneously creates the need for a backing payment system able to manage all forms of "settlement risk", i.e. systemic, credit, liquidity, operational and/or legal risk (Kokkola 2010). It is common knowledge that e-payments are vulnerable to fraud, operational failure, and cyberattacks. Yet it is important to insist that security, resilience and settlement in central bank money are of paramount importance when initiating an e-payment in the euro area (Cœuré 2019c; Bank of England 2020). In this context, it is important to stress that in Europe there is a single system of banking supervision, ensuring the safety and soundness of the European commercial banking sector, a single framework for resolving failing commercial banks, with minimal costs for taxpayers and the real economy, and a single resolution fund financed by the commercial banking sector[18] (Cœuré 2019c).

E-money[19] payments are currently of marginal importance and magnitude in the euro area (Tobias 2019). The ECB defines e-money as "an electronic store of monetary value on a technical device that may be widely used for making payments to entities other than the e-money issuer" (European Central Bank 2020a). Consequently, e-money transactions do not necessarily involve commercial bank accounts. Instead, they involve prepaid instruments mostly used to execute small value retail transactions (Chiu and Wong 2014, 2015). The user initiates an e-money payment from a digital wallet which stores: (i) secure information necessary for authenticating the user; and (ii) payment data necessary for initiating a payment transaction usually through a mobile-based application. The e-money directive (EMD) regulates the storage and use of e-money in retail payments. The result is a payment experience very similar to the use of a traditional commercial bank account. The key difference relates to the nature of the transaction, as e-money is neither a unit of account nor a widespread store of value, and by definition nor legal tender. Usually, full backing in local fiat currency, through deposits held with a supervised commercial bank, enables e-money institutions to retain one-to-one parity with said currency, i.e. the euro in the case of the euro area.

A cryptocurrency[20], such as Bitcoin, Ethereum or Ripple, has its own denomination, is created/mined by non-trusted intermediaries and is issued on a blockchain[21] (Milne 2018; Pichler and Summer 2018; Fatás 2019). In this respect, it is important to note that cryptocurrencies (unlike commercial bank deposits) are not easily converted into fiat currency and most importantly they are nobody's liability. In fact, even when they perform some of the functions of money, they remain speculative assets with unstable value that suffer from excessive volatility[22] (Yermack 2013).

17 Visa by launching a new service, Visa Direct, intends to offer a card payment solution very similar to an instant payment.
18 Single Supervisory Mechanism (SSM – Regulation (EU) No 468/2014), Single Resolution Mechanism (SRM – Regulation (EU) No 806/2014).
19 The e-money directive (EMD) sets out the rules for the business practices and supervision of e-money institutions.
20 As mentioned above, we rather consider cryptocurrencies as cryptoassets since they do not satisfy the three basic functions of money.
21 Blockchain refers to all types of distributed ledger technologies (DLT) including the protocol, network, and application layers. DLT refers to a combination of technologies that together create a digital, shared and automatically updated ledger of verified transactions or information among parties in a network. DLTs are designed to operate with varying degrees of control, ranging from centralised models through to instances where there is no control by a central authority(ies).
22 Currently some cryptoassets have been classified as "stablecoins". For example, Facebook, driven by strong network effects, seeks to stabilise Libra's price by linking its value to a basket of stable currencies. As noted in the Introduction, a detailed analysis of stablecoins is beyond the scope of this paper. However, the author does agree with the outcome of the G7 Working Group on stablecoins that "their adoption is, as yet, uncertain as they face significant legal, regulatory, supervisory and operational challenges. Stablecoins, regardless of size, pose challenges and risks to AML/CFT efforts across jurisdictions, as well as operational resilience (including for cyber security), consumer/investor and data protection, and tax compliance" (BIS 2019, p. 20).

Nevertheless, the main attractive feature of cryptocurrencies is their ability to offer anonymity of transactions to their users (Ali et al. 2014a, 2014b; Auer 2019). However, they are not used in large value transactions and are accepted only by a limited number of retailers (Biais et al. 2019). In addition, they do not fully satisfy the function of a medium of exchange since limited acceptance prevents them from being a universally accepted means of payment (Mancini-Griffoli et al. 2018). Finally, anonymity of transactions often facilitates money laundering and financing of terrorism and hence poses a direct threat to economic stability (Fung and Halaburda 2014; Bank for International Settlements 2015; European Central Bank 2015).

CBDC is defined as the digital cash which can be issued by central banks for payments and settlements (Bjerg 2017; Adrian and Mancini-Griffoli 2019). Thus, if one wanted to use cash in digital form, then one would have to use CBDC (called here d-euro (DEUR) in the case of the Eurosystem). The relevant literature (Bech and Garratt 2017; Mancini-Griffoli et al. 2018; Barontini and Holden 2019; Carstens 2019; Kahn et al. 2019) divides CBDC into two main categories, according to the accessibility criterion, i.e. retail and wholesale CBDC. Retail CBDC would offer public access to central bank liabilities and can additionally be divided into two sub-categories based on the verification of the transaction. The retail token-based CBDC is the case of central banks providing the general public with direct access to CBDC[23] (World Economic Forum 2020). In this direct tokenised form, CBDC can be stored either on a mobile phone or on a prepaid card. Retail account-based CBDC[24] is created when commercial banks provide the public with indirect access to CBDC through a specific type of commercial bank accounts[25] (Fung and Halaburda 2016; Bjerg 2017). In this indirect access form, central banks would create, maintain, hold, regulate and operate the CBDC accounts for commercial banks while the latter would provide the client interface, such as know your customer (KYC) and front-end innovative payment solutions[26]. This type of CBDC involves a partnership between public and private sectors (Lagarde 2018) whose effectiveness is enhanced by their separate and distinct roles (Kashyap et al. 2002).

In another type called wholesale token-based[27] CBDC, central banks provide commercial banks and/or other financial institutions with restricted direct access to accounts where they can settle interbank payments (Bank for International Settlements 2018). Such an innovation could improve cost efficiency, increase speed, and provide 24/7 access to payments. However, discussing the merits and costs of wholesale CBDC as well as its monetary policy implications lies beyond the scope of this paper. The latter focuses only on the implications of a commercial bank account-based CBDC providing access to central bank money to the general public, instead of a selected number of users (e.g. eligible counterparties that have the obligation to hold minimum reserves).

The following figures summarise the foregoing discussion. Figure 1 presents d-euro within the taxonomy of currently existing forms of money, on the basis of access criteria. Figure 2 shows an altered version of the money flower originally designed by Bech and Garratt (2017). This version highlights the property of convertibility, as shown in the red petal. In fact, the coexistence of central and commercial bank money requires that they are convertible at par, leaving the quantity of central bank money unaffected. Figure 2 stresses the fact

23 According to Kahn and Roberts (2009, p. 11), the main difference between an account and a token lies in the verification needed, since the account holder is verified through a messaging process and the token's validity is verified by the beneficiary (Bank for International Settlements 2018, p. 10).
24 Sometimes referred to as a "synthetic CBDC" (Tobias 2019).
25 An alternative (not supported by the author) is a retail direct account-based CBDC when central banks offer to the general public direct access to accounts.
26 The author's business model of issuing a retail account-based CBDC, presented at the 1st EUROchain Hackathon, proposed a special type of account called "Dedicated Digital Account" (DDA) for d-euro transactions via the TARGET TIPS service (TARGET Instant Payment System). A detailed outline is provided in Section 4.
27 Double spending is the main worry in the digital world, i.e. whether the token has already been spent.

Figure 1 The proposed d-euro within the taxonomy of currently existing forms of money

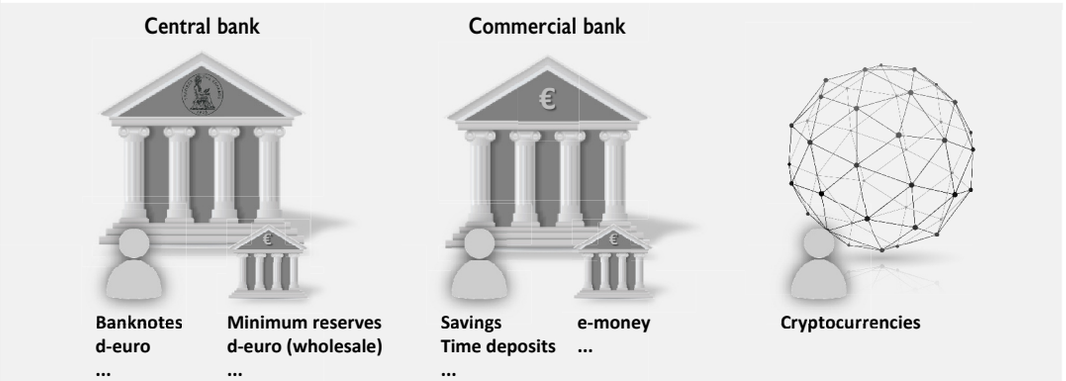
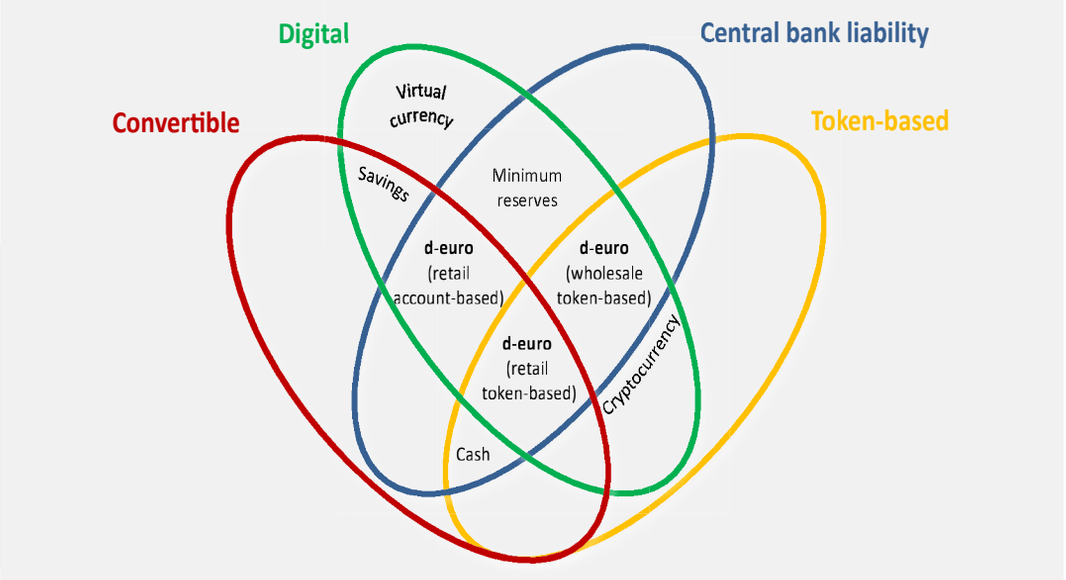


Figure 2 d-euro and the money flower



that cryptocurrencies, including Bitcoin, are inconvertible and not backed by any asset, unlike commercial bank money.

A close observation of the proposed d-euro as a retail account-based CBDC shows that it satisfies three of the four properties presented in the money flower diagram: it is convertible, it is digital and it constitutes a central bank liability.

For an account-based d-euro to be available to the general public, six principles have to be fulfilled (Bank for International Settlements 2018).

- **Principle 1: Anonymity.** This is the feature that makes cash the most attractive and popular means of payment nowadays (Athey et al. 2017). Accordingly, d-euro must offer a competitive degree of anonymity as a vital attractive feature to potential users (Mancini-Griffoli et al. 2018). In contrast to cash, which is fully anonymous and untraceable, providing an advantage in terms of privacy, the use of cash-like d-euro must

be semi-anonymous (Lagarde 2018)[28] (anonymity may be lifted due to AML concerns[29] – Garratt and van Oordt 2019; European Central Bank 201b, 2019c). This semi-anonymity[30] property makes d-euro an ideal alternative anti-money laundering solution unlike physical cash.

- **Principle 2: Trust.** The account-based d-euro must be fiat money with legal tender status. As by definition d-euro would be a liability on a central bank's balance sheet, it should inspire the same level of trust as cash. Such trust would emanate from the fact that d-euro would be issued by the central bank and would be convertible at par with all other forms of the euro[31]. The Eurosystem's national central banks (NCBs) would carry out the task of persuading the general public that d-euro's value is the same as that of euro banknotes and coins. It is envisaged that, by achieving a stable and safe asset status, the d-euro will create positive reputation and trust spillover effects for central banks. The latter are seen by the public "as part of a financial system which has failed to deliver growth and fairness" (Cœuré 2019b). Central banks should view the issuance of d-euro as an opportunity to respond to the rapid evolution of digital reality, the decline in the use of cash, as well as the multiplicity of FinTech solutions (He et al. 2017; Cœuré 2019b; Fatás 2019) and privately issued cryptocurrencies. Central banks must not be left behind but instead exploit their incumbent position and issue digital trust themselves. As Europeans show a positive attitude towards holding payment accounts, there is a significant potential for a public-private partnership in this area (Lagarde 2018; Bank of England 2020). It is the only way for central banks to underpin trust[32] in fiat currency and disincentivise the general public from adopting private sector front-end solutions[33].

- **Principle 3: Scalability.** The account-based d-euro would be used mainly for person-to-person (P2P), person-to-business (P2B), and person-to-government (P2G) payments (like physical cash). The pivotal role of d-euro lies in its efficiency and scalability in both online and POI payments. The issuance of the d-euro could play a widespread role in the use of the single currency in the European retail payments market, thereby contributing to the autonomy of the European payment systems as well as promoting the international role of the euro. In other words, d-euro should form the cornerstone both of the digital approach to the euro and of the effort to enhance its position as an international currency[34]. Therefore, it is expected to be a decisive step in the Eurosystem's attempts to meet the increasing needs of consumers for efficient and secure domestic and cross-border retail payments complementing already existing solutions[35] (Hasan et al. 2013; Cœuré 2019c). Summarising, scalability, combined with trust, will most probably be the decisive factors behind the wide adoption of d-euro.

28 The author's business proposal maintains semi-anonymity, as the NCB which participates in the consensus-driven validation process does not see the content of the transaction. The latter can be seen only by order of the AML officer.

29 In principle, under Article 2(2) of the 4th EU AML Directive (EU 2015/849), cash transactions are out of scope when there is not any intermediary intervention.

30 It should be underlined, strictly speaking, that in a given d-euro payment transaction the identity of the payer and the payee should be fully anonymous to all parties involved. Only the central bank can retrieve such information if and only if there is an AML officer decision, and given that there is reasonable suspicion of an illegal economic activity. In addition, at the 2nd EUROchain Hackathon in October 2018, the author's proposal was that the account-based CBDC should be fully anonymous for transactions of up to DEUR 500 (currently in Greece any P2B transaction in excess of EUR 500 is only allowed via e-payment) and semi-anonymous for payments above that ceiling.

31 The author's business proposal outlined the necessity of price stability in all economic circumstances and hence of the one-to-one parity rule vis-à-vis the physical euro.

32 Because the value of money resides in trust, one may argue that once people start using private money, they may lose a degree of trust in the sovereign currency.

33 Mobile payments platforms that are based on the network effect, like Apple Pay, have been witnessing a significant growth in the payments landscape.

34 Given that the US dollar is the dominant international currency, private initiatives have a competitive advantage in front-end solutions, brand loyalty and global acceptance, compared with central banks and as stated by Gresham's law, "bad money drives out good money" (Giffen 1891, p. 304), the issuance of the d-euro should be seen as the right step to a "euroized" digital economy.

35 Cœuré (2019a) has argued that "it is probably easier to connect a new currency to an existing network – the case of Libra – than to build a new network on an existing currency – the case of the euro". In other words, the issuing of [the d-euro] achieves a hybrid solution: it introduces a new digital currency to an existing network, i.e. TARGET services.

- **Principle 4: Interest rate.** The account-based d-euro should be interest rate free[36] and hence unable to function as a monetary policy tool[37]. Such a semi-anonymous d-euro, issued by the central bank, with a zero nominal return embedded in its initial design, is more trustworthy and likely to be adopted than most private cryptocurrencies. Thus, under normal economic conditions, d-euro should be designed so as to set the effective interest rate lower bound equal to zero (Hall 2013; Agarwal and Kimball 2015; McAndrews 2015; Dyson and Hodgson 2016; Engert and Fung 2017; Meaning et al. 2017; Middleton and Sinha 2019). However, that being said, the decision of whether or not the d-euro will be interest-bearing is an issue with multiple implications for monetary policy and financial stability (Eggertsson and Woodford 2003; Mancini-Griffoli et al. 2018; Agur et al. 2019; Keister and Sanches 2019; Kim and Kwon 2019).

- **Principle 5: Acceptance.** Initially, the account-based d-euro should be used in payment systems and by payment solutions that offer pan-European reachability with global acceptance as a long-term goal[38] (Cœuré 2019c). Global acceptance should reinforce economies of scale, support the euro's international role, and meet the increasing needs of European consumers for global reachability. In fact, Europe has made substantial progress in the promotion of the euro as an international currency since its introduction on January 1, 2002. Cash payments have been carried out using the single currency across the euro area with the same ease and convenience, but this has not been the case for electronic payments. The development and implementation of the Single Euro Payments Area (SEPA) in 2014[39] resulted in the creation of a single payments area for cashless payment instruments. Since the creation of SEPA, the d-euro seems the natural next step towards pan-European acceptance and reachability for both proximity and e-commerce payment transactions. While GAFA[40] are leveraging their extensive networks and are increasing their presence in the front-end retail payment environment in Europe, the issuance of the d-euro could be seen as turning this challenge into an opportunity.

- **Principle 6: Convenience.** The account-based d-euro should be designed according to customers' demands for convenience, speed, efficiency and global acceptance for both proximity and e-commerce payments. The d-euro issuance should be seen as a possible response of the Eurosystem to private sector stablecoin and cryptocurrency initiatives and card scheme global players (Cœuré 2019c). The d-euro has to cater for consumers' changing needs by combining the characteristics of cash and payment cards[41]. Thus, it must be user-friendly, equal to available instant payment solutions, and capable to offer 24/7/365 payments in real time. In addition, it should be available through different tools, payment instruments, and technologies, enhancing the payment experience and becoming synonym of convenience to both consumers and merchants. So far we have argued in favour of a public-private partnership between central and commercial banks, capable of creating a pan-European retail payment solution, like a European-governed payment card scheme, where central banks provide the back-end infrastructure and the private sector the front-end solutions.

As already stated, a CBDC initiative will have to serve the three basic functions of money, i.e.

36 The author's business proposal for the 1st EUROchain Hackathon outlined the necessity of the one-to-one parity rule vis-à-vis the physical euro and hence argued for a non-yield-bearing CBDC.
37 The next section considers the possibility of using the d-euro as a monetary policy instrument.
38 The key advantage of the stablecoin initiatives, based on their global clientele, is their cross-border functionality.
39 SEPA is an area where consumers, enterprises and public entities can make and receive domestic and cross-border electronic payments in euro under the same basic conditions and with the same rights and obligations. SEPA has created an integrated, competitive and innovative retail payments market, where all cashless euro payments are conducted via a single payment account and a single set of payment instruments in a fast, safe and efficient manner.
40 The non-European tech giants Google, Apple, Facebook and Amazon are often referred to collectively as "GAFA".
41 A payment card with a common European brand and logo, open access to NFC interfaces for proximity payments, and a global acceptance for e-commerce should be an efficient solution.

stable unit of account, costless medium of exchange, and secure store of value (Bordo and Levin 2018). Additionally, and in view of the aforementioned set of principles, the case for the d-euro raises a number of new policy considerations that merit further investigation (Andolfatto 2018).

3 CBDC AND THE ROLE OF CENTRAL BANKS

It is worth noting that digitalisation in the field of payments has affected consumers' payment behaviour (Cœuré 2019a). However, high demand for digital payment solutions may question public trust in major financial institutions. Consequently, many central banks have realised that they should respond immediately to the recent technological innovations in banking and payment systems, as well as to the digitalisation of money (Ahmat and Bashir 2017; Engert and Fung 2017; Bergara and Ponce 2018; Juks 2018; Kumhof and Noone 2018; Panetta 2018; Sveriges Riksbank 2018b; Norges Bank 2019; Bank of England 2020). In Europe, the Eurosystem has started to consider the issuance of a CBDC and to analyse its possible design and implications (Cœuré 2018). Thus, digitalisation has challenged the role of central banks, to the extent that they have to be involved in the retail payments market and to act beyond their traditional role as guarantors of price and financial stability and ensurers of the smooth operation of the payment systems. Central banks are presented with the significant opportunity of analysing the potential implications and risk considerations arising from the issuance of a digital currency such as the d-euro. By doing so, and by deciding that they must not be left behind in the digital race, they are also faced with a key question: what are the main motivations behind the issuance of an account-based retail CBDC and why might central banks wish to proceed with it?

Motive 1: Trust and the digital transformation of the economy. Facebook's Libra, based on permissioned blockchain technology (Libra 2019), is a token-based stablecoin backed by a pool of assets. It seeks to reach wide-scale adoption and global acceptance and expects to benefit from network effects and economies of scale (Cœuré 2019a). Indeed, Facebook (which claims 2.45 billion core active users in 2019[42], as well as 2 billion WhatsApp and 1 billion Instagram users) tailors its payment solutions to consumers' changing behavioural trends and attempts to turn a means of payment into a global currency (Gans and Halaburda 2013; Fung and Halaburda 2014; Cœuré 2019a). By entering the realm of retail payments and financial services, Facebook plans to provide both front-end and back-end solutions, thus eliminating the need for central clearing and settlement performed by central banks. Furthermore, Alipay and WeChat Pay,[43] using mobile payment solutions and non-social networking apps, together account for 93% of all digital transactions in China.[44] These third-party online and mobile payment solutions strive to become globally available by signing deals with European banks and digital wallet companies. By doing so, they intend to provide tailor-made services meeting the needs of European customers.

Moreover, Google Pay and Apple Pay are card-based wallet solutions that allow users to initiate proximity payment transactions at the POI and are prominently focusing on e-commerce payments. Thus, they offer services that have been traditionally provided by the banking sector. Given their branding power, they are gradually replacing the existing front-end banking solutions and provide additional back-end core banking services which usually lie outside of the banking perimeter (Cœuré 2019b). In addition, as these solutions are fast, cheap, user-friendly and offer cross-border functionality, they may eagerly be adopted by European customers for purchases at domestic or foreign merchants.

42 The world's population at that year was 7.71 billion.
43 Alipay and WeChat Pay provide mainly front-end services, while at the same time decreasing merchants' costs by using the QR code technology, which is cheaper than the card-based technology.
44 According to the People's Bank of China annual report.

Alipay, WeChat Pay, Google Pay, Apple Pay, and many others are targeting to shift consumers' payment preferences by importing proprietary practices that are alien to European consumers' habits and needs. In an extreme scenario, given information asymmetry and adverse selection, based on a winner-takes-all effect, the Eurosystem's market infrastructures services, TARGET2 and TIPS, may be impacted. In this case, the bigtech firms that offer payment solutions may exploit their comparative advantages, bringing about a significant decrease in the share of euro area banks in the European retail payments market and accordingly a tantamount drop in the volume of assets settled in central bank money, via TARGET2. Given that under the European payments strategy, the pan-European solution must be market-led and meet the objectives of the Eurosystem, the foregoing solutions offered could cause an adverse impact on standardisation, interoperability and reachability in the European retail payments market.

By acting as operators, overseers and catalysts, central banks are responsible for providing efficient and sound clearing and payments systems as well as for maintaining the value and trust of the currency (Kokkola 2010). The safe and efficient use of the currency as a stable medium of exchange is a basic pillar of consumers' trust in it. The fact that a privately issued stablecoin may replace traditional payment and financial assets is a wake-up call for central banks to start considering issuing a digital alternative that warrants maximum reachability, stability, and resilience. The d-euro should be an ideal answer, as it enables pan-European SCT-Inst-based[45] POI solutions via TIPS. By offering such pan-European reachability, it minimises any potential reputational risks regarding the role of the Eurosystem in the payments ecosystem.

In order to be prepared for the advent of 5G technology and to start promoting climate risk disclosure in their tasks, central banks have to be ready to take the leadership regarding the provision of technological innovation. In this context, the potential issuing of the d-euro can be seen as the next step in the digitalisation process of the retail payments market. Central banks would thus become active players in the process of money digitalisation in order to foster trust and to promote a reliable and efficient means of payment. In other words, the issuance of the d-euro as the digital version of a sovereign currency, i.e. the euro, would support the resilience and strength of the European monetary policy project. In addition, it would support the safety and soundness of the European retail payments market and could promote the international use of the euro as a stable and convenient currency. It is a well-established principle that "it is difficult to build a new network on an existing currency"[46]. The Eurosystem has created TIPS, a TARGET service, with the potential to ensure full pan-European reachability and settlement of instant payments in d-euro as well. Thus, and since TIPS has a multicurrency technical capacity, d-euro can be introduced from day one as a stable means of payment with immediate pan-European reach and potential global acceptance.

Motive 2: Decline in the use of cash. Cash is the dominant payment instrument in the euro area. However, an extreme scenario could materialise in the future where physical cash will not be generally accepted as a means of payment and demand for it will decrease. Currently, in some countries, most notably Sweden, the use of physical cash for retail payment transactions has been declining rapidly and a number of retailers do not accept cash at all[47] (see for example Bordo and Levin 2017). Additionally, according to the latest payment statistics,[48] the euro area has experienced a steady decline in the number of bank-operated ATMs and an increase in the number of card pay-

45 SCT Inst stands for SEPA Instant Credit Transfer.
46 See footnote 36.
47 The discussion of a cashless society goes beyond the scope of this paper (for a discussion about this subject-matter, see Engert et al. (2018a) and Gnan and Masciandaro (2018)). The Eurosystem treats all available means of payments on a non-discriminatory basis. The author does not entertain the idea that cash will be abolished and hence any theoretical discussion about cashless societies is at present meaningless.
48 ECB Payment Statistics.

ments. These trends are likely to further accelerate in the future, given the widespread adoption of open banking solutions and the introduction of new services offered by regulated third party providers (TPPs)[49], especially the payment initiation service providers (PISPs)[50]. The declining use of physical cash observed in many northern European countries may be a warning signal about possible structural changes in consumers' behaviour at the euro area level. Given the proactive stance that central banks are likely to adopt in the new digital paradigm and as Europe is moving towards a cashless payment environment (Engert et al. 2018a), one may ask: how will they fulfil their mandates of providing resilient, efficient and stable payment systems?

Cash constitutes a fraction of a central bank's balance sheet and of the money supply (M1). Its popularity rests on the fact that it is risk-free central bank money that settles payments with anonymity and finality. In addition, strictly microeconomically speaking, a cash payment[51] is a zero-sum game, where both parties (payer and payee) enjoy Pareto optimality, since a banknote is exchanged in order to redeem an obligation. Cash plays no role in the operation of TARGET services. There, payment orders are submitted to the platform for processing and are irrevocably settled via risk-free transfers between the respective dedicated cash accounts that the participants hold with the central bank.[52] Thus, a significant decline (or increase for that matter) in the use of cash cannot affect the back-end payment operations of the Eurosystem. Any change in the volume of physical cash in circulation will neither obstruct nor interrupt the continuous operation of TARGET services and hence will not affect the primary objective of central banks to promote the smooth operation of the payment systems and to ensure efficiency and sound clearing (Kokkola 2010). However, the demand for small-denomination coins is rather low as they are not used very often (Judson 2018). Hoarding of coins increases the opportunity cost of using cash against all other instruments and holding cash for saving reasons[53] due to its physical nature.[54] It can be argued that this decline in the use of physical cash may break the bond of trust between the public and the central bank, as the former loses confidence and starts to question the latter's mandate and role (Middleton and Sinha 2019). The trust that people place in cash is merely a reflection of their trust in central bank issuers. Hence, the issuance of the d-euro, as digital cash, could be seen as a credible way of avoiding reputational risks and regaining trust.

It must be noted that as part of a portfolio diversification strategy, people may hold certain amounts of cash as a precautionary reserve since it is the most trusted form of money. In fact, it has been observed that demand for cash increases dramatically during bank runs[55] as the public becomes more risk averse and looks for risk-free assets (Brown et al. 2017). During the recent euro area crisis, two major events were observed in Greece which was also going through a sovereign debt crisis: (i) an increase in demand for cash as a safe asset; and (ii) a realisation that access to commercial bank deposits is subject to regulatory and liquidity restrictions. In June 2015, capital controls as well as regulations enforcing the use and acceptance of electronic payment instruments (mainly cards) were imposed in order to stem capital flight. Argentina has experienced a phenomenal demand for foreign currency (i.e. the US dollar) and safe assets during its last economic crisis, as they were perceived as more stable and secure. Recommendations for the promotion of electronic payment instruments in a crisis environment are neither addressed only to the technology-adept generations, nor are they necessarily related to financial reasons, as the COVID-19 pandemic has revealed

49 The EU's revised Payment Services Directive (PSD2).
50 The PISPs are authorised to initiate payments from a user's payment account.
51 In strictly economic terms, a payment is indeed a transfer of funds by using either cash or deposits held with credit institutions and discharges an obligation on the part of the payer vis-à-vis the payee.
52 T2S settles securities transactions on a delivery-versus-payment (DvP) basis using optimisation and auto-collateralisation mechanisms to enhance settlement efficiency.
53 Store of value.
54 The cost of cash has been described in Section 2.
55 Financial crises have very low probability tails (Engert et al. 2018a).

with the nationwide lockdowns, the restriction of movement, and the "stay home" campaign.[56]

All the cases discussed above exhibit one common characteristic: at the moment physical cash has proved to be the only form of risk-free central bank asset available to the public. In particular, a decline in the use of cash gradually prompts consumers to depend greatly on payment solutions provided by the private sector and to lose their trust in efficient and reliable payment systems. Therefore, central banks, by issuing the d-euro as a semi-anonymous digital means of payment alternative to cash, would provide the public with access to central bank money that is a secure store of value and a stable means of payment in periods of financial (Mancini-Griffoli and Ranaldo 2011) and societal crisis. After all, is this not one of their roles?

Motive 3: Financial stability considerations.[57] One of the main issues related to financial stability concerns possible bank runs as a consequence of the d-euro's competition with commercial banks' deposits (Stein 2012; Dyson and Hodgson 2016; Raskin and Yermack 2016; Bank for International Settlements 2018). Such cases have attracted significant interest in the recent literature and policy debates and can be summarised in two main scenarios: (i) a surge in conversion of commercial bank deposits into d-euro during normal financial times; and (ii) conversion of commercial bank deposits into d-euro (rather than cash) during periods of financial crisis. It must be noted that in this analysis, d-euro deposits are interest-free as credit is provided entirely by commercial banks. In both scenarios the d-euro accounts are held with and managed by commercial banks, while deposits are guaranteed, up to a limit, by national deposit guarantee schemes[58].

The first scenario presupposes information asymmetry between account holders, which leads a part of them to hold d-euro as a safer store of value and hence to increase its demand. In such a case, central banks may intervene by issuing d-euro up to a specific amount per holder, providing a certain horizontal quota[59]. Thus, by imposing ceilings on the amount of d-euro allowed per customer, central banks can promote the currency's function as a medium of exchange instead of a store of value.[60] However, one could argue that commercial banks will react to the introduction of the d-euro by adjusting deposit rates even if limits are imposed on d-euro account holders, thereby leading to an insignificant deposit outflow into d-euro under a financial system in which the same authority guaranties both types of deposits. Commercial banks are expected to raise revenues from the management of accounts (in the form of fees, etc.) as well as from a number of customer-tailored payment solutions that will be provided and treated as premium services. Commercial banks will probably react and offer additional services to account holders, similar to those provided to card holders in order to make deposits more attractive to potential customers. Finally, as an alternative measure, they may raise interest rates on saving deposits in order to win clientele from their competitors. Such increases may spark a hike in lending rates, in order to readjust the interest rate margins to their initial level. In an extreme scenario, commercial banks should consider replacing part of their outflows of retail deposits with secured wholesale funding in order to reduce their dependence on them.[61] Central banks may consider

56 The decline in the use of cash experienced during the COVID-19 pandemic has helped to prevent the spread of the disease to a certain degree. Banknotes are coronavirus carriers and people opt for contactless payments instead (COVID-19 stays on a note's surface for a number of days and thus people using cash have to wash their hands regularly). However, attitudes adopted during such emergency periods may have a more permanent nature and can thus change consumers' payment habits, leading to a faster reduction in cash use.

57 Future work could consider a deeper analysis of this issue.

58 In the EU, deposit guarantee schemes protect depositors' savings up to EUR 100,000 and prevent the mass withdrawal of deposits in the event of bank failures.

59 Assuming there is parity between all forms of money, i.e. cash and commercial bank deposits, quotas must aim to enhance the efficiency of d-euro as a means of payment.

60 The author's business proposal at the 1st EUROchain Hackathon stressed that for social reasons this quota should be closely associated with the total amount of euro banknotes and coins in circulation. Thus, according to this proposal, the Eurosystem should introduce a single tier system for the account-based d-euro with a dynamic ceiling, given the decrease in the use of physical cash. The proposal called for an initial issuance of DEUR 4,000 per citizen.

61 Commercial banks with high retail deposits are more sensitive.

continuing to provide liquidity while accepting riskier collateral and thus a higher degree of credit risk. Theoretically speaking, this situation could lead to higher costs of funding, reduced and riskier profits and hence bank funding problems and financial instability, as d-euro deposits will not be available for lending. Yet again, given the low d-euro ceiling per account holder, the likelihood of reduced bank profits and undermined financial stability is arguably low in an environment where central banks and/or prudential authorities safeguard the stability of the financial system and operate in partnership with commercial banks.

So far we have argued that during normal financial times, deposits in central bank money, held with and managed by commercial banks, are both risk-free and perfectly liquid. However, during periods of financial crisis, citizens may perceive the d-euro as a safe-haven, risk-free store of value backed by the central bank, and when in panic they may cause a bank run. The Greek sovereign debt crisis, which led to a series of austerity measures and the debt swap through private sector involvement (PSI), has shown that risk-free assets do not exist in a financial crisis environment (see Jobst and Stix 2017). During periods of financial crisis and panic, d-euro may be perceived as an "asset of the last resort" offered by the central bank. Two major potential benefits from issuing d-euro become apparent in times of economic turbulence: (i) given that Greece as member of the euro area has lost its monetary flexibility, liquidity may stay longer in the country, as capital flight may, to some extent, be avoided (capital outflows would severely increase the NCB's liability vis-à-vis the ECB[62]); and (ii) trust in the central bank and the euro as legal tender may be underpinned,[63] thus averting any additional reputational costs. Before the Greek experience of capital controls, a shift towards safe assets (notably cash) had been observed. Central banks could also, in future, consider introducing a two-tier d-euro system in order to meet money demand for precautionary reasons (Bindseil 2020). Thus, besides the d-euro used for payments, central banks could introduce a tier-two d-euro which would act exclusively as a store of value to households and enterprises. The amount of each tier allocated to each account holder would be determined and subject to change by the central bank. The central bank would also be able to change the interest rate (Lenza et al. 2010) of tier-two deposits at will (Bindseil 2020), applying even a negative rate during normal times so as to make them highly unattractive. Nonetheless, the aforementioned concerns expressed in the literature regarding the possibility of digital bank runs should inform the exact CBDC design.

Finally, d-euro is expected to be preferred over cash as a medium of exchange, due to non-financial reasons such as the time-consuming process of visiting ATMs or the cost of holding cash (including the risk of being lost or stolen during transportation). As evidenced during the very recent COVID-19 pandemic crisis, the d-euro should appear to be suitable to serve as a semi-anonymous, cheap, secure, and efficient means of payments used for remote transactions (including e-commerce).

Motive 4: Monetary policy considerations. The potential impact from the introduction of the d-euro is expected to be of limited relevance for monetary policy (see for example Bordo and Levin 2017). As long as physical cash is not abolished in the near future (Niepelt 2018), d-euro is both highly unlikely and undesirable (on the part of policy makers) to bear interest and serve as a monetary policy instrument (e.g. Hamilton and Wu 2011; Edgar 2012; Goodfriend 2016; Rogoff 2016; Dell'Ariccia et al. 2017; Davoodalhosseini and Mohammad 2018). Conventional monetary policy dictates that when short-term interest rates are at or near the so-called zero lower bound (ZLB),

62 https://www.bankofgreece.gr/en/main-tasks/payment-systems-and-settlements/target-services/large-value-payment-system-target2/target2-account-balance.

63 In situations of panic, d-euro could also be affected and treated as a "lemon" because of adverse selection according to the well-known Akerlof's paper (1970) and thus d-euro holders should also be expected to withdraw their assets, thereby increasing the elasticity of demand for all deposits.

central banks cannot reduce them further in order to stimulate lending and demand when the availability of zero return physical cash serves as a stable floor for all interest rates (Dyson and Hodgson 2016; Borgonovo et al. 2018; Strournaras 2018). It can be argued that as d-euro is the digital equivalent of cash, and its supply is constrained by design, then it acts as an interest-free asset and a concrete floor to all interest rates in the wider economy. In a negative interest rate economy, people will prefer to hold a zero-interest bearing asset like cash, d-euro, a foreign currency (e.g. USD) or even a stablecoin, which should set the effective lower bound to zero (Engert and Fung 2017; Bordo and Levin 2018). By designing d-euro as an attractive complement to cash and keeping its supply constant (at a certain ratio to the amount of cash in circulation), there should be no effect on short-term interest rates and on the alleviation of the ZLB constraint. Thus, in fact, the circulation of physical cash (rather than the issuance of d-euro) is the main binding constraint to the application of negative interest rates during periods of deflation and limited aggregate demand[64]. On the other hand, one might argue that a zero-interest rate d-euro would free the Eurosystem from the ZLB issue. Niepelt (2018) argues that it would relax central bankers' ability to conduct monetary policy based on interest rate manipulation in order to stimulate the economy, thereby allowing them to focus on the primary objective of the Eurosystem's monetary policy, i.e. price stability.

Since it is not feasible to reduce interest rates below certain limits, there are alternative monetary policy tools that the d-euro could serve, with a view to boosting aggregate demand. Quantitative easing (QE) has proven to be one of the most effective policy tools in the euro area during the financial crisis. When central banks apply quantitative easing, they buy securities (e.g. government bonds) in order to push down interest rates and provide liquidity to the banking sector (McLeay et al. 2014; Meaning et al. 2018). The ECB has recently announced a new asset purchase programme[65] in response to the COVID-19 pandemic, ensuring "that all sectors of the economy can benefit from supportive financing conditions that enable them to absorb this shock ... equally to families, firms, banks and governments" (European Central Bank 2020b). The implementation of such a programme could be further facilitated if people were able to hold d-euro accounts. In another case, central banks could perhaps more easily provide liquidity directly to households and other designated account holders (e.g. firms, pension funds, etc.) in what is known as "helicopter money" (Reichlin et al. 2013; Dyson and Hodgson 2016; Ward and Rochemont 2019). Unlike QE where central banks purchase assets (using printed money) by increasing their liabilities, with helicopter money central banks make an impact on the economy by issuing money and distributing it directly to households and enterprises (Dyson and Hodgson 2016). Especially in cases like the COVID-19 pandemic crisis when firms close down and strategic industries suffer financial losses or face bailouts, d-euro could facilitate the implementation of a helicopter money scheme, which intends to help society cope with staff redundancies and lockdowns.

All in all, like cash, a d-euro would play a rather minor role in monetary policy implementation (Broadbent 2016; Agur 2018; Engert et al. 2018b; Albertazzi et al. 2020). However, d-euro may be used as a direct channel through which central banks can transmit monetary policy to households and enterprises. Central banks have been unwilling to open and manage public d-euro accounts. Therefore, this task should be assigned to commercial banks, along with the customer onboarding process as well as the provision of front-end payment solutions. The next section presents our case for a possible d-euro issuance that is based on exactly such a public-private partnership.

64 Altavilla et al. (2019) argued that when the ZLB has been hit, healthy banks are better off, compared with weak banks. However, one may argue that the former penalise depositors and could therefore accuse central banks of failing to deliver growth and fairness.

65 The so-called Pandemic Emergency Purchase Programme (PEPP).

4 TARGET SERVICES AND D-EURO AS A MEANS OF PAYMENT

The present section aims to offer a more detailed presentation of the design and functionalities of a prospective d-euro. Recently, much research activity has been devoted to the development of CBDC blueprints[66] (mainly Ahmat and Bashir 2017; Engert and Fung 2017; Bergara and Ponce 2018; Juks 2018; Kumhof and Noone 2018; Panetta 2018; Sveriges Riksbank 2018b; Yao 2018; Armelius et al. 2018; Norges Bank 2019; Bank of England 2020; Boar et al. 2020; Jung and Uhlig 2020). As a result, many similar theoretical models have been conceived and presented (see also Barrdear and Kumhof 2016; Gouveia et al. 2017; Engert et al. 2018b; Fernández 2018; Mancini-Griffoli et al. 2018; Kahn et al. 2019; Bank of England 2020; Bindseil 2020). Such models present several similarities and are often distinguished by subtle differences. The model presented here attributes to the proposed d-euro a number of features that may be shared by other theoretical efforts. Nevertheless, this project is marked by the unique characteristic of trying to implement a CBCD under the limitations and the design of the Eurosystem's current payment infrastructure. This is the main factor behind some of the specificities presented here, which will be scrutinised accordingly and through this prism.

Central banks that operate in the area of payment, clearing and settlement systems have to examine whether d-euro would improve the security and efficiency of retail payment systems and (in the case of the Eurosystem) TARGET services. In fact, central banks, in order to provide convertibility between different forms of money, operate RTGS systems (Martin and McAndrews 2008; Kokkola 2010) whereby commercial banks submit payment orders and settle interbank transactions without the use of cash. In addition, such systems are closely associated with monetary policy considerations (TARGET2 settles payments related to the Eurosystem's monetary policy operations and implements monetary policy decisions) and financial stability (it provides secured liquidity to the financial system). However, when issuing d-euro, central banks have to apply design features that would allow them to continuously fulfil their mandate of providing safe, stable, efficient, reliable and secure payment systems.[67]

First and foremost, the d-euro must satisfy the distinct properties of cash, i.e. to emulate cash in a digital environment. As can be seen in the following table, d-euro is designed as a low-cost and efficient means of payment that warrants maximum acceptance, accessibility, semi-anonymity, availability, convenience, scalability, reachability, and stability. In addition, the support of monetary policy and the improvement of financial stability should be the core considerations of the d-euro design. The two core principles behind d-euro issuance are: (i) convertibility at par with commercial bank deposits, which makes it a liability of the Eurosystem; and (ii) zero remuneration (like cash), which excludes it from serving as a monetary instrument. Moreover, some legal considerations related to d-euro's design should be clarified. Since the Court of Justice of the European Union (CJEU) and the Treaty on the Functioning of the European Union (TFEU) do not explicitly authorise the Eurosystem to issue a CBDC and given that d-euro should have legal tender status (Mancini-Griffoli et al. 2018), a clear authorisation for d-euro issuance does not exist.[68] Given that d-euro offers zero remuneration and that a priori its design should improve payment infrastructures' safety and efficiency, Articles 17 and 13.1 of the ESCB/ECB Statute are not relevant.[69] In addition, it seems that the issuance of the d-euro will not affect settlement finality and insolvency procedures as expressed in the

66 Some 66 central banks replied to a survey, covering 75% of the world's population and 90% of its economic output, and reported that more than 80% are working on CBDC (Boar et al. 2020).
67 Under Article 3.1 of the ESCB/ECB Statute.
68 Mersch (2020) argued that "without legal tender status, the legal basis would need to be clarified, as would the relationship between a CBDC and euro banknotes and coins, along with the process by which one could be exchanged for the other".
69 However, an important legal issue that is outside the scope of this paper is whether TFEU (for example Article 128) or other legal documents need to be amended.

D-euro as account-based retail central bank digital money

	Cash	d-euro	Reserves
Acceptance	High (majority of retailers still accept cash)	High	Low
Access	Anyone	Anyone	Supervised credit institutions
Account provider	–	Authorised credit institutions	Central bank
Anonymity	Anonymous	Semi-anonymous	Not anonymous
Availability	24/7/365	24/7/365	TARGET2 operating hours
Convenience	Medium (requires both parties to be present)	High	High
Convertibility	Par	Par	Par
Cost	Medium (withdrawal and storage)	Low	Low
Finality	Final	Final and irrevocable	Final and irrevocable
Form	Physical	Digital	Electronic
Interest rate	No	No	Yes
Legal tender	Yes	Yes	No
Limits	Yes	Yes	None
Scalability	Low and medium value transactions	All value transactions	Large value transactions
Settlement[1]	Immediate	Instant	Real-time
Reachability	Medium (only proximity payments)	High (pan-European and cross-border)	High (Eurosystem's supervised credit institutions)
Risk	Medium (counterfeit, steal)	Low	None

1 See Bech et al. (2017).

settlement finality directive (SFD) (Article 1 of SFD). PSD2, although not originally oriented towards instant payments, assigns central banks with the tasks of improving the efficiency of payments throughout the Monetary Union, ensuring a high level of consumer protection (from fraud), and respecting and protecting fundamental rights, including the ones of privacy and confidentiality (Articles 59, 68, 72-74, 94, 97). D-euro compatibility with KYC guidelines, adherence to AML/CTF requirements, and compliance with the GDPR are legal considerations that must also be taken into account, on a preliminary basis, in relation to the issuance of d-euro (Bank for International Settlements 2015). However, a further in-depth analysis should establish a robust legal regime.

D-euro is a retail account-based CBDC, whereby central banks verify the validity of instant payment transactions by using a centralised ledger structure[70]. According to this approach, households and enterprises do not have direct access to central bank liabilities but instead hold accounts with commercial banks. The latter are the administrators of these

70 DLT does look very promising. However, at present it is not mature enough to support the issuing of the d-euro. In a previous short article describing DLT, the author concluded that: "personally, I believe that this new technology could potentially prove to be as important as the internet. However, I also believe that we are still at the beginning of the exploration of its promises, while at the same time we need a careful analysis of its possible consequences both in terms of monetary policy and financial stability. In fact, the marriage of this new code with the existing infrastructure of the financial sector has just taken place. And the honeymoon, exciting and full of inspiration, will be long" (Korfiatis 2018, p. 12).

accounts and provide any account-related services. This specific d-euro implementation, whereby commercial banks act as intermediaries, requires a public-private partnership of a manner described later in this section. In fact, the objective of this section is to present the main features of d-euro and its technical design. The table compares d-euro as an account-based retail central bank digital currency with the other existing forms of central bank money.

The features[71] of d-euro in a two-dot model: given the proposed attributes shown in the table above, the designed features of d-euro in this paper were originally presented by the author at the 1st and 2nd 2018 ECB EUROchain Hackathons. Specifically, we propose a two-dot model account-based d-euro. Central banks (ECB and NCBs) are viewed as dot-one entities that settle all d-euro transactions by crediting and debiting account balances. End users do not interact directly with central banks but indirectly through Payment Service Providers (PSPs). PSPs can be viewed as dot-two entities and mainly function as intermediaries between end users and central banks. Commercial banks can act as PSPs and are able to provide their clients with d-euro accounts. The proposed two-dot structure is explained in greater detail in the next section. In fact, there are several sets of different proposed features that could make CBDC an efficient means of payment, a stable unit of account, and a secure store of value. That being said, it all boils down to a policy decision whose adoption depends on the central bank's wish to be involved in the retail payments landscape and on the implications that this decision may have for the safety and the efficiency of retail payments, monetary policy and financial stability. Given the foregoing argumentation, an ideal account-based d-euro would exhibit the following features (see also Bank for International Settlements 2015):

Anonymity: d-euro is semi-anonymous, a property which renders it the ideal alternative anti-money laundering solution and offers an advantage in terms of privacy compared with physical cash[72]. The attractiveness of this semi-anonymous design rests on the fact that anonymity may be only lifted due to AML concerns and/or suspicion of illegal economic activity such as money laundering and terrorist financing. Thus, d-euro satisfies, especially for lower-value payment transactions, the privacy and traceability requirements that help avert the misuse of the financial system to channel illicit transactions that damage its integrity, stability and reputation.

Availability: d-euro is available to all users, providing a 24/7/365 payment experience and immediate transfer of funds. Unlike cash whose availability depends on ATM withdrawals (which are costly and may include withdrawal fees), visits to a bank branch (which operates during banking hours and includes transactional fees) or access to secure storage locations (which bears security costs), d-euro is universally available, without restrictions, and meets the general trend towards digitalisation. Thus, it meets users' need for secure and around-the-clock digital money, irrespective of the underlying payment instrument used, and can execute both online and offline payments.

Convenience: d-euro is convenient, as transactions can be initiated via different devices (e.g. mobile phones, wearables and payment cards), channels and technologies (e.g. NFC, QR-code, AI, AR and IoT). In fact, the proposed d-euro has been designed with convenience in mind and accordingly replicates all the crucial characteristics of physical cash (that have made it the most convenient means of payment so far), while at the same time facilitating the digital transformation of the economy (Selgin 1994; Ruth 2018). In addition, with the exception of web-based services which are energy-consuming and rely on internet access (e.g. smart-

71 Those characteristics were described and presented at length at the 1st and 2nd EUROchain Hackathons (April and November 2018, respectively).

72 The "... CBDC would be acting as an instrument with the liquidity and anonymity of cash, but without the limitations on portability that come with physical cash" (FATF 2020, p. 28).

phones), d-euro can be available to the user via a payment card,[73] thus incorporating the main feature of the most popular electronic payment instrument, i.e. convenience.

Cost: d-euro is a digital means of payment alternative to cash and hence its issuance has zero cost on the public. D-euro accounts are provided, managed and maintained by commercial banks, and do not have opening or maintenance fees. In addition, transferring liquidity from a commercial bank deposit account to a d-euro account is free, while the pricing structure is the same, i.e. there is free usage of e-banking or the ATM. Consequently, the proposed d-euro is conceived as a cost-efficient means of payment that does not suffer from the aforementioned cost of cash.

Interest: d-euro offers zero remuneration and accordingly plays a rather minor role in monetary policy implementation and financial stability. Thus, it is attractive to users without violating the parity rule (see further below) and conflicting with anonymity (if interest is subject to taxation). In addition, it discourages commercial bank account holders from moving liquidity between traditional and d-euro accounts. Again, with users facing maximum holding limits, it becomes highly unlikely that the d-euro would affect the ZLB, since the opportunity for depositors to hold unremunerated d-euro as the best costless alternative (avoiding both possible negative bank deposit rates and the costs generated to holding cash) is offset by its imposed limit (Dyson and Hodgson 2016; Yanagawa and Yamaoka 2019).

Issuance: d-euro is issued by central banks in order to promote convenience, efficiency, transparency, stability and accessibility in retail payments, and to modernise the Eurosystem's TARGET services, keeping up with technological developments and consumers' demands. The main advantages of issuing d-euro for central banks, as analysed in the previous sections, are: (i) to regain trust by promoting a third form of base money; (ii) to respond to the significant decline in the use of cash; (iii) to facilitate the digital transformation of the economy by addressing users' needs and demands for a convenient, secure, global, flexible and instant payment experience; (iv) to contribute to the strategic autonomy and resilience of European payments, thereby supporting the reputation of the Eurosystem and the international role of the euro; (v) to promote the vision for an innovative retail payment solution providing safety, convenience, cost-efficiency, and pan-European (possibly global) reach; and (vi) to offer an attractive alternative to the proliferation of digital currencies.

Quantity: d-euro holders (households) face an amount limit per account (in the next section we analyse further the amount and the limits). Thus, the maximum amount of d-euro per household is constrained by a limit that can be adjusted in order to safeguard the parity rule. This limit could be subject to change depending on the amount of the banknotes in circulation in the euro area (inversely proportional), the financial conditions (in a financial crisis central banks could increase the limit) and certain inequalities across EU countries. In the latter case, wealthier countries may increase the account's ceiling as they face a greater decline in the use of cash. A household can transfer liquidity from its traditional to its d-euro account up to the maximum amount determined by the central bank. In any case, when there would be a change in the limit amount, central banks have to calculate the exact digital money supply which permits d-euro to function as a stable, reliable, and efficient means of payment and to avert a bank run. Under the model proposed here, enterprises are allowed to receive d-euro. Such

73 The ECB's European strategy for retail payments includes a market-led solution that allows users to initiate a payment by using a card with a common European brand and logo. Recently, the ECB has welcomed the decision by 16 European banks to launch the European Payments Initiative (EPI) as a new European payment solution. EPI "seeks to replace national schemes for card, online and mobile payments with a unified card and digital wallet that can be used across Europe, thereby doing away with the existing fragmentation. As it is based on the SCT Inst scheme, it can immediately capitalise on powerful and sophisticated existing infrastructures, such as the Eurosystem's TIPS" (European Central Bank 2020c).

accounts cannot be used for the initiation of d-euro payments. After the receipt of a d-euro payment, the funds are irrevocably transferred to the firm's "traditional" euro bank account. In this way, said digital funds are "subtracted" from circulation and the d-euro money supply is adjusted accordingly.

Two-dot model: d-euro issuance follows the specifications of the two-dot model. Households and enterprises do not hold d-euro accounts directly with central banks in order to get access to central banks' liabilities. At the first dot, central banks open Dedicated Digital Accounts (DDAs) in TIPS to TIPS participants (usually commercial banks already holding DCAs)[74]. Central banks are responsible for the opening and management of the accounts, the setting of liquidity limits, the monitoring of liquidity positions, the performance of local contingency and the provision of help desk functions. At the second dot, commercial banks do provide end customers with d-euro accounts. Commercial banks are responsible for the opening and management of the accounts, ensuring adherence to KYC requirements and providing innovative front-end solutions for the initiation of d-euro payments. In fact, we could say that the two-dot model draws a dividing line between the back-end settlement and the front-end customer services, creating an efficient and promising public-private sector partnership.

Reachability: d-euro transactions are settled in TIPS[75] whose pan-European reachability is ensured by the Eurosystem.[76] TIPS is an extension of TARGET services and enjoys the participation of the overwhelming majority of the Payment Service Providers (PSPs) in the EEA. Additionally, it is in an optimal position to facilitate pan-European reachability since it had been developed[77] to facilitate instant payments becoming the new normal. Therefore, households and enterprises have the possibility to make and receive domestic and cross-border instant payments in d-euro using exclusively their central bank d-euro liquidity pool. Users enhance their convenience and reachability by using IBAN proxies (like mobile phone numbers) based on "trusted hardware"[78] and they experience P2P and P2B mobile payment solutions. Moreover, since a multi-currency facility is a core principle of TIPS,[79] every d-euro account holder could conduct global instant payments via one single account in a fast, safe and efficient manner.

Security: d-euro transactions are settled one by one in central bank money with instant finality. Central banks have the statutory task to secure the smooth operation of payment and settlement systems. Therefore, settlement in central bank money eliminates credit risk and ensures safety, consistency, efficiency, transparency and effectiveness. Since TIPS complies with all relevant legal and oversight requirements, it offers a robust and resilient market infrastructure that adheres to the Eurosystem oversight requirements and the internationally applied CPMI-IOSCO Guidance on cyber resilience. At the front-end, PSPs shall ensure a high level of consumer protection by applying strong customer authentication and common and secure open standards of communication[80]. Thus, strong cryptography and authentication would make d-euro the most secure digital asset, able to initiate anonymous payments in central bank money.

Speed: d-euro payments are settled via the state-of-the-art settlement engine of TIPS that

74 Strictly legally speaking, TIPS accounts in d-euro are opened in TARGET2 by the competent central bank. In addition, central banks, as non-profit organisations, are commercial bank account provider agnostic, i.e. every credit institution established in the European Economic Area (EEA) that holds a RTGS DCA in central bank money may offer d-euro accounts to its customers.

75 The Eurosystem in 2017 offered to settlement banks the connectivity option of ASI6 RT in order to manage their instant payment via their respective ACH. However, this solution, which allows ACHs to offer instant payments in commercial bank money with the final settlement in central bank money, requires cash collateral (which is not included in the calculation of the reserve requirement) in order to remove the counterparty risk associated with instant transactions.

76 "TIPS is in an optimal position to facilitate pan-European reachability, but it cannot guarantee it" (European Central Bank 2018, p. 3).

77 "The value of TIPS service will be increasing accordingly to the percentage of participating PSPs" (Korfiatis 2019, p. 37).

78 Trusted hardware encompasses encryption and data authentication.

79 Riksbank decided to use TIPS for the Swedish krona (Flodén 2019).

80 According to PSD2 and Regulation (EU) 2018/389.

offers final and irrevocable settlement for instant d-euro payments. A d-euro payment is available to the beneficiary in less than ten seconds, simulating a cash payment where both parties are required to be present to settle the transaction. Although speed in retail payments has been recognised as the new normal, recent experience has showed that both time and effort must be spent so that end users start adopting instant payments in their daily transactions (Hartmann et al. 2019). Payments in d-euro would cost much less than TARGET2 customer payments (also suffering from operational time limitations), would not suffer from fragmentation like the various interbank solutions offered by local Automated Clearing Houses (ACH)s[81] (usually also operating only during TARGET2 hours) and would thus comprise one instant, stable, efficient, and user-friendly pan-European payment solution.

The 1:1 parity rule: d-euro supply is perfectly elastic, as d-euro is issued and exchanged at par with the other forms of central bank money (Stournaras 2018). Therefore, converting commercial bank deposits into d-euro should be the same as withdrawing cash (in this context, EUR 100 of commercial bank deposits are exchanged for DEUR 100 instead of banknotes). Thus, the parity rule ensures that a credit risk-free d-euro could be seen as a secure store of value equal to a commercial bank deposit (since they trade at par without entailing any credit risk), as a stable unit of account (since central banks issue the d-euro and commercial banks provide it), and as a low-cost medium of exchange (parity ensures that euro and d-euro purchase the same quantity of goods and services) (Meaning et al. 2018). In other words, d-euro is a stable, secure and easy to use form of money. Additionally, the imposed ceiling on the amount of the d-euro allocated could be seen as adding stability to the financial market, creating fairness to society, and minimising the likelihood of a digital bank run.

Based on these attributes, the next section analyses how the proposed d-euro should be implemented in order to improve the efficiency of the system and promote widespread adoption and usage. In this context, Figure 3 presents the key benefits of d-euro deriving from the aforementioned design features.

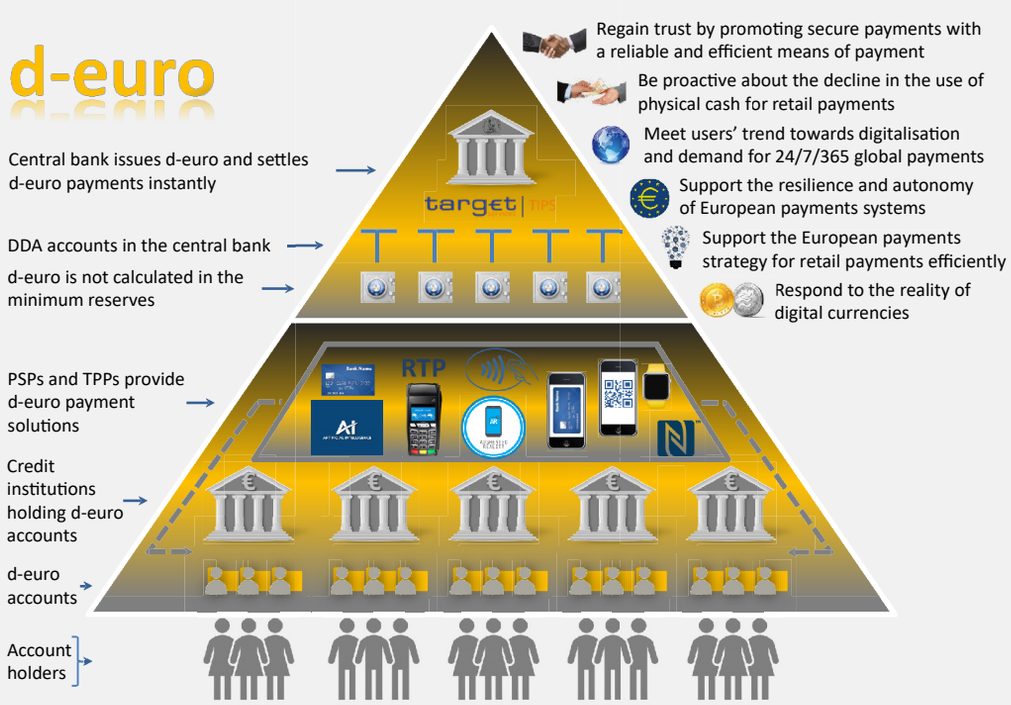
Technical design: d-euro issuance follows the structure of the two-dot model shown in Figure 4. The upper layer of the pyramid is occupied by central banks, which are both d-euro issuers and TIPS operators. However, households and enterprises cannot open accounts directly with the central bank and consequently a commercial bank acts as an intermediary to enable their access to central bank money. In order to issue d-euro, central banks have to meet three main objectives: first and foremost, to act as operators, overseers and catalysts of retail payments systems; second, to set limits on d-euro accounts; and, third, to settle d-euro transactions in real time via TIPS. While these three objectives are complementary, they also form three distinct steps of the technical design. Central banks have to convince the public to show confidence and trust in d-euro as a settlement asset. Hence, in their capacity as operators, they provide accounts and settlement-related services; as overseers, they promote and ensure the safety and efficiency of payment systems and instruments; and finally as catalysts, they prevent market fragmentation and ensure a level playing field for both end users and service providers. In short, central banks' aim will be to create a meaningful and secure d-euro ecosystem.

The importance of imposing limits on individual d-euro holdings and the associated policy implications have already been discussed in this paper. Such individual limits have to be determined and adjusted if deemed necessary by the central banks (Chiu et al. 2019; Bindseil 2020). These limits are subject to change according to the amount of banknotes in circulation, financial market conditions, and cer-

81 In Greece, DIAS supports the IRIS Online Payments solution that enables the immediate execution of interbank fund transfers within Greece.

Figure 3 The key benefits of d-euro

Figure 4 The two-dot model



tain indices of inequalities across EU countries. The proposed limit has been set up to DEUR 4,000 per active[82] person and retiree[83]. Assuming a euro area population of 342 million[84] people whereby 228 million are active persons and retirees[85], the total amount of initial d-euro supply is estimated at around EUR 912 billion. Inactive persons younger than 15 years shall not be eligible to hold d-euro accounts. During episodes of financial crisis, enterprises may be allowed to hold d-euro accounts (for monetary policy purposes e.g. helicopter money) but in normal circumstances the default limit is zero since the main objective of the d-euro is to maximise the effectiveness of households' retail payment transactions. The proposed amount of DEUR 4,000 lies between the value of per capita payments with cards issued by resident PSPs (EUR 5,300) and the value of per capita cash withdrawals at ATMs provided in the euro area by resident PSPs (EUR 1,110)[86]. Thus, it is calculated on the basis of the use of cash, which is currently the dominant instrument in proximity retail payments in the euro area, and of cards, which form the most popular electronic means of retail payments at POI in the euro area (46%). In addition, the proposed ceiling of DEUR 4,000 per capita, summing up to EUR 912 billion for the euro area, seems at present an estimated amount that covers the basic retail payment needs of a household when currency in circulation (EUR 1.2 trillion) averages EUR 5,300 per active person and retiree, and the average monthly net income in the euro area after deducting the average monthly saving rate (of 13%)[87] amounts to EUR 1,400. However, the above number should be subject to increase in countries with higher average net income or if currency in circulation is perceived to decline in the euro area (to below DEUR 912 billion), the reason being that some households do not top up their d-euro accounts or some elderly people use d-euro only as a store of value.

TIPS provides a harmonised and standardised pan-European service that settles instant payments in central bank money. It is available 24/7/365 and hosts euro dedicated cash accounts (TIPS DCAs) and (in our model) d-euro dedicated digital accounts (TIPS DDAs)[88]. D-euro would be the second currency settled on the TIPS multi-currency platform.[89] TIPS DDAs, unlike TIPS DCAs, are not linked to the unique payment account of TARGET2 (PM account) responsible for the management of liquidity, and their balance will not count towards the fulfilment of the minimum reserve requirements and excess reserves (Barrdear and Kumhof 2016; Bjerg 2017; Brunnermeier and Niepelt 2019). However, any existing (or future) participant in TARGET2 is seen as an eligible TIPS DDAs holder. Moreover, TIPS allows for three types of participation:[90] (i) participants, i.e. PSPs eligible to open a PM TARGET2 account; (ii) reachable parties, i.e. entities able to access a participant's TIPS DCA in order to settle payments in TIPS; and (iii) instructing parties, i.e. entities or third parties authorised by participants or reachable parties to send/receive instant payments in TIPS on their behalf. Therefore, it becomes obvious that households can only perform the role of reachable party. Thus, a person who opens a d-euro account at a commercial bank,[91] in order to have access to central bank

82 Active population of an economy is the sum of employed and unemployed inhabitants.
83 Population, economic and social conditions data provided by Eurostat. Payment data provided by the Statistical Data Warehouse (ECB).
84 https://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=demo_gind&lang=en.
85 The population aged between 15 and 64 is calculated at 160 million, while estimated retirees number 68 million.
86 The distribution of euro banknotes to households is made via ATMs and commercial bank branches.
87 Source: https://ec.europa.eu/eurostat/documents/2995521/10159175/2-14012020-AP-EN.pdf/7d8ef583-6e77-99d5-779e-424de674dd5f.
88 This paper contains an abridged description of how a DDA fits into the TIPS platform. However, the author, having the experience of being both T2S project manager and TIPS project manager for the Bank of Greece, is more than eager to discuss and/or provide any additional information on the technical aspects of issuing d-euro via TIPS.
89 TIPS could support cross-currency instant payment transactions. However, at the moment, legally speaking, TIPS DDAs, just as TIPS DCAs, fall under the legal and operational perimeter of TARGET2 as defined in the revised TARGET2 Guideline.
90 In the future, a fourth type of participation may be added, called "Ancillary System", in order to allow ACHs to interact with TIPS.
91 Participation in TIPS is not mandatory by the Eurosystem. However, participation in TIPS was proposed to be a mandatory application requirement concerning DDA openings by the significant entities directly supervised by the ECB.

money, will automatically become a reachable party to TIPS with a predefined payment capacity limit. Local ACHs[92] could assume an important role in achieving settlement of instant d-euro payments by acting, based on a contractual agreement, as the instructing party of a participant. Thus, TIPS seems the optimum solution for d-euro settlement, as it provides pan-European reachability,[93] settles instant payments in central bank money with high processing capacity, guarantees security and around-the-clock availability, and meets growing consumer demand for secured instant payments with a potential global acceptance[94].

The role of commercial banks in the two-dot model is to provide the new ecosystem with the know-how and best practices that they have accumulated from the existing euro ecosystem, e.g. the client interface, KYC procedures and front-end innovative payment solutions[95]. On the other hand, households substitute their commercial bank deposits with d-euro ones up to the imposed ceiling. We assume that, up to a certain estimated limit (in our model the d-euro supply is a policy choice after assessing the consequences for monetary policy and financial stability), the d-euro will not significantly affect the size of commercial banks' balance sheets but only their composition, as end users substitute euro deposits with d-euro ones. As a result, households' disposable liquidity remains unchanged, while they make an important efficiency gain[96]. With d-euro replacing only a part of physical cash, we do expect a "stolen benefit"[97] effect since, given households' d-euro limit and income constraint, an increase in d-euro will probably only reduce cash withdrawals from ATMs. Citizens wishing to open d-euro accounts in order to initiate instant payments in central bank money will have to address to the commercial banks where they already hold accounts (payroll or savings accounts). Commercial banks, according to the KYC guidelines, will open such accounts and provide d-euro customers and TPPs with innovative onboarding and front-end services. Thus, customers will be able to initiate d-euro payments following modern and innovative solutions thanks to the use of open APIs and user-friendly interfaces even in a post-PSD2 era. In the default version, d-euro accounts will be credited or debited during the processing of a retail payment transaction or liquidity transfer via TIPS, and P2P payments will be processed anonymously. Anonymity, as well as privacy and data protection are provided by commercial banks. As already stated, d-euro is semi-anonymous and therefore payers do not reveal their identity to the intermediaries. Anonymity is achieved by mapping the account holder's personal information to random unique alphanumeric characters that are used in the payment message[98]. Finally, when a d-euro payment is requested, commercial banks debit the ordering customer's account, and transfer the instructed d-euro amount via the central

92 To date, ACHs cannot open a TIPS account since they have to adhere to the SCT Inst scheme, which is restricted only to PSPs (SCT Inst Rulebook). In addition, it was suggested that ACHs cannot open an ASI6 RT technical account for settling d-euro since d-euro instant payments will strictly be processed within the perimeter of TARGET2.

93 TIPS is an extension of TARGET2 and is based on the SCT Inst scheme.

94 TIPS participated in the proof of concept for SWIFT gpi, needing only 0.06 seconds to process a transaction.

95 For enterprises, commercial banks could support electronic invoicing presentment and payment (EIPP) solutions both at the domestic and the European level.

96 Legally, households (acting as reachable parties) own the liquidity of the commercial bank's DDA (in any other DCA in TARGET2, the owner of the liquidity is the commercial bank). Therefore, the total liquidity on the DDA is independent of the main account and cannot be a subject to a change triggered by the TIPS participant (for example to provide a loan).

97 The "stolen benefit" is a term coined by the author in the periodic exhibition of the Bank of Greece's museum ("e-payments: a road map") to describe the inverse relationship between the use of two substitute means of payments. During the Greek crisis, households had to a great extent adapted to conducting electronic payments. However, this relative increase in card payments (from 23,4% in 2015 to 52,6% in 2018 as a percentage of the total number of payments) was not accompanied by a concurrent decrease in cash withdrawals from ATMs but by a decline in the use of other electronic means of payments (mainly credit transfers).

98 A new global messaging standard, known as "ISO 20022", although it contains the identity of the parties involved in the transaction (the names of the initiator and of the beneficiary are mandatory message fields), can facilitate more structured identity fields. Thus, in order to keep anonymity, the sender's field is populated with the special alphanumeric characters provided by the ordering institution. This proxy is only known to the latter and the central bank and remains unknown to the receiver (a cryptographic key is required to open the message). As a result, only central banks can fully trace the transfers of funds in order to prevent, investigate and detect money laundering and terrorist financing. In specific cases such as tax payments, it will be possible to use tax identification codes with the initiator ID instead of the anonymous proxy and hence to remove anonymity.

bank's platform to the recipient's d-euro account[99].

The two-dot model is an efficient approach to conducting d-euro retail payments. It provides pan-European reach, and boosts convenience, safety and efficiency by driving central banks, commercial banks, TPPs, and ACHs to offer a superior payment experience. In this model, the initial use of d-euro as a retail payment medium serves as a stepping stone to become the new cash of a digitalised ecosystem. Additionally, we have faced a number of challenges concerning the aforementioned features[100]. For example, due to policy considerations, central banks may increase the d-euro limit to avoid creating a shortage of minimum reserves[101]. The presented model guarantees a high level of efficiency and ensures the safety and smooth operation of payment systems by defining specific roles for all parties involved in the payment chain and the d-euro ecosystem. However, further research is warranted in order to facilitate its adoption and implementation.

5 CONCLUSION

The widespread use of digital technology has radically reshaped the way we share and exchange information, as well as how we engage in transactions and perceive payments. Accordingly, the ECB has acknowledged that greater attention should be paid to the front-end sector of European retail payment systems, with a view to protecting its strategic autonomy and resilience and to enhancing the international role of the euro. Nowadays, the ECB has started weighing the costs and benefits of issuing a CBDC, as well as analysing its feasibility and merits. In this context, we started our analysis by comparing CBDC with the currently existing forms of money in order to highlight its property of convertibility, which constitutes the crucial building block of our model as it leaves the quantity of central bank money unaffected.

CBDC is the digital cash issued by a central bank for use in payments and settlement. This paper presented a retail account-based CBDC, where the latter is provided indirectly to the public by commercial banks via commercial bank accounts. We argued that this type of CBDC involves a public-private partnership whose effectiveness is enhanced by establishing a separate and distinct role for each stakeholder.

This paper analysed four main motivations: (i) the issue of trust and the digital transformation of the economy; (ii) the decline in the use of cash; (iii) financial stability considerations; and (iv) monetary policy considerations. We have concluded that central banks have to act proactively instead of adopting a defensive stance towards a downward trend in cash use. D-euro is to play a rather minor role in monetary policy implementation and financial stability considerations since it is likely to be irrelevant to

99 Assuming that a DEUR 20 payment is initiated. The commercial bank of the payer (B_p) instructs (via TIPS) the central bank to pay DEUR 20 (debiting its TIPS DDA_p) to the commercial bank of the beneficiary (B_b) (crediting TIPS DDA_b). The central bank debits the B_p's account with DEUR 20 and accordingly the B_p debits the payer's account with DEUR 20. Simultaneously, the central bank credits the B_b's account with DEUR 20 and accordingly the B_b credits the beneficiary's account with DEUR 20. Furthermore, let's assume that a household triggers a liquidity transfer of EUR 40 from its deposit account to its d-euro account. In that case, B_p orders the central bank to debit its RTGS DCA_p (simultaneously reducing the available liquidity in its main account and hence its reserves) with EUR 40 and to credit its TIPS DDA_p with DEUR 40. Therefore, while the household's liquidity remains the same, there are only a change in the composition of central bank money and a decrease in the commercial bank's reserves.

100 Paraphrasing Lancastrian demand theory, the two-dot model has been carefully designed by predicting demand on the basis of certain d-euro features (attributes) in order to make it households' preferable means of payment in a retail payment. Deciding on the desirability of individual d-euro features, our motivation has been to achieve widespread adoption and hence to create strong network effects and boost the effectiveness of the system. One may argue that proposing a low limit is not the most desirable feature, compared with a private issuer (with no imposed limits) or SEPA Inst (with a limit of up to EUR 100,000), since some users may find d-euro restrictive in their desired purchases. However, in our model, limits are subject to change according to the foregoing argumentation. In addition, there is a possibility for a certain limit to the provision of full anonymity (the proposed amount was EUR 500 following the Greek ceiling on cash payments), as presented by the author at the 2nd EUROchain Hackathon.

101 The ECB requires commercial banks established in the euro area to hold minimum reserves. However, when central banks increase the d-euro supply (and assuming that households top up their d-euro account up to the new ceiling), a shortage of liquidity (reserves) is created. This happens because households transfer liquidity from deposits to d-euro accounts (both held with the same commercial bank). This conversion of commercial bank money into central bank money is mapped by a transfer from the TARGET PM account (Main Cash Account – MCA) after the T2-T2S consolidation) to the TIPS DDA. In normal financial conditions, central banks use open market operations (OMO) to supply commercial banks with the necessary liquidity (increasing reserves).

inflation targeting. However, it may be used as a direct channel through which central banks can transmit monetary policy decisions to households and enterprises.

An account-based d-euro has to follow six principles: (i) semi-anonymity (d-euro should be semi-anonymous due to AML concerns); (ii) trust (digital trust is issued directly by central banks); (iii) scalability (it should form the cornerstone of the efforts to respond to modern technological challenges, as well as to enhance the position of the euro as an international currency); (iv) interest rate neutrality (it should be interest rate-free and hence unfitting as a monetary policy tool); (v) acceptance (it should be used by payment solutions that offer pan-European reachability and possible global acceptance); and (vi) convenience (it should be tailor-made according to customers' demands for convenience, speed, and efficiency). We argued that the aforementioned principles also constitute the key benefits of the d-euro.

When issuing d-euro, central banks have to consider how to fulfil their mandate of providing safe, stable, efficient, reliable and secure payment systems. We presented a framework to study the specific attributes of an ideal account-based d-euro and we proposed the technical design of a two-dot model. Additionally, we showed how d-euro should be implemented in order to improve the efficiency of the payment infrastructure and to promote its widespread adoption and usage. That being said, given the introduced technical design, we discussed the importance of imposing limits on individual d-euro holdings, as well as the associated policy implications. Specifically, we proposed a concrete non-binding limit that is subject to change depending on the amount of banknotes in circulation, financial market conditions, and certain regional inequality indices.

We proposed TIPS as the harmonised and standardised pan-European service that settles instant payments in d-euro. TIPS is available 24/7/365 and d-euro would be the second currency settled on its multi-currency platform, where commercial banks would hold d-euro dedicated digital accounts (TIPS DDAs), and households may connect too as reachable parties. We have concluded that, as the present DLT technology is not mature enough, TIPS seems the optimum solution for settlement in d-euro, as it provides pan-European reachability, settlement in central bank money, high processing capacity, security and around-the-clock availability, and meets growing consumer demand for secured instant payments and global acceptance.

Central banks offer the back-end solutions and are the guarantors of anonymity. On the other hand, the role of commercial banks is to provide the new ecosystem with their know-how and best practices. Our model clarifies the provision of anonymity, as well as of privacy and data protection. We have concluded that the two-dot model is an efficient approach to conducting d-euro retail payments. It provides pan-European reach, and boosts convenience and safety by driving all participating stakeholders (central and commercial banks, TPPs, and ACHs) to offer a superior payment experience. According to our understanding, d-euro could be used initially as a retail payment medium and serve as a stepping stone towards becoming the new digital cash.

Central banks have been responding to the fact that digital currencies are part of the global monetary system. Thus it is in their interest to ensure that they are not left behind in the technology race. Whether or not d-euro will be the next step in the evolution of money is subject to further analysis. Issuance of such a currency should contribute towards the autonomy and the resilience of the European payment ecosystem as well as a climate-neutral and digital Europe. This paper argues that d-euro may be the answer to central banks' concerns about the issuance of a digital medium of payment.

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WORKING PAPERS (JANUARY – JULY 2020)

This section contains the abstracts of Working Papers authored by Bank of Greece staff and/or external authors and published by the Bank of Greece. The unabridged version of these texts is available on the Bank of Greece's website (www.bankofgreece.gr).

CONTENTS

Perceived vs actual financial crisis and bank credit standards: is there any indication of self-fulfilling prophecy?

Working Paper No. 277
Dimitrios Anastasiou, Zacharias Bragoudakis and Stelios Giannoulakis

The authors link senior bank loan officers' responses regarding their decisions for bank credit standards, from successive rounds of the European Bank Lending Survey, to investigate two important issues. First, they examine the relationship between bank credit standards (CS) and perceived and actual financial crisis. Second, they investigate whether the notion of the self-fulfilling prophecy is applicable in the case of the 2008 global financial crisis. In particular, the second main research question that they try to answer is whether the perceived crisis (as implied by the Google search query "financial crisis") contributed to the acceleration of the outburst of the actual crisis. The authors find that both perceived and actual financial crisis affect senior bank loan officers' credit standards, with the actual crisis having the greatest impact. These results are consistent both in the short and in the long run. Finally, by putting forward a binary choice model the paper finds sufficient evidence to support the Self-Fulfilling Prophecy notion.

The effect of Emergency Liquidity Assistance (ELA) on bank lending during the euro area crisis

Working Paper No. 278
Heather D. Gibson, Stephen G. Hall, Pavlos Petroulas, Vassilis Spiliotopoulos and George S. Tavlas

The paper examines the impact of emergency liquidity assistance (ELA) on bank lending in eleven euro area countries during the financial crisis. With the intensification of the crisis, ELA took on a pivotal role in some countries. However, assessments of the quantitative impact of ELA in the literature are nonexistent. The authors estimate a structural panel model for the determination of bank lending, which includes the amount of ELA received by each bank, allowing them to investigate the direct effect of ELA on lending. The model corrects a misspecification found in the prototype model used in the literature. The authors then undertake a VAR analysis, which allows them to address the effect of ELA on GDP. Finally, they examine spillover effects among banks, indicating that ELA generated positive spillovers to other banks.

On the controversy over the origins of the Chicago Plan for 100 percent reserves

Working Paper No. 279
George S. Tavlas

The idea of 100 percent reserve requirements against demand deposits received a renewed impetus following the 2007-08 financial crisis. In 1933, a group of University of Chicago economists, led by Frank Knight and Henry Simons, circulated two memoranda that called for 100

percent reserve requirements. The idea became known as the Chicago Plan of Banking Reform. That same idea had been proposed in 1926 by Frederick Soddy, a Nobel Laureate in chemistry, in his book *Wealth, Virtual Wealth and Debt*. Soddy claimed precedence, a claim that caught on. The paper provides evidence showing that Knight, and probably Simons, conceived the idea of 100 percent reserves prior to the publication of Soddy's 1926 book. By 1934, however, Simons raised concerns that 100 percent reserves would not be sufficient in a world where financial markets could innovate around legal restrictions on banks.

A study of the effect of data transformation and "linearization" on time series forecasts. A practical approach

Working Paper No. 280
Alexandros E. Milionis and Nikolaos G. Galanopoulos

Very often in actual macroeconomic time series there are causes that disrupt the underlying stochastic process and their treatment is known as "linearization". In addition, variance non-stationarity is in many cases also present in such series and is removed by proper data transformation. The impact of either (data transformation – linearization) on the quality of forecasts has not been adequately studied to date. This work examines their effect on univariate forecasting considering each one separately, as well as in combination, using twenty of the most important time series for the Greek economy. Empirical findings show a significant improvement in forecasts' confidence intervals, but no substantial improvement in point forecasts. Furthermore, the combined transformation-linearization procedure improves substantially the non-normality problem encountered in many macroeconomic time series.

Did the absence of a central bank backstop in the sovereign bond markets exacerbate spillovers during the euro area crisis?

Working Paper No. 281
Heather D. Gibson, Stephen G. Hall, Deborah GeFang, Pavlos Petroulas and George S. Tavlas

The euro area sovereign debt crisis was characterised by feedback loops between (1) sovereign bond ratings and sovereign spreads in single jurisdictions and (2) sovereign spreads and ratings among jurisdictions. One explanation of this circumstance is that the ECB was unable to perform the role of lender of last resort in the sovereign bond markets during the crisis. The authors provide a spatial framework that allows distinguishing among European countries whose central banks were permitted to function as lender of last resort in those markets and countries whose central banks were not permitted to do so. Their results are consistent with the view that the absence of a central bank backstop in the sovereign bond markets exacerbated feedback loops.

A suggestion for a Dynamic Multi Factor Model (DMFM)

Working Paper No. 282
Heather D. Gibson, Stephen G. Hall and George S. Tavlas

The authors provide a new way of deriving a number of dynamic unobserved factors from a set of variables. They also show how standard principal components may be expressed in state space form and estimated using the Kalman filter. To illustrate their procedure they perform two exercises. First, they use it to estimate a measure of the current account imbalances among northern and southern euro area countries that developed during the period leading up to the outbreak of the euro area crisis, before looking at adjustment in the post-crisis period. Second, they show how these dynamic factors can improve forecasting of the euro-dollar exchange rate.

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