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Quarterly Report on the Euro Area

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- **The structural economic impact of the Covid-19 pandemic on the euro area: a literature review** by Maya Jollès and Eric Meyermans
- **Economic impacts of climate change and mitigation** by Anna Dimitríjevics, Björn Döhring, János Varga and Jan in 't Veld
- **Fiscal policy reactions to the uncertainty of fiscal outcomes** by Philipp Mohl and Gilles Mourre
- **Economic benefits of the euro** by Paul Brans, Ulrich Clemens, Christina Kattami and Eric Meyermans

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Economic and Financial Affairs

The **Quarterly Report on the Euro Area** is written by staff of the Directorate-General for Economic and Financial Affairs. It is intended to contribute to a better understanding of economic developments in the euro area and to improve the quality of the public debate surrounding the area's economic policy.

DISCLAIMER

The views expressed are the author's alone and do not necessarily correspond to those of the European Commission.

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Maarten Verwey
Director-General

The euro area economy remains firmly in the grip of the COVID-19 pandemic and very high short-term uncertainty continues to interrupt the recovery. However, the rapid development of vaccines and roll-out of a vaccination strategy offers a positive perspective in the medium term. Reflecting on the challenges once the pandemic has subsided and laying the foundations for a more modern and more sustainable euro area is now a clear priority for policy makers.

This Quarterly Report on the Euro Area (QREA) covers a variety of research topics of direct relevance. More specifically, it reviews the literature on the structural economic impact of the COVID-19 pandemic, provides an assessment of the economic impact of climate change and mitigation, analyses the impact of the uncertainty of fiscal outcomes on expected fiscal efforts, and presents a retrospective on benefits of the euro.

The first section provides a literature review of the structural economic impact of COVID-19 once the pandemic has subsided. Downside risks include scarring effects caused by the underutilisation of labour, bankruptcies, lack of private sector investment and disruptions to value chains. Upside risks stem from the acceleration of digital applications such as the expansion of digital workplaces, e-commerce and FinTech services. The review also suggests that investments that accelerate the replacement of old and polluting infrastructure with modern, clean and efficient solutions across all sectors could significantly reduce the downside risks and strengthen the upside ones.

The second section examines the economic impact of climate change and mitigation. A literature review reveals that our ability to quantify the economic impact of climate change is still incomplete, and considerable uncertainty remains. Based on current knowledge, and in view of the severe downside risks, ambitious mitigation policies are warranted to reach the goals of the Paris Agreement. Simulations with a new version of the Commission's QUEST model suggest that, depending on how carbon tax revenues are used, pricing carbon may achieve decarbonisation at little aggregate economic cost. The most beneficial scenario in terms of GDP effects is through recycling of carbon revenues into subsidies on the purchase of clean capital and capital tax reduction.

The third section analyses the impact of the uncertainty of fiscal outcomes on the expected fiscal effort in EU Member States. This section introduces four key indicators to measure the uncertainty of fiscal outcomes. The analysis indicates that Member States tend to react late and asymmetrically to forecast errors: relaxing their fiscal efforts when there are positive surprises and leaving them unchanged when the surprises are negative. While the analysis is backward looking, these findings are especially important for the recovery in view of the sustainability risks which policy makers will face going forward.

The fourth section describes how euro area Member States and their citizens have benefited from the euro since its launch more than 20 years ago. While the section highlights some of the tangible benefits and opportunities, it also recognises that the full potential of the single currency has not yet fully realised because of an incomplete EU architecture. Completing the Banking Union and Capital Markets Union, an economic governance framework that reflects the challenges the euro area is facing, further deepening of the Single Market, and collective actions to strengthen the role of the euro internationally will remain on the policy agenda after the crisis is over.

Although the future remains uncertain and the pandemic is not yet fully under control, now is the time to rise to the challenges that the COVID-19 legacy will pose. The EU response strategy to COVID-19 does not only offer a number of short-term instruments but also focuses on re-building a stronger and more resilient euro area. The various sections in this QREA illustrate some aspect of this reflection for a better long-term strategy.

I. The structural economic impact of the COVID-19 pandemic on the euro area: a literature review

By Maya Jollès and Eric Meyermans

This section provides a brief literature review of the structural economic impact of the COVID-19 pandemic on the euro area. The pandemic and the risk of its recurrence are expected to increase private savings and lower private investment and in so doing exert additional downward pressure on interest rates and inflation. Downward risks to the well-functioning of markets are expected to stem from scarring effects caused by the underutilisation of labour and capital, lack of investment and distortions of global supply chains. Upward risks are expected to arise from the acceleration of the ongoing transformations such as digital workplaces, e-commerce and FinTech services. A recovery path out of the COVID-19 crisis based on a large-scale economic transformation that favours the green and digital transition is generally expected to temper the adverse legacy of the COVID-19 crisis ([1]).

I.1. Introduction

The COVID-19 pandemic represents a major global shock of unseen speed and intensity. On impact, it had a direct adverse effect on economic activity as its spread was being contained by social distancing and lockdowns that severely hindered the capacity of economic agents to consume and produce. The outcome was an unprecedented contraction in output and international trade across the globe as illustrated by, for instance, the economic forecasts reported by several international institutions ([2]).

At the same time, the pandemic's impact was not spread evenly as infection rates differed markedly across countries, while countries' capacity to withstand this shock also differed notably - as documented by, for instance, the European Commission (2020) and the OECD (2020) ([3]).

Based on a literature review, this section provides an assessment of the structural economic impact of the COVID-19 pandemic on the euro area once the pandemic has subsided.

The review suggests that there is a broad consensus in the economic literature that the COVID-19 pandemic and its possible recurrence will have a lasting impact on fundamental macro-economic factors such as potential output and economic resilience via various transmission channels that do not all point in the same direction.

The following four sections summarise the main macro-economic channels through which the pandemic is expected to leave its mark, i.e. macroeconomic stability, the well-functioning of product, labour and financial markets as well as international trade.

Important structural economic changes that are expected to persist include the expansion of digital workplaces, e-commerce and FinTech services, as well as the changes in production networks and risk of rising inequality. While these structural changes create both down- and upward risks, many of them are not new. What is different is how fast some of the underlying developments have accelerated and interact.

The sixth section reviews briefly the literature on how to re-ignite growth, in a sustainable and inclusive way, and overcome scarring effects in the aftermath of the pandemic. The last section draws some conclusions.

It should be noted that until there is a better sense of when and how the COVID-19 crisis will be resolved, the subsequent analysis will be tentative and very time-sensitive. Therefore, it may be

([1]) The authors wish to thank Moises Orellana, Erik Canton, Martina Krobath, Mirko Licchetta, Kieran Mcmorrow, Allen Monks, Plamen Nikolov, Silwia Nowak, Alessio Terzi and Bořek Vašíček and an anonymous reviewer for useful comments. The drafting of this section was finalised on January, 4 2021.

([2]) See for instance European Commission (2020), Autumn 2020 Economic Forecast: Rebound interrupted as resurgence of pandemic deepens uncertainty, International Monetary Fund (2020), World Economic Outlook,. A Long and Difficult Ascent, International Labour Organisation (ILO) (2020), COVID-19 and the world of work, World Trade Organisation (WTO) (2020), COVID-19 and world trade.

([3]) European Commission (2020), *op. cit.* and OECD (2020), 'The territorial impact of COVID-19: Managing the crisis across levels of government', *OECD Policy Responses to Coronavirus (COVID-19).*

subject to (major) revisions as new important information becomes available ([4]).

I.2. Macro-economic stability challenges

One of the most severe crises ([5])

The pandemic has had a strong impact on the macro-economic aggregates. For instance, the available data show that the household savings rate rose sharply across the euro area in the wake of the pandemic, up from 12.5 % of gross disposable income in the last quarter of 2019 to 24.5% in the second quarter of 2020. See Graph I.1.

At the same time the investment rate of firms fell from 25.6% of gross value added in the last quarter of 2019 to 23.19% in the second quarter of 2020. See Graph I.1.

For 2020 and 2021, the increase in private savings is forecast to largely outweigh the increase in private savings observed during the global economic and financial crisis, i.e. 5¾ pps. versus 1¾ pps. of GDP respectively ([6]).

Simultaneously, public borrowing and debt (as percentage of GDP) increased sharply during the pandemic and are forecast to rise respectively from 0.6% of GDP in 2019 to 8.8% in 2020 and from 85.9% of GDP in 2019 to 101.7% in 2020 ([7]).

Looking forward

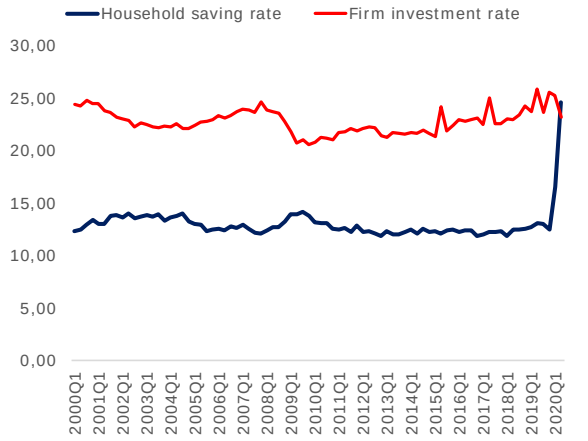
There is a strong expectation in the economic literature that the COVID-19 outbreak and the fear of its recurrence will lower private investment and increase private savings even after the pandemic has phased out. At the same time, the public sector is expected to come under increasing pressure to deleverage its debt. However, there is no consensus in the literature on its pace.

It is also broadly agreed that while the pandemic affected some Member States more than others, the euro area's overall external position is expected to remain fairly stable as the rest of the world experiences similar pressures. However, the risk of getting trapped in a deflationary spiral ([8]) may intensify if the private sectors' skewed savings-investment balance does not get corrected.

I.2.1. Persistently weaker private sector investment

The pandemic is expected to have a persistent negative impact on private investment for several reasons. First, Malmendier and Nagel (2020) ([9]) argue that the propensity to invest decreases persistently in the face of major shocks as risk taking such as investment decisions is strongly affected by life-time experiences.

Graph I.1: **Household saving rate and firm investment rate – euro area**



(1) Seasonally adjusted. The household saving rate is defined as gross saving, which is not spent as final consumption expenditure divided by gross disposable income. The firm investment rate is defined as gross fixed capital formation (buildings, machinery etc.) divided by gross value added of non-financial corporations.
Source: Eurostat, National Accounts (nasq_10_ki).

Furthermore, the surge in corporate indebtedness following the lockdown may also hamper future investments as it hinders a smooth access to capital

([4]) Apart from the usual lags in the release of data to the public, the statistical authorities face serious constrains collecting and processing data in the traditional manner such as face-to-face interviews. See Eurostat's COVID-19: support for statisticians https://ec.europa.eu/eurostat/data/metadata/covid-19-support-for-statisticians.

([5]) De Grauwe, P. and Y. Ji (2020), 'A tale of three depressions', VoxEU.

([6]) European Commission (2020), 'The 2020 Stability & Convergence Programmes', An Overview, with an Assessment of the Euro Area Fiscal Stance, *Institutional paper* No.131

([7]) European Commission (2020), *op. cit.*

([8]) For instance, Fornaro, L. and., M. Wolf (2020), 'Covid-19 Coronavirus and Macroeconomic', *CEPR Discussion Paper* No. DP14529, argue that with interest rates hitting their lower-bound, self-fulfilling pessimistic animal spirits triggered by the pandemic may drive the economy towards an equilibrium of low growth and high unemployment.

([9]) Malmendier, U. and S. Nagel (2020), 'Depression Babies: Do Macroeconomic Experiences Affect Risk-Taking?', *NBER Working Paper* No. 14813

markets and bank funding (Mersch (2020)) ([10]). For instance, Revoltella et al. (2020) estimate that the pressure of deleveraging and hence reducing the debt accumulated during the pandemic will result in private investment falling at around twice the fall recorded during the financial crisis, when corporate investment fell by 19% ([11]).

The pandemic also reduces the labour supply ([12]) without a parallel destruction of capital as happens during wars or natural disasters. As such, private investment is expected to decrease as the return on capital falls (Jordà et al. (2020)) ([13]).

In addition, the pandemic has accelerated the use of digital technologies, such as teleworking and e-commerce ([14]). As such, massive investments in physical capital such as offices and brick-and-mortar retailers could go down if these changes in work organisation would persist (Bloom et al. (2015)) ([15]). Although investments in ICT platforms will increase, they are generally less capital-intensive than investments in physical infrastructure (as shown in analyses relative to capital intensity by sector).

Even so, the productivity of the existing capital stock is likely to decline as the lockdown left it unused. This will then reduce the incentive for investment. At the same time, new innovative firms may be prevented from entering the market and investing as their access to capital would remain weak in the wake of the pandemic (ECB (2020)) ([16]).

I.2.2. Persistently higher private savings rates

Conversely, while pent-up demand may decrease temporarily household savings once the restrictions are fully lifted, precautionary savings will remain high for some time (Dossche and Zlatanos (2020)) ([17]) - in line with an overall rise in uncertainty about future income and employment (Campos and Reggio (2015)) ([18]). Nevertheless, the phasing out of income support measures and business failures that would further raise unemployment may force households to save less.

Moreover, continued voluntary social distancing in the post-COVID-19 economy could temper social consumption. The effect of this could then be propagated to the rest of the economy via input-output linkages between sectors, as for instance, less restaurants visits will reduce demand for maintenance and repair services for dishwashers (Guerrieri, et al. (2020)) ([19]).

I.2.3. The public debt legacy of COVID-19

While private sector investment has decreased and private sector savings have increased during the pandemic, public expenditures have increased sharply and tax revenue dropped notably. Governments have helped credit-constrained but viable firms to survive, supported households hardest hit, and increased expenditures on health care ([20]). At the same time, public revenues have decreased following a sharp fall in economic activity, further aggravated by tax reliefs and payment holidays. Simultaneously nominal GDP has contracted sharply, so that fiscal deficits and public debt as a percent of GDP have increased notably in several Member States, see Graph I.2.

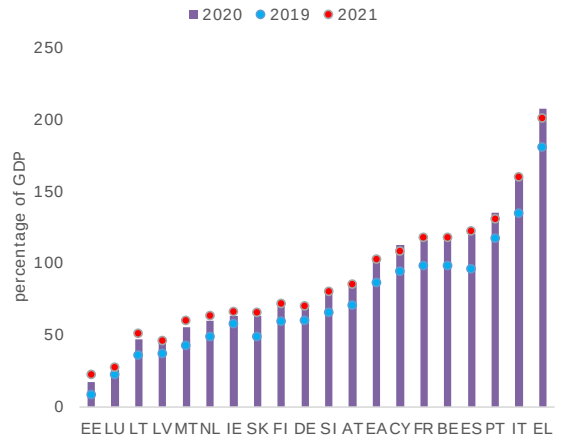
Several authors (e.g. Grund, et al. (2020)) ([21]) argue that once the COVID-19 pandemic has subsided, the sharp increases in public debt carry the risk that either some Member States do not spend as much as needed, or they spend as much as needed but then face high debt and market risks.

([10]) Mersch, Y. (2020), 'The World Economy Transformed', speech delivered at the Reinventing Bretton Woods Committee Webinar Series.
([11]) Revoltella, D., L. Maurin and R. Pal (2020), 'After COVID -19: How can we support investment without excessive debt?', European Investment Bank.
([12]) As discussed below, a distinction can be made between temporary (e.g. sick leave/travel restrictions for cross-border workers) and permanent losses (mortality impact of pandemic, though mostly affected are older people) in labour supply.
([13]) Jordà, O., Singh, S. and A. Taylor (2020), 'The Long Economic Hangover of Pandemics, History shows COVID-19's economic fallout may be with us for decades', *IMF Finance & Development*, Vol. 57, No. 2, pp.
([14]) See sub-sections 3 and 4 below.
([15]) Bloom, N. et al. (2015), 'Does Working from Home Work? Evidence from a Chinese Experiment', *The Quarterly Journal of Economics*, Vol. 122, No. 4, pp. 1351-1408.
([16]) ECB (2020), Survey on the access to finance of enterprises
([17]) Dossche, M. and S. Zlatanos (2020), 'COVID-19 and the increase in household savings: precautionary or forced?', *ECB Economic Bulletin*, Issue 6.
([18]) Campos, R. and I. Reggio (2015), 'Consumption in the shadow of unemployment', *European Economic Review*, Vol. 78, pp. 39-54.
([19]) Guerrieri, V., Lorenzoni, G., L. Straub, and I. Wernin (2020), 'Viral recessions: Lack of demand during the coronavirus crisis', *VoxEU*.
([20]) European Commission (2020), 'COVID-19: Commission sets out European coordinated response to counter the economic impact of the Coronavirus', and Lane, P., 'The Monetary Policy Package: An Analytical Framework', *ECB Blog*
([21]) Grund, S., L. Guttenberg and C. Odendahl (2020), 'Sharing the fiscal burden of the crisis: A Pandemic Solidarity Instrument for the EU', *VoxEU*.

It is also expected that fiscal measures to boost demand and flank structural reforms will become more effective in the first years after the pandemic as more people are allowed to leave their homes and go back to work (Gopinath (2020)) ([22]).

Even so, some authors (e.g. Krugman (2020) ([23])) argue that strong public spending could help reverse the trend towards secular stagnation, especially as long as the annual cost of servicing the debt is below nominal GDP growth. Nevertheless, a strong fiscal stimulus could stoke expectations of future fiscal consolidation, thereby tempering its boosting effect (Bartsch et al. (2020)) ([24]).

Graph I.2: **Public debt**



(1) General government consolidated gross debt: excessive deficit procedure.
Source: AMECO.

I.2.4. Uncertain inflation dynamics

While disinflationary pressures have been at play since the onset of the global financial crisis, there is a consensus in the economic literature that the COVID-19 pandemic and its possible recurrence may reinforce ongoing disinflationary pressures.

In the short run, the rate of price inflation may slow down for several reasons, ([25]) such as a widening negative output gap, rising unemployment, and falling commodity prices as stressed by the IMF (2020) ([26]).

In the medium term, as uncertainty is expected to continue to put downward pressure on expenditures such as investment and consumption, Blanchard (2020) ([27]) expects that inflationary pressures arising from excess aggregate demand should be unlikely.

However, pent-up demand could temporarily stoke inflationary pressures. Even so, if some sectors would already be operating at full capacity, then untargeted demand stimulus could increase inflationary pressures. Conversely, targeted policies that stimulate spending in demand-constrained sectors could increase output without raising prices excessively (Baqaee and Farhi (2020)) ([28]).

The upward inflation risk could strengthen if a series of (recurrent) virus-related negative supply shocks such as disruptions in global value chains were to reduce potential growth permanently (IMF (2020) ([29]); or if trade barriers imposed in the wake of the pandemic were to persist (Panetta, F. (2020)) ([30]).

Even so, Goodhart (2020) ([31]) argues that a strong increase in the velocity of money, which may occur when people have more opportunities to spend money, could give rise to significant inflationary pressures.

([22]) Gopinath, G. (2020), 'Limiting the Economic Fallout of the Coronavirus with Large Targeted Policies', *IMF Blog*
([23]) Krugman, P. (2020), 'Notes on the Coronacoma (Wonkish)', New York Times Blog
([24]) Bartsch, E., Boivin, J., Fischer, S. and P. Hildebrand (2020), 'Dealing with the next downturn: From unconventional monetary policy to unprecedented policy coordination', *SUERF Policy Note*, Issue No 105
([25]) It is a challenge to measure inflation when expenditures on some consumer items such as restaurants and tourism are rationed significantly. For instance, using real-time scanner data in UK, Jaravel, X. and M. O'Connell (2020), 'Real-time inflation measurement during COVID-19', report that once they take account of reduced product variety, month-to-month inflation in the first month of lockdown increased by over 3 percentage points relative to the same month in prior years.
([26]) IMF (2020), 'Global Prospects And Policies', chapter 1 in *World Economic Outlook*, May 2020.
([27]) Blanchard, O. (2020), 'High inflation is unlikely but not impossible in advanced economies', *PIIE RealTime Economic Issues Watch*.
([28]) Baqaee, D, and E Farhi (2020), 'Supply and Demand in Disaggregated Keynesian Economies with an Application to the Covid-19 Crisis', *NBER Working Paper* No. 24007.
([29]) International Monetary Fund (01/04/2020) at https://blogs.imf.org/2020/04/01/economic-policies-for-the-covid-19-war/
([30]) Panetta, F. (2020), 'The price of uncertainty and uncertainty about prices: monetary policy in the post-COVID-19 economy', keynote speech at a Capital Markets webinar organised by the European Investment Bank and the European Stability Mechanism.
([31]) Goodhart, C. (2020), 'Inflation after the pandemic: Theory and practice', *VoxEU*. He notes that since the emergence of the pandemic the velocity of broad money has been decreasing just about as fast as its overall supply has been increasing. The former was triggered by increased uncertainty and because people could not spend their money on social consumption such as tourism and restaurants.

Last but not least, persistent low inflation rates also carry the risk of a long-term de-anchoring of inflation expectations, possibly pushing the economy into a deflationary spiral in the face of a new anti-inflationary shock (Lane (2020)) ([32]).

I.2.5. Very low interest rates persist

Extra downward pressure on interest rates

Before the outbreak of the COVID-19 pandemic, nominal interest rates were already low mainly due to too-low inflation and subdued growth reinforced by adverse demographic developments (e.g. Ferrero et al. ([33])). By leaving policy rates close to the zero lower bound and providing extra liquidity with unconventional monetary policies, the monetary authorities aimed at averting the risk of deflation (Draghi (2016) ([34])).

If low private investment and high private savings persist, then they may continue to put downward pressure on interest rates (The Economist (2020) ([35])). However, some argue that strong increases in public debt may exert an upward pressure on interest rates (e.g. Cochrane (2020) ([36])) and raise the risk of an adverse feedback loop between high public debt and the risk premium (Lian et al. (2020) ([37])).

Important macro-economic feedbacks

Nominal interest rates close to their effective lower bound may have important macroeconomic feedbacks of an ambiguous nature. On the one hand, lower interest rates may stimulate economic activity as it lowers financing costs for investment, raises asset prices that stimulate private consumption and may trigger higher multipliers for government expenditure and investment (Di Serio et al. (2020)) ([38]). Once negative, interest rates may incentivise high cash-holdings firms to reduce their liquid assets and invest more in tangible and intangible assets (Altavilla et al. (2019)) ([39]).

On the other hand, however, Brunnermeier and Koby (2019) ([40]) argue that very low or negative nominal interest rates may have a negative impact on bank sector stability, the cleansing of "zombie" firms, as well as on the effectiveness of monetary policy because the pass-through of policy rates to loan rates is lower at lower rates. In turn, this may lower economic activity.

Furthermore, low interest rates may support the survival of nearly-insolvent firms especially in the presence of inefficient insolvency procedures and weak banks that continue to lend to nearly-insolvent firms (Schnabel (2020)) ([41]). This could then create excess capacity, postpone the reallocation of resources, and crowd out lending to more productive firms (Andrews and Petroulakis (2019)) ([42]). However, compared with the global financial crisis such risks are assessed to be low as the pandemic is hitting firms in sectors that are generally viable, and banks have high capital positions so that they are less prone to "zombie" lending (Laeven et al. (2020)) ([43]).

In addition, Lane (2020) ([44]) argues that if market interest rates are very low then the short-term

([32]) Lane, P. (2020), 'Low inflation: macroeconomic risks and the monetary policy stance', keynote speech at the financial markets workshop of the Economic Council.

([33]) Ferrero, G., M. Gross and S. Neri (2017), 'On secular stagnation and low interest rates: demography matters', ECB Working Paper Series No. 2088.

([34]) Draghi M. (2016), 'Addressing the causes of low interest rates', speech delivered at the Annual Meeting of the Asian Development Bank, Frankfurt am Main, 2 May 2016.

([35]) The Economist (2020), 'The eternal zero', Special report October 8 2020.

([36]) Cochrane, J. (2020), 'The Grumpy Economist: Perpetuities, debt crises, and inflation', linking inflation referring to the fiscal theory of inflation whereby unsustainable public debt and persistent structural deficits require at some time in the future strong inflation to lower the real debt burden. In turn, this would then trigger monetary authorities to raise interest rates.

([37]) Lian, W, Presbitero A. and U. Wiriadinata (2020), 'Public Debt and r-g at Risk', IMF Working Paper 20/137

([38]) Di Serio, M., Fragetta, M. and E. Gasteiger (2020), 'The Government Spending Multiplier at the Zero Lower Bound: Evidence from the United States', *Oxford Bulletin of Economics and Statistics*, Vol. 82, No. 6, pp. 1262-1294.

([39]) Altavilla, C., Burlon, L., Giannetti, M. and Holton, S. (2019), 'Is there a zero lower bound? The effects of negative policy rates on banks and firms', ECB Working Paper Series, No 2289.

([40]) As discussed by Brunnermeier, M. and Y. Koby (2019), 'The Reversal Interest Rate', *NBER Working Paper No. 25406*., the "reversal interest rate" is the rate at which accommodative monetary policy reverses and becomes contractionary for lending. Its determinants are i) banks' fixed-income holdings, ii) the strictness of capital constraints, iii) the degree of pass-through to deposit rates, and iv) the initial capitalisation of banks.

([41]) In combination with inefficient insolvency procedures and weak banks that continue to lend to weak firms. See, for instance, Schnabel, I. (2020), 'Narratives about the ECB's monetary policy – reality or fiction?', speech delivered at the Juristische Studiengesellschaft 11/02/2020.

([42]) Andrews, D. and F. Petroulakis (2019), 'Breaking the shackles: Zombie firms, weak banks and depressed restructuring in Europe', *ECB Working Paper Series* No 2240.

([43]) Laeven, L., G. Schepens and Il Schnabel (2020), 'Zombification in Europe in times of pandemic', *VoxEU*.

([44]) Lane, P. (2020), 'The monetary policy toolbox: evidence from the euro area', keynote speech at the 2020 US Monetary Policy Forum.

policy interest rate will hit its effective lower bound more often and remain longer at this bound.

Furthermore, ESRB (2016) ([45]) highlights that low interest rates increase risk-taking by banks, making the bank sector more vulnerable to shocks ([46]).

Finally, low interest rates may weaken the intermediary function of the financial sector, because low interest rates compress banks' net interest margins ([47]), so that they may try to restore profits by increasing fee income and cut costs including human resources that are crucial for intermediation.

I.3. Product markets: uneven sectoral disruptions and innovations

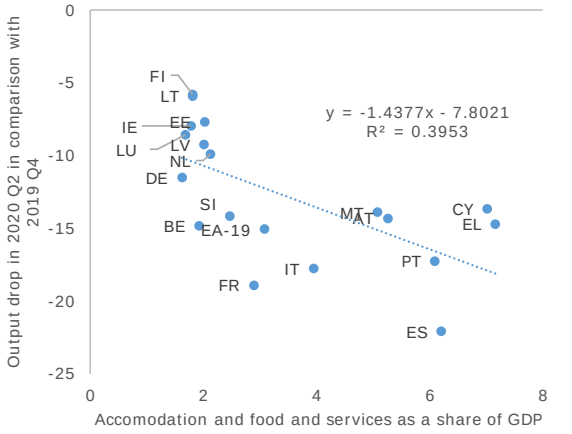
Economic activity in the euro area fell dramatically with euro-area GDP in the second quarter of 2020 14.8% below its level in the second quarter of 2019. The sectors hardest hit were entertainment and recreation down by almost 27% as well as retail trade, transport, accommodation and food services down by about 25%.

Structural changes in product markets that will affect potential output once the pandemic has subsided include: (i) a change in sectoral composition, (ii) the accelerated use of digital platforms, (iii) disrupted global value chains and (iv) a heterogeneous, uncoordinated mix of national state aid programmes.

I.3.1. Sectors set to struggle in the wake of the pandemic

Two types of sectors were especially hard hit by the pandemic: (i) the sectors highly integrated in GVCs ([48]), and (ii) many 'contact-intensive' sectors ([49]) such as hospitality or collective transport (e.g. airlines) where physical proximity is hardly avoidable. The former are likely to be more resilient as they depend less on the movement of people ([50]). While strongly affected by the first lockdown measures, these companies have adapted to carry on their activities during the resurgence of the virus ([51]). Conversely, some 'contact-intensive' sectors, such as the healthcare sector ([52]), experienced notable growth during the pandemic.

Graph I.3: **Share of accommodation and food in 2018 relative to the fall in GDP in the second half of 2020**



Source: Eurostat.

The Member States with the strongest specialisation in accommodation and food services, such as Greece Cyprus, Spain or Portugal, experienced the strongest output contraction (and thus also loss of revenues) in the first half of 2020. See Graph I.3.

Furthermore, McKinsey & Company (2020) ([53]) estimate that the COVID-19 recovery could take

([45]) ESRB (2016), 'Macroprudential policy issues arising from low interest rates and structural changes in the EU financial system'.

([46]) Such risk taking can take many forms such as increasing the duration of bond portfolios, stronger reliance on wholesale funding markets (if deposit rates cannot drop below zero) or lending more to emerging economies yielding a higher return but also a higher risk. See for instance IMF (2017), 'Low Growth, Low Interest Rates, and Financial Intermediation', Chapter 2 in *Global Financial Stability Report* April 2017.

([47]) While lower interest rates may raise the value of banks' assets, such one-off effects will dissipate if low interest rates persist and risk taking will increase.

([48]) OECD (2020), 'COVID-19 and global value chains: Policy options to build more resilient production networks', *OECD Policy Responses to Coronavirus (COVID-19)* and OECD (2020), 'Evaluating the initial impact of COVID-19 containment measures on economic activity', *OECD Policy Responses to Coronavirus (COVID-19).*

([49]) There are different terminologies that have appeared in the economic literature that looked at the sectoral impact of the pandemic in 2020: 'contact-intensive', 'nonessential client-facing', 'pandemic-sensitive', 'virus-sensitive', 'person-to-person', 'face-to-face' (etc…). They regroup the sectors, which are the least 'essential' and were more directly affected by the lockdowns. The COVID-19 virus has affected them more directly because of the physical proximity that such activities imply.

([50]) European Commission Summer 2020 (Interim) forecast and Miroudot, S. (2020), 'Resilience versus robustness in global value chains: Some policy implications', *VoxEU.*

([51]) Hatzius J. (2020), 'Global Views: Cavalry Coming', *Goldman Sachs Economic Research*

([52]) The healthcare sector is projected to increase by around 0.6 % of EU GDP in 2020. See, European Commission (2020),'Identifying Europe's recovery needs', SWD(2020) 98 final.

([53]) McKinsey & Company (2020), 'US small-business recovery after the COVID-19 crisis'.

more than 5 years in hardest-hit sectors. Many in those industries are small businesses.

Such dramatic product market disruptions may trigger adverse scarring effects as they can force viable firms to close, leading to a permanent loss of firm-specific human capital (Graham et al. (2013)) ([54]) as well as organisational capital (Stiglitz (2020)) ([55]).

At the same time, they may prevent new innovative firms from entering the market as their access to capital or intermediary inputs gets cut off when firms have to close or reduce production ([56]). Moreover, such disruptions may also weaken investment in R&D and foreign direct investment (Dieppe (ed., 2020)) ([57]).

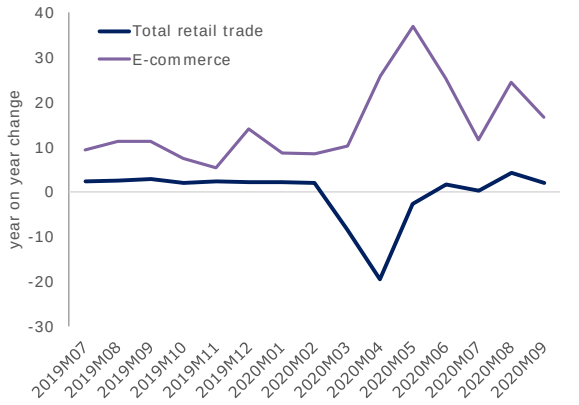
I.3.2. Increased use of e-commerce

Lockdowns, social distancing and closure of borders increased online sales. For instance, internet retail trade across the European Union peaked in May 2020 at 37% above its May 2019 volume, but it levelled off afterwards. See Graph I.4.

Moreover, depending on individual characteristics, such as income level or concerns about health, the propensities to purchase online had been very divergent (Unnikrishnan and Figliozzi, (2020) ([58])). More particularly, house deliveries were more limited among households who were cost-conscious, while households concerned about health were more likely to spend more online and have more home deliveries.

An increased use of e-commerce is expected to have an important structural impact on the well-functioning of product markets. First, it may intensify competition in product markets (Goolsbee and Klenow (2018) ([59])). As a consequence, (relative) prices may show a stronger responsiveness to changes in demand and supply improving the transmission of the information necessary to reallocate production factors in the face of shocks (Cavallo (2018) ([60])).

Graph I.4: **Impact of the COVID-19 crisis on retail trade in the euro area**



(1) Turnover in constant prices; year on year change.
Source: Eurostat.

Furthermore, e-commerce makes demand for goods and services less vulnerable to domestic idiosyncratic shocks, because it lowers search and transaction costs as well as the cost incurred by firms when changing prices (Cavallo and Rigobon, 2016) ([61]). It also provides firms with more geographically diverse and stable markets.

A strong uptake in e-commerce is also likely to accelerate structural changes in other parts of the economy, such as the labour market, especially in the logistics sector and affect urban planning and the environment ([62]). However, network effects in e-commerce ([63]) could also lead to market concentration and market dominance that undermines price flexibility (Schnabel (2020)) ([64]).

([54]) See for instance Graham J., K. Hyunseob K., S. Li and J. Qiu, 2013. 'Human Capital Loss In Corporate Bankruptcy', Center for Economic Studies, *U.S. Census Bureau Working Papers* 13-37.
([55]) Stiglitz, J. (2020), 'Priorities for the COVID-19 Economy', *Project Syndicate.*
([56]) Such as limited access to credit and capital during an economic downturn its aftermath
([57]) Dieppe, A. (ed., 2020), Global Productivity. Trends, Drivers, and Policies.
([58]) Unnikrishnan A. and M. Figliozzi, (2020), 'A Study of the Impact of COVID-19 on Home Delivery Purchases and Expenditures' *Portland State University Working Paper, 2020.*
([59]) Goolsbee, A. and P.J. Klenow (2018), 'Internet Rising, Prices Falling: Measuring Inflation in a World of E-Commerce', *NBER Working Paper* No. 24649.
([60]) Cavallo, A. (2018), 'More Amazon Effects: Online Competition and Pricing Behaviors', Paper prepared for the 2018 Jackson Hole Economic Policy Symposium, September 7, 2018.
([61]) The so-called 'menu' costs. Cavallo, A. and R. Rigobon (2016), 'The Billion Prices Project: Using Online Prices for Measurement and Research', *Journal of Economic Perspectives*, Vol. 30(2), pp. 151-78.
([62]) Pettersson F., L. Winslott Hiselius and T. Koglin (2018), 'E-commerce and urban planning – comparing knowledge claims in research and planning practice', Urban, Planning and Transport Research
([63]) Network effects imply that the larger the number of users on a platform, the larger the benefits it produces for all users.
([64]) Whereby large cash-rich firms absorb liquidity-strapped start-ups, see, for instance, Schnabel (2020), *op. cit.*

I.3.3. Reorientation of international trade

By 2019, more than two-thirds of world trade occurred through global value chains (GVCs) (World Bank (2019)) ([65]). However, in the wake of the pandemic, international trade contracted sharply as firms and borders were closed, giving rise to notable changes in both the level and composition of international trade ((Jean (2020)) ([66]) and (World Economic Forum (2020)) ([67])).

More particularly, the World Trade Organization (WTO) ([68]) expects a significant downturn in global trade of 9.2% in 2020 and an increase of 7.2% in 2021. Transport equipment and electrical machinery turn out to be hardest hit (DG TRADE's Chief Economist (2020)) ([69]), and trade will likely contract the most in sectors with complex value chains (WTO (2020)) ([70]).

It is widely agreed in the literature that one of the legacies of the pandemic may be that lead firms of global value chains will bring the critical elements of the production process closer to home (World Economic Forum (2020)) ([71]), or preserve the long chains but start to accumulate strategic reserves of vital intermediary inputs and diversify suppliers (Seric and Winkler (2020)) ([72]).

Moreover, there is also the risk that if the political equilibrium were to shift towards a more protectionist stance, then the temporary measures to slow the spread of the virus would persist (Baldwin (2020)) ([73]).

In a European context, Javorcik (2020) ([74]) expects that it is primarily the countries located in Eastern Europe and the Southern Mediterranean that will benefit from 're-shoring' or 'near-shoring'. While not necessarily offering the lowest costs, they can offer geographical proximity as well as a more stable and predictable environment (notably in terms of trade policy).

However, shorter and less complex global value chains may reduce countries' opportunities to specialise in those activities in which they have a comparative advantage, which lowers overall productivity. Nevertheless, at the same time shorter GVCs may create more incentive to better integrate emerging technologies (Vyas, (2016)) ([75]), such as machine learning, 3-D printing ([76]) and robotics. However, it is an empirical matter to determine which of these factors will dominate.

I.3.4. State aid and increased importance of the public sector

During the pandemic, state aid has aimed to support those hardest hit companies that were viable. In practice, the support provided under the temporary state aid framework has differed strongly across the euro area ([77]). In addition to state aid, euro-area governments have also increased their shares in private companies.

However, the support in Member States depends highly on their available fiscal capacity (Motta and Peitz (2020) ([78])). As such, it may generate unfair competitive advantages or interference with business decisions (Abate et al. (2020)) ([79]),

([65]) See for instance World Bank (2019), 'Global Value Chain Development Report 2019: Technological Innovation, Supply Chain Trade, and Workers in a Globalized World'. This outcome was mainly driven by innovations in communication and coordination technologies starting in the early 1990s as well as by reduced trade barriers and decreases in transportation costs.

([66]) Jean, S. (2020), 'How the COVID-19 Pandemic Is Reshaping the Trade Landscape and What to Do About It', *Intereconomics*, Vol. 55, No. 3, pp. 135–139.

([67]) World Economic Forum (2020), 'Managing COVID-19: How the pandemic disrupts global value chains'.

([68]) https://www.wto.org/english/news_e/pres20_e/pr862_e.htm

([69]) DG TRADE's Chief Economist (2020), The impact of the Covid-19 pandemic on global and EU trade, April 2020

([70]) WTO (2020), *op. cit.*

([71]) World Economic Forum (2020), 'Coronavirus is disrupting global value chains. Here's how companies can respond'.

([72]) Seric and Winkler (2020), 'COVID-19 could spur automation and reverse globalisation – to some extent', *VoxEU*.

([73]) Baldwin, R. (2020), 'Hysteresis in Globalisation: What will COVID have wrought?',doi: https://julkaisut.valtioneuvosto.fi/bitstream/handle/10024/162224/VN_2020_13_Liite2_Baldwin.pdf?sequence=3&isAllowed=y.

([74]) Javorcik B, (2020), 'Global supply chains will not be the same in the post-COVID-19 world' in Baldwin, R. and S. Evenett (eds., 2020), *COVID-19 and Trade Policy: Why Turning Inward Won' Work*, VoxEU.

([75]) Vyas, N. (2016), 'Disruptive technologies enabling supply chain evolution', *Supply Chain Management Review*, pp. 36-41.

([76]) 3-D printing, which represents less than 0.1% of global manufacturing revenues, has a potential for penetration in mainstream industries, which is still unclear; see Cernat, L. (ed., 2020), 'Trade policy reflections beyond the COVID19 outbreak', Chief Economist Note DG Trade (European Commission), Issue 2, June 2020

([77]) European Commission (2020), 'Coronavirus Outbreak - List of Member State Measures approved under Articles 107(2)b, 107(3)b and 107(3)c TFEU and under the State Aid Temporary Framework'

([78]) Motta, M. and M. Peitz (2020), 'State Aid Policies in Response to the COVID-19 Shock: Observations and Guiding Principles', *Intereconomics*, Vol. 55, No. 4, pp. 219–222.

([79]) Abate, C, A Elgouacem, T Kozluk, J Stráský and C Vitale (2020), 'State ownership will gain importance as a result of COVID-19', *VoxEU*

adversely impacting the well-functioning of the Single Market.

Moreover, as argued by the OECD (2020) ([80]), it may also increase moral hazard risks unless governments impose strict recovery plans on the firms benefiting from these interventions, set clear conditions for exit from state ownership, and rely on independent advisory to ensure sound valuations of investments and divestments.

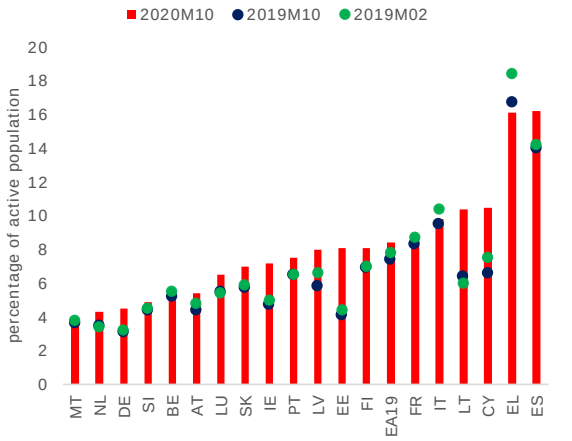
I.4. Labour markets: possible scarring effects and digital uptake

Following the outbreak of the pandemic, strict lockdown measures affected directly the functioning of labour markets. However, the increases in unemployment were less sharp than the drops in output, but the hours worked dropped notably in some Member States ([81]) while youth unemployment (15-24) increased markedly and the share of young people not in employment nor in education or training (NEET) soared ([82]). Such an outcome was partly triggered by the strong uptake of short-time working arrangements and temporary lay-offs (European Commission (2020) and Dias da Silva et al. (2020) ([83])).

Furthermore, work organisation changed dramatically as a large part of the work force started to telework (Pierri and Timmer (2020)) ([84]); but not all workers were affected in the same way (European Commission (2020) and Eurofound (2020)) ([85]).

The channels through which recent labour market developments may affect potential output well beyond the current pandemic include: i) digitalisation of the work place, ii) human capital formation, and iii) increased inequality of opportunity and income.

Graph I.5: **Unemployment rate – euro area**



(1) EE and EL 2020 M09 instead of 2020 M10.
Source: Eurostat (une_rt_m).

I.4.1. Accelerated digitalisation of work organisation

While the introduction of ICT applications in the workplace has been a gradual process since the late 1980s, (voluntary and involuntary) teleworking surged during the pandemic, though with strong differences across Member States and sectors.

For instance, by early April 2020 ([86]) slightly more than 60% of employed persons started to work from home in Finland in comparison to 15.2% before the Pandemic. On the other side of the spectrum, the shares of employed persons teleworking are much smaller in Slovenia (23%) and Greece (26%), but much higher than before the outbreak of the pandemic (8.6% in Slovenia and 11.7% in Greece) ([87]). See Graph II 6.

([80]) See, for instance, OECD (2020), 'The COVID-19 crisis and state ownership in the economy: Issues and policy considerations', *OECD Policy Responses to Coronavirus (COVID-19)*.

([81]) The activity rate (age group 20-64) dropped by 1.6% while total hours worked saw a sharp reduction of some 12.8% in Q2 2020. See European Commission (2020), 'Analysis of the euro area economy', SWD/2020/276.

([82]) The quarterly NEET rate increased up to 12% in the euro area in Q2-2020 (from a minimum of 9.9% in Q2-2019).

([83]) European Commission (2020), *Proposal for a Joint Employment Report 2021*, and Dias da Silva, A., M. Dossche, F. Dreher, C. Foroni and G. Koester (2020), 'Short-time work schemes and their effects on wages and disposable income', *ECB Economic Bulletin*, Issue 4/2020.

([84]) Pierri, N. and Y. Timmer (2020), 'IT Shields: Technology Adoption and Economic Resilience during the COVID-19 Pandemic', *IMF Working Paper* WP/20/208 estimate for the US that if the pandemic had hit the world 5 years ago, the resulting unemployment rate would have been 2 percentage points higher during April and May 2020 (16% vs. 14%), due to the lower availability of IT.

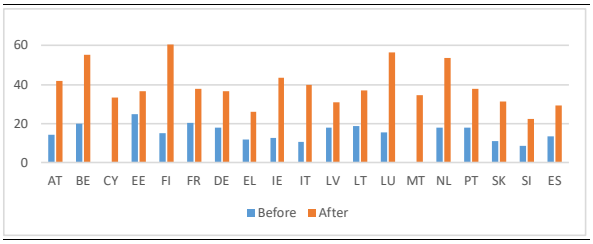
([85]) Eurofound (2020), Living, working and COVID-19, *COVID-19 series*.

([86]) See, Eurofound (2020), Living, working and COVID-19 dataset, Dublin. As indicated in the introduction, this section provides recent evidence within the limits set by data availability. As of August 2020, there were no more recent telework data available.

([87]) Eurostat (2020), *op cit.* identifies several factors driving this diverse outcome across Member States, including a country's affinity for technology; the availability and quality of its technological infrastructure; management culture and the drive for higher productivity within companies; and employees' needs for spatial and temporal flexibility to balance work demands with family commitments and other personal responsibilities.

The uptake in teleworking was strongest in sectors with better educated, high-paid employees, and weakest in sectors with mainly manual employees such as agriculture, construction, industry or personal care sectors (European Commission (2020), Eurofound (2020), Brynjolfsson et al. (2020) and Bartik (2020)) ([88]).

Graph I.6: **Work from home: before versus after the COVID-19 crisis**



Source: Eurofound (2020), Living, working and COVID-19 dataset, Dublin, http://eurofound.link/covid19data.

Several authors argue that the intensified use of teleworking during the pandemic has accelerated its use on a permanent basis as people learned at an unprecedented pace new ways to work remotely. Businesses reorganised their operational mode and voluntary social distancing is expected to continue well beyond the acute COVID-19 phase (See Ozimek (2020), Barrero et al. (2020) and Global Workplace Analytics (2020)) ([89]).

New opportunities and challenges for employment

There is broad consensus in the literature that such changes in work organisation will have an important structural economic impact. First, an increased use of digital workplaces may raise overall labour supply as it facilitates the labour market participation of the older workers, workers with family responsibilities or workers with disabilities (European Commission (2015)) ([90]).

In addition, such work arrangements give more autonomy and responsibility to workers, while facilitating new forms of contractual arrangements, such as iPros (Leighton (2015)) ([91]). With a reduction in sick-days taken by home workers, longer working time and an increased use of digital training platforms, teleworking may also raise labour productivity (Bloom (2004)) ([92]). In turn, this may then strengthen the economy's productivity and innovation capacity.

Downward risks of telework

However, the uptake of telework also presents downsides and requires careful design to maximise its benefits (OECD (2020)) ([93]). Workers' well-being may decrease because of increased spatial distance among employees or distorted work-life balance leading to hidden overtime. Telework may dampen innovation because personal interactions or exchanges of knowledge are less effective in a virtual environment.

The pandemic made also bare the insufficient levels of digital skills of adults and the wide gaps between countries (European Commission (2020)) ([94]). The risk exists that the digital work place supports job opportunities mainly for high-skilled workers or is limited to specific occupations or sectors (OECD Skills Outlook (2019)) ([95]).

Furthermore, the fear of a recurrence of the pandemic may strengthen the incentives to substitute especially low-skilled workers with computers and robots (Chernoff and Warman

([88]) Brynjolfsson, E. et al. (2020), 'COVID-19 and Remote Work: An Early Look at US Data', *NBER Working Paper* No. 27344, surveying a sample of the US population, report that US states with a higher share of employment in information work including management, professional and related occupations were more likely to shift toward working from home and had fewer people laid off or furloughed. See also Bartik, A. (2020), 'How the COVID-19 crisis is reshaping remote working', *VoxEU*.

([89]) Ozimek, A. (2020), op. cit., surveying US firms, reports that the remote working experiment has proceeded better than expected from the perspective of working conditions, and there is potential for improving productivity. Based on US survey data, Barrero, J., Bloom, N. and S. Davis (2020), 'COVID-19 and labour reallocation: Evidence from the US', *VoxEU*, report that several factors are giving teleworking a more permanent character, including a sharp fall in the stigma of working from home, huge amounts of time and resources spent to make teleworking effective, and its strong performance. Global Workplace Analytics (2020), 'Work-at-home After Covid-19—Our Forecast' estimates that 56% of the U.S. workforce holds a job that is compatible (at least partially) with remote work.

([90]) European Commission (2015), Employment and Social Developments in Europe.

([91]) Independent professionals (iPros) are self-employed without employees who are flexible and innovative and operate in high-value, high-knowledge professional sectors. See, for instance, Leighton, P. (2015), 'Future Working: The Rise of Europe's Independent Professionals (iPros)'.

([92]) Bloom, N. (2004), 'To raise productivity, let more employees work from home', *Harvard Business Review*, Vol. 92, N.1-2, pp. 28-29.

([93]) OECD (2020), Productivity gains from teleworking in the post COVID-19 era: How can public policies make it happen?', *OECD Policy Responses to Coronavirus (COVID-19)*.

([94]) European Commission (2020), 'Proposal for a Joint employment Report 2021'

([95]) OECD Skills Outlook (2019), 'Thriving in a Digital World'.

(2020)) ([96]). In addition, an increased use of teleworking may also reduce the demand for local services related to the workplace such as catering that are often delivered by low-skilled workers (Goos et al. (2014)) ([97]).

New opportunities and challenges for work organisation

Increased ICT based mobile work also creates new opportunities for offshoring and further specialisation, in as well as outside the euro area (Baldwin (2019)) ([98]). Anecdotal evidence suggests also that the pandemic has accelerated practices such as 'globotics' ([99]) making it easier to digitally outsource tasks across the world (Baldwin and Forslid (2020) and Baldwin (2019)) ([100]). Nevertheless, since services are less tradable than goods and represent only a fraction of global trade, the overall net trade effect, i.e. the balance between re-shoring and offshoring, is difficult to predict ([101]).

Furthermore, as international business travel involving face-to face contacts is an important channel for conveying specific types of knowledge, its downsizing in the expanding digital workplace may adversely affect productivity (Coscia et al. (2020) ([102])).

Finally, a more intensive use of the digital workplace will make economic activity more vulnerable to cybersecurity risks (Andrade (2020)) ([103]) but less vulnerable to other shocks such as strikes in the public transport sector.

I.4.2. Human capital formation

Challenges

The impact of the pandemic on human capital formation is ambiguous. On the one hand, the pandemic adversely affects human capital formation. First, the young generations' opportunities to learn have adversely been affected by the disruptions in the delivery of educational services (OECD (2020)) ([104]); and available evidence suggests that children with disadvantaged backgrounds are hardest hit (Schleicher (2020) ([105]) and (European Commission (2020) ([106])).

In addition, social distancing prevents workers from gaining practical experience on the work floor, while persistent unemployment spells may erode the skills of the unemployed or discourage them from searching for a job (Tumino (2015)) ([107]).

In this context, it should also be noted that the increased use of short-term working arrangements (STWA) mitigated part of the job loss and skill erosion (European Commission (2020)) ([108]) because STWAs preserve existing employer-employee relationships, provide income support and often encourage or oblige workers to take training.

However, if not well-designed such schemes may also delay the necessary structural adjustments, lead

([96]) Chernoff, A. and C. Warman (2020), 'Covid-19 and Implications for Automation', *NBER Working Paper* No. 27249, examining US data, estimate that females are in occupations that are about twice as likely at risk of disappearing in the wake of the COVID-19 pandemic and automation.

([97]) Goos, M., A. Manning and A. Salomon (2014), 'Explaining job polarization: routine-biased technological change and offshoring', *American Economic Review*, Vol. 104, No 8, pp. 2509–26.

([98]) Telemigration was already a growing trend before the COVID-19 crisis. See, for instance, Baldwin R (2019) , The globotics upheaval

([99]) I.e. telemigrants working in our offices while sitting abroad (the globalisation part), and software robots replacing particular office-tasks (the robotics part). See, Baldwin, R. (2020), 'Covid, hysteresis, and the future of work',*VoxEU*.

([100]) Baldwin, R. and R. Forslid (2020), 'Covid 19, globotics, and development', *VoxEU*, and Baldwin, R. (2019), *The Globotics Upheaval: Globalisation, Robotics and the Future of Work*, Sherdan Books

([101]) The lack of systematic data available makes it difficult to estimate and predict this phenomena, see Filippo Albertoni F., S. Elia, S. Massini, L. Piscitello (2017), 'The reshoring of business services: Reaction to failure or persistent strategy?', Journal of World Business, Volume 52, Issue 3

([102]) For instance, Coscia, M., Neffke, F., and R. Hausmann, 'Knowledge Diffusion in the Network of International Business Travel', *Nature Human Behaviour*, Vol. 4, pp. 1011–1020, provides empirical evidence that suggests that a permanent shutdown of international business travel would reduce global gross product by 17%.

([103]) Andrade, R., Ortiz-Garcés, I. and M. Cazares (2020), 'Cybersecurity Attacks on Smart Home During Covid-19 Pandemic', 2020 Fourth World Conference on Smart Trends in Systems, Security and Sustainability

([104]) Its significance is difficult to assess at the moment.

([105]) Schleicher, A. (2020), 'The Impact of Covid-19 on Education. Insights from Education at a Glance 2020', OECD.

([106]) European Commission (2020), Proposal for a Joint Employment Report 2021.

([107]) These risks are strongest for young people and increase in a non-linear way with the duration of the unemployment spell. See Tumino, A (2015), 'The scarring effect of unemployment from the early '90s to the Great Recession', *Institute for Economic and Social Research Working Paper* 2015-5.

([108]) For an overview of short-time working arrangements in the wake of the pandemic see European Commission (2020), 'Section 3.1.2. Measures taken by Member States', in *Proposal for a Joint Employment Report 2021*.

to an excessive take-up by firms ([109]), support "zombie" jobs and become an undue financial burden on national unemployment insurance schemes (European Commission (2020), Schnabel (2020) and Arpaia et al. (2010)) ([110]).

Opportunities

On the other hand, for those who stay employed, remote working could sharpen their ICT skills, which may make them also more receptive to future ICT innovations in the work place.

In addition, the pandemic also provided an impetus for the development of digital learning platforms, not only for students but also for workers, making it easier and cheaper to train workers (World Bank (2020)) ([111]).

I.4.3. Inequality and poverty

The COVID-19 pandemic affects socio-economic groups differently in terms of income and job opportunities (Furceri et al. (2020)) ([112]).

The most vulnerable groups include (i) the young as they usually face higher rates of unemployment and underemployment when labour demand decreases, (ii) women as they are over-represented in more affected sectors (such as services), (iii) the self-employed, casual and gig workers as they do not have access to paid or sick leave mechanisms, and are less protected by conventional social protection mechanisms and other forms of income smoothing and (iv) migrant workers (European Commission (2020), Torrejón Pérez et al (2020) ([113]) and Hynes et al. (2020) ([114])).

These workers are also most likely to lack the financial buffers to absorb a sudden income loss (See Furceri et al.) ([115]).

If such developments were to persist, rising inequality and poverty may have an adverse structural impact (Dabla-Norris et al. (2015) and Ostry et al. (2014)) ([116]). For instance, inequality and poverty could lead to underinvestment in human capital and health for the low-income workers who would lack access to private credit or public financing for education and training. Furthermore, socio-economic instability stemming from rising inequality may also lower investment, especially foreign direct investment (ILO (2017) ([117]), or lead to higher marginal taxes that discourage innovation (Akcigit et al. (2018) and Bredemeier et al.) ([118]).

I.5. Stabilising financial markets and expanding FinTech services

The COVID-19 outbreak had an immediate adverse impact on financial markets across the globe: equity markets experienced turmoil and corporate credit markets deteriorated sharply (IMF 2020, and Roubini (2020)) ([119]). In this environment, fostering financial market stability and maintaining the supply of bank credit across

([109]) Excessive use can be tempered by experience rating schemes whereby firms contribute to the scheme on the basis of past/expected use of the scheme.

([110]) European Commission (2020), *Proposal for a Joint Employment Report 2021,* Schnabel, I. (2020), 'The ECB's policy in the COVID-19 crisis – a medium-term perspective', remarks at an online seminar hosted by the Florence School of Banking & Finance and Arpaia, A., Curci, N., Meyermans, E., Peschner, J. and F. Pierini (2010), 'Short time working arrangements as response to cyclical fluctuations' *European Economy Occasional Paper* No. 64.

([111]) World Bank (2020), 'How countries are using edtech (including online learning, radio, television, texting) to support access to remote learning during the COVID-19 pandemic'.

([112]) Furceri D., Loungani P., J.. Ostry and P. Pizzuto (2020): "COVID-19 will raise inequality if past pandemics are a guide", *VoxEU.*

([113]) Torrejón Pérez, S., Fana, M., González-Vázquez, I., and E. Fernández-Macías (2020), 'The asymmetric impact of COVID-19 confinement measures on EU labour markets', *VoxEU.*

([114]) Employees especially hard hit are those working in the gig-economy, who often work on short contracts, sometimes with weak or no social protections, and with limited options for working remotely. See, for instance, Hynes, W., I. Linkov, and B. Trump (2020), 'A Systemic Approach to Dealing with Covid-19 and Future Shocks', *OECD Policy Responses to Coronavirus (COVID-19).*

([115]) Pérez, T. et al. (2020), *op. cit.*. However, families at the bottom of the income distribution are less likely to income loss as they are also most likely not to have members in employment – as is, for instance, reported for the case of Ireland by Beirne, K et al. (2020), 'The Potential Costs and Distributional Effect of Covid-19 Related Unemployment in Ireland', *EUROMOD Working Papers* EM5/20 .

([116]) Dabla-Norris, E. et al. (2015), 'Causes and Consequences of Income Inequality: A Global Perspective', *IMF Staff Discussion Note* SDN/15/13, estimate that making the rich richer by one percentage point lowers GDP growth in a country over the next 5 years by 0.08 percentage points—whereas making the poor and the middle class one percentage point richer can raise GDP growth by as much as 0.38 percentage points. See also Ostry, J., A. Berg and Ch. Tsangarides (2014), 'Redistribution, Inequality, and Growth', *IMF Staff Discussion Note* SDN/14/02.

([117]) International Labour Organisation (2017), *World Employment and Social Outlook*: Trends 2017.

([118]) Akcigit, U. et al. (2018), 'Taxation and Innovation in the 20th Century', *NBER Working Paper* No. 24982 and Bredemeier, C., Juessen, F. and R. Winkler (2020), 'Cutting labour taxes brings back the jobs lost to COVID-19', *VoxEU.*

([119]) IMF (2020), 'Economic Policies for the COVID-19 War', *IMF Blog,* and Roubini (2020), 'A Greater Depression?', *Project Syndicate.*

the euro area were high on the agenda of policy makers (Lagarde (2020) and Lane (2020) ([120])).

While it is too early to assess the full impact of the COVID-19 pandemic on the amount of non-performing loans (NPLs) ([121]), it is to be expected that NPL resolution could be fast if these NPLs mainly relate to viable illiquid firms, rather than unviable "zombie" firms as was the case of the global financial crisis (Ari et al. (2020)) ([122]). However, banks' NPL ratios are expected to increase once debt moratoria and liquidity support schemes for corporates expire.

At the same time, the pandemic has also accelerated the transition towards digital financial services, especially digital payment triggered by an increased online shopping as well as the fear that the virus could be spread by cash (Carletti, et al. (2020)) and Auer et al. (2020)) ([123]). For instance, SPACE survey data indicate that by July 2020, 40% of the respondents replied that they had used less cash since the start of the pandemic, and almost 90% of them stated that they would continue to pay less with cash after the pandemic was over ([124]).

Habit formation and network effects are likely to trigger self-reinforcing increases in FinTech services as they lower costs and increase acceptability of digital currencies (Crouzet et al. (2019), Fernandez et al. (2020) Auer et al. (2020)) ([125]).

In turn, this increased use of digital financial services is expected to affect how and where economic agents consume, produce and sell goods and services. This will then create new opportunities and challenges.

Opportunities

FinTech services such as digital payment systems may facilitate cross-border trade, and provide firms and households access to a more diversified supply of credit at a lower cost (IMF (2017)) ([126]).

Moreover, FinTech services also have the potential to promote access to financial services by under-served groups (Sahay et al. (2020) ([127])), better and more tailored banking services, lower transaction costs, faster banking services, and increased competition leading to lower prices (Basel Committee on Banking Supervision (2018)) ([128]).

In addition, as these FinTech innovations also entail a shift from paper to digital cash, monetary policy's effectiveness could strengthen as the effective lower bound on interest rates would become less binding (Mancini-Griffoli et al. (2018) and Rogoff (2016)) ([129]).

Challenges

However, ongoing developments in FinTech services accelerated by the pandemic may also carry downward risks in terms of competition, financial stability, consumer protection and cybersecurity.

Network effects could lead to the emergence of dominant platforms for digital (cross-border) payment. Such dominant positions could then adversely affect competition and innovation in

([120]) Lagarde, C. (2020), 'How the ECB is helping firms and households', *ECB Blog*, and Lane, P. (2020), 'The monetary policy response to the pandemic emergency', *ECB Blog*.

([121]) Non-performing loans (NPLs) tend to lag GDP growth by 12-18 months as estimated at https://www.eib.org/en/readonline-publications/covid-econ-weekly-briefing-15-april.htm

([122]) Ari, A., Chen, S. and Ratnovski, L. (2020), "The dynamics of non-performing loans during banking crises: a new database", *ECB Working Papers* No 2395, label NPL levels "high" once NPLs exceed 7% of total loans.

([123]) Carletti, E., Claessens, S., Fatás, A. and X. Vives (2020), 'The Bank Business Model in the Post-Covid-19 World', Centre for Economic Policy Research and Auer, R., Cornelli, G. and J. Frost (2020), 'Covid19, cash and the future of payments', *BIS Bulletin* No 3, pp. 1-7.

([124]) ECB (2020), Study on the payment attitudes of consumers in the euro area (SPACE).

([125]) See for instance Crouzet et al. (2019), Fernandez, S., Jenkins, P. and B. Vieira (2020), 'Europe's digital migration during COVID-19: Getting past the broad trends and averages', *McKinsey Digital*, and Auer, R., Cornelli, G. and J. Frost (2020), 'Rise of the central bank digital currencies: drivers, approaches and technologies', *BIS Working Papers* No 880.

([126]) IMF (2017), 'FinTech and Financial Services: Initial Considerations', *IMF Staff Discussion Note*, SDN/17/05.

([127]) Sahay, R. et al. (2020), 'The Promise of FinTech Financial Inclusion in the Post COVID-19 Era', *IMF Monetary and Capital Markets Department Paper* No. 20/09

([128]) Basel Committee on Banking Supervision (2018), 'Sound Practices: implications of FinTech developments for banks and bank supervisors'

([129]) Mancini-Griffoli, T. et al. (2018), 'Casting light on central bank digital currencies', *IMF Staff Discussion Note* SDN/18/08 and Rogoff, K. (2016), *The Curse of Cash*, Princeton University Press.

finance (BIS (2019) ([130]), Carletti et al. (2020) ([131]) and Panetta (2020) ([132])).

Moreover, an increased use of digital wallets denominated in private digital currency with weak links to a sovereign currency, could weaken monetary sovereignty (Lagarde (2020) and Official Monetary and Financial Institutions Forum (2020)) ([133])).

In addition, a more pro-cyclical credit provision is likely if FinTech credit provision were to occur outside of the purview of financial regulation and supervision (FSB and BIS (2017)) ([134]).

Finally, ongoing FinTech innovations, accelerated at an unprecedented speed by the pandemic, may also carry important risks in terms of consumer protection and cybersecurity (World Bank and CCAF (2020)) ([135]). This calls then for double-pronged financial and ICT regulations that provide a better alignment of EU financial services regulation to the digital age (European Commission (2020)) ([136]) fostering secure digital services for everyone such as regulation of digital ID in FinTechs (Ehrentraud and Garcia (2020)) ([137]).

I.6. The shape of the recovery: mitigating scarring effects and strengthening growth

The previous sub-sections summarised the scarring effects and adaptation responses in labour, product and financial markets that may persist once the pandemic has subsided and may have an impact on potential output. The persistence of these effects are expected to be proportional to the speed and depth of the recovery.

Initially, the literature identified various shapes that the recovery could take, ranging from a V (e.g. Sharma et al.) ([138]) and W shape (e.g. Frankel (2020)) ([139]) to an L shape (e.g. Roubini (2020)) ([140]). However, by mid-2020, some authors (e.g. Summers (2020) ([141])) argued that the pandemic and the risk of its recurrence would reinforce secular stagnation as it increases households precautionary savings and decreases businesses investment in a persistent way (Jordà et al., (2020) ([142])). See also sub-section I.2 above.

In order to radically strengthen growth expectations and confidence and avoid secular stagnation, several authors call for a strong policy response that supports investment and innovation (e.g. Benigno et al, 2018 ([143])).

More particularly, recognising the strong synergies with other pressing major challenges such as climate change, several authors argue that targeted investments should pave the way towards a larger-scale economic transformation favouring the green and digital transitions while tempering scarring effects and promoting sustainable and inclusive growth.

For instance, the Stern–Stiglitz report ([144]) highlights that forward-looking green fiscal policies such as renewable energy investments have a high multiplier effect generating many jobs especially during their construction phase ([145]). This has then

([130]) Bank for International Settlements (BIS) (2019), 'Big tech in finance: opportunities and risks', chapter III in *BIS Annual Economic Report*, pp.55-79.

([131]) Partly steered by the BigTech companies with access to big data. See for instance Carletti, E., Claessens, S., Fatás, A. and X. Vives (2020), 'The Bank Business Model in the Post-Covid-19 World', Centre for Economic Policy Research.

([132]) Panetta, F. (2020), 'On the edge of a new frontier: European payments in the digital age', speech delivered at the ECB Conference 'A new horizon for pan-European payments and digital euro'

([133]) Lagarde (2020), *op cit.,* and Official Monetary and Financial Institutions Forum (2020), 'Digital Currencies: A question of trust'.

([134]) Financial Stability Board (FSB) and Bank for International Settlements (BIS) (2017), 'FinTech credit. Market structure, business models and financial stability implications'.

([135]) World Bank and CCAF (2020), 'The Global Covid-19 FinTech Regulatory Rapid Assessment Report', World Bank Group and the University of Cambridge.

([136]) European Commission (2020), 'Digital finance strategy for the EU', COM(2020) 591 final.

([137]) Ehrentraud J. and D. Garcia (2020), 'Managing the winds of change: policy responses to FinTech', *VoxEU*.

([138]) Sharma, D., Bouchaud, J-P, Stanislao Gualdi, M. Tarzia, and F. Zamponi (2020), 'V-, U-, L-, or W-shaped recovery after COVID: Insights from an Agent Based Model', Papers 2006.08469, arXiv.org, revised Sep 2020.

([139]) Frankel, J. (2020), 'How to Avoid a W-Shaped Recession', *Project Syndicate*.

([140]) Roubini, R. (2020), 'The Coming Greater Depression of the 2020s', *Project Syndicate*.

([141]) Summers, L. (2020), 'Larry Summers on COVID-19 and the Global Economy', Princeton Webinar on 22 May 2020,

([142]) Jordà, O eta al. (2020, op cit.

([143]) Benigno G., L. Fornaro (2018), 'Stagnation traps', Review of Economic. Studies., Vol. 85, No. 3, pp. 1425-1470.

([144]) Hepburn C, O'Callaghan B, Stern N, Stiglitz J, and D. Zenghelis (2020), 'Will COVID-19 fiscal recovery packages accelerate or retard progress on climate change?', *Oxford Review of Economic Policy*, Vol. 36, Supplement 1, pp. S359–S381.

([145]) High multipliers are also reported by Lahcen, B., Brusselaers, J., Vrancken, K., Dams, Y., Da Silva Paes, C., Eyckmans, J and S. Rousseau (2020), 'Green Recovery Policies for the COVID-19 Crisis: Modelling the Impact on the Economy and Greenhouse Gas Emissions', *Environmental and Resource Economics*, Vol. 76, pp. 731–750, who estimate that in the case of Belgium for emissions

a strong potential to limit the negative scarring effects described in previous subsections.

At the same time, a green recovery can make the most of the shifts in human habits and behaviour accelerated by the pandemic. For instance, on impact, the COVID-19 pandemic caused a notable reduction in greenhouse gas (GHG) emissions as, for instance, telework and a dramatic decrease in travelling limited transport-related emissions, i.e. GHG emissions down by 8% in 2020 in comparison to 2019 (International Energy Agency (2020)) ([146]).

However, such reductions are still too small to have an impact on climate change mitigation (Dechezleprêtre et al. (2020) ([147])). Moreover, Lahcen et al. (2020) ([148]) demonstrate, for instance in the case of Belgium, that while the COVID-19 pandemic damages economies considerably, the associated reduction in GHG emissions is less than proportionate. This is because the sectors affected most have the smallest carbon intensities.

As such, in the medium to long run, it is green investments and structural reforms that will ultimately drive the impact of the COVID-19 pandemic on climate change (Hepburn et al. (2020)) ([149]).

Moreover, in previous sub-sections, it was argued that private investment is expected to decrease in the wake of the pandemic as overall uncertainty is expected to remain high. Such underinvestment creates then opportunities for policies aimed at replacing old and polluting infrastructure with a modern, clean and efficient one without the risk of crowding out other investments ([150]).

Finally, the debate in the literature on shaping the recovery and limiting scarring effects also covers 'green money' such as green refinancing operations that provide banks with cheap funding if they lend in accordance with the EU's taxonomy of green activities (van 't Klooster and van Tilburg (2020) de Santis (2018) and Lagarde (2020)) ([151]). Though the impact of this channel is expected to remain limited ([152]).

I.7. Conclusion

This section provided a brief literature review of the structural economic impact of the COVID-19 pandemic on the euro-area economy. The literature identifies downward as well as upward risks.

The downward risks stem from factors such as scarring effects caused by underutilisation of labour and capital, bankruptcies, a lack of private sector investment and disruptions of value chains.

The upward risks stem from the acceleration of digital applications such as the increased use of digital workplaces and e-commerce, as well as from the structural reforms and policies centred around the digital and green transitions such as the European Green Deal.

The literature review suggests that addressing these risks requires (i) preserving the well-functioning markets, (ii) well-designed social and active labour market policies to support the hardest-hit and (iii) investments that accelerate the replacement of old and polluting infrastructure with modern, clean, and efficient infrastructure across all sectors that tackle the green and digital transitions in a more forceful way and at the same time limits the scarring effects of the pandemic.

to fall by 1 percentage point, GDP has to fall by 2.17 percentage points, whereas if a policy aimed at investing in the renovation of housing units is introduced GDP increases by 0.2 percentage points for each 1 percentage point reduction in emissions.

([146]) The International Energy Agency (2020), *Global Energy Review 2020* estimates that GHG emissions will have dropped by 8% in 2020 in comparison to 2019.

([147]) Dechezleprêtre, Elgouacem, Kozluk, Kruse (2020), 'COVID-19 and the low-carbon transition: Impacts and possible policy responses', OECD Policy Responses to Coronavirus (COVID-19).

([148]) Lahcen et al., *op cit.*

([149]) Hepburn et al. (2020), *op cit.*

([150]) However, it should be recognised that several other factors may also hold back private green investments during a pandemic, such as the very long time horizon of infrastructure investments, low fossil-fuel energy prices reducing the incentives for investment in low-carbon technologies or the absence of market signals such as in the case of biodiversity. See Biller, D. (2007), 'The Economics of Biodiversity Loss', in B. Lomborg (ed.), *Solutions for the World's Biggest Problems: Costs and Benefits*, Cambridge University Press.

([151]) van 't Klooster, J. and R. van Tilburg(2020), 'Targeting a sustainable recovery', Positive Money Europe, De Santis, R., K. Hettler, M. Roos, M. and F. Tamburrini (2018), 'Purchases of green bonds under the Eurosystem's asset purchase programme', ECB Economic Bulletin, Issue 7/2018, and the interview with Christine Lagarde, President of the ECB, conducted by Léa Salamé and Thomas Sotto on 4 June 2020.

([152]) De Grauwe, P. (2020), 'Green money without inflation', CEP Council on Economic Policy argues that such instruments could favour environmental investments without endangering price stability

II. Economic impacts of climate change and mitigation

By Anna Dimitríjevics, Björn Döhring, János Varga and Jan in 't Veld

For decades, economists have been studying the implications of climate change, in broad interdisciplinary cooperation with natural scientists. Despite significant advances, economic research continues to face formidable challenges. This section reviews what we know and examines the numerous and large uncertainties surrounding the economic impact of greenhouse gas emissions. Point estimates of GDP losses arising from limited climate change, as they are used in standard integrated assessment models, are typically not too large. However, they are based on partial representations of the impact channels. Moreover, the damage differs considerably across regions and income groups. Uncertainty and elements that are not covered, or only incompletely, in analyses of the cost of climate change suggest that the economic consequences of unabated greenhouse gas emissions could be dramatically worse than those point estimates. The section then goes on to provide an example of evidence-based design of climate mitigation policy. For this, it uses E-QUEST, a new version of the Commission's DSGE model QUEST, which has been developed to assess climate mitigation policies. The simulations show that pricing carbon might allow decarbonisation at little aggregate economic cost, depending on how the carbon tax revenues are used. These findings justify high ambition at all levels in operationalising climate mitigation targets such as the Paris Agreement's temperature goals and Europe's ambition to become climate-neutral by 2050. Climate change is a global challenge. Nonetheless, its impacts have specific euro-area dimensions, as they might e.g. affect economic convergence, prices or financial stability ([153]).

II.1. Introduction

Climate change has been described as 'the ultimate challenge for economics' as significant gaps in our understanding and knowledge remain, despite an impressive number of articles and studies published over the past four decades ([154]). Such gaps concern the analysis of the economic cost of greenhouse gas (GHG) emissions, the choice of effective mitigation tools, their timely implementation in view of damages that will occur with long lags as well as the coordination problem involved in tackling GHG externalities at a global level.

Any assessment of the economic impact of climate change involves both economic and bio-physical phenomena. Starting with the accumulation of GHG related to economic activity in the atmosphere, it involves understanding how the concentration of GHG in the atmosphere affects the climate ('climate sensitivity') and how atmospheric changes interact with other parts of the Earth's systems. Only then can the impact of climate change on future economic activity ('damage') be estimated. This is the subject of the literature review in the first part of this section. While the channels through which warming affects the economy are global in nature, their impacts differ across regions. Within the euro area, such differentiated impacts ([155]) could exacerbate economic divergence. Potential financial-stability impacts of climate change have also attracted heightened attention in the euro area ([156]).

The second part of the section examines the economic impact of different policies to reduce the release of GHG into the atmosphere, using a new version of the Commission's QUEST model with a disaggregated energy sector. Mitigation policies are mostly designed to reduce the burning of fossil fuels ([157]) and will affect output in economic sectors specialised in these activities. The aggregate economic impact of emissions reductions depends on the instruments used for mitigation and the structural adaptability of the economy. One question in this context is whether a 'double

([153]) The authors wish to thank Frank Dentener, Quentin Dupriez, Sven Langedijk, Andrea Mairate, Arnaud Mercier, Yvon Slingenberg, Thomas Stoerk, Tom van Ierland and an anonymous reviewer for useful comments. This section represents the authors' views and not necessarily those of the European Commission.

([154]) Nordhaus, W. (2019), 'Climate Change: The Ultimate Challenge for Economics', *American Economic Review* 109(6), 1991-2014; Burke, M. M. Craxton, C. Kolstad and C. Onda (2016), 'Some Research Challenges in the Economics of Climate Change', *Climate Change Economics* 7(2), 1650002.

([155]) Szewczyk, W., L. Feyen, J.C. Ciscar, A. Matei, E. Mulholland and A. Soria (2020), 'Economic analysis of selected climate impacts: JRC PESETA IV project – Task 14', *JRC Technical Report*, Luxembourg.

([156]) Giuzio, M., D. Krusec, A. Levels, A.S. Melo, K. Mikkonen and P. Radulova (2019), 'Climate change and financial stability' in: *ECB Financial Stability Review* May 2019.

([157]) Greenhous gases are also emitted in activities and processes that do not involve fossil fuels (e.g. methane from cattle farming and waste).

dividend' is possible, where mitigation not only limits the emission of GHG and the related rise in global temperatures but would also increase economic output and employment.

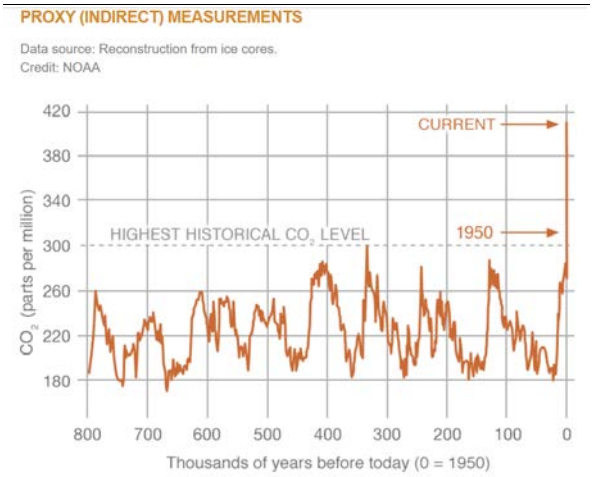
II.2. The economic impact of climate change

Standard integrated models of the climate and the economy use quantifications of the economic impact of climate change to assess the benefits of mitigation policy against a 'no-policy-change' baseline However, our understanding of many relevant mechanisms determining the economic impact of climate change remains incomplete. It is also surrounded by large uncertainty that is known to be asymmetrical, and extremely negative events are likely (the probability distribution has a 'fat tail' on the downside). Our literature review looks at how economic impacts of climate change are estimated, covering existing modelling approaches and findings, and highlighting important missing elements and areas of dispute.

II.2.1. Climate dynamics

The emission of CO2 due to economic activity has already increased its atmospheric concentration by around 50% compared to its previous peak going back hundreds of thousands of years (see graph II.1. Among other important gases, the concentration of CH4 has well over doubled). Over the lifespan of the Earth, there has been even higher concentration, but corresponding to different geological periods and never a rate of rise as great as during the last century ([158]). Most of this change has taken place within a single human lifetime, and globally the trend is still accelerating. These are dizzyingly fast and large changes, and it is important to understand what they imply.

Graph II.1: **Atmospheric CO2 concentration**



CO2econstruction from air bubbles in ice cores; observational measurement in recent decades
Source: NASA and NOAA (2020).

To project the macroeconomic impact of climate change requires assumptions about the biophysical consequences of reaching a given level of GHG concentration. It is crucial to grasp the range of probable outcomes as point estimates may be a poor guide for economic policymakers.

Climate sensitivity. Our expectations of the amount of global heating that GHG concentrations will translate to in the future are defined through the concept of 'climate sensitivity'. This concept captures the estimated global average warming at the Earth's surface due to a doubling of atmospheric GHG from pre-industrial levels. The best guess estimate for climate sensitivity (CS) has been given as 3°C since a seminal report in 1979 ([159]), although the Fifth IPCC Assessment Report (2014) demurred from providing such a best estimate (while keeping the same range as the Fourth IPCC Assessment Report).

([158]) To illustrate, the CO2 rate rise in the aftermath of the asteroid whose impact led to the extinction of dinosaurs was an order of magnitude lower than the current rate. See Wadhams, P (2016) *A Farewell to Ice,* Allen Lane

([159]) Charney, J. et al (1979). *Carbon dioxide and climate: a scientific assessment.* Washington DC: National Academy of Sciences. See also IPCC (2007) *Fourth Assessment Report*

Graph II.2: **Climate risks**

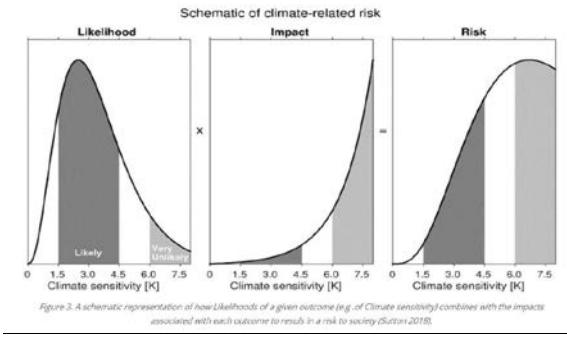


Figure 3. A schematic representation of how likelihoods of a given outcome (e.g. of Climate sensitivity) combines with the impacts associated with each outcome to results in a risk to society (Sutton 2018).

Source: CRESCENDO (2020) 'Climate Sensitivity in CMIP6: some initial findings'.

What is often less understood is the degree of confidence and the probability distribution around CS estimates. As per the Intergovernmental Panel on Climate Change (IPCC), the likely range of climate sensitivity spans from 1.5°C to 4.5°C ([160]), where 'likely' corresponds to an agreed definition of above 66% probability ([161]). Climate scientists tend to be able to robustly rule out the lower end of the likely CS distribution, but have had trouble bounding the upper end. A CS of 6°C or above is defined as 'very unlikely', corresponding to an up to 10% probability – yet the combination of a low probability with a large or even catastrophic outcome significantly affects the distribution of risks as illustrated ([162]) in Graph II.2 ([163]).

Where the shape of the risk distribution differs significantly from that of the probability distribution, adequate policy-making requires addressing not only the question of "what is likely?", but also "how bad could it be/what must we avoid?" ([164]) In other words, basing economic policy on the probability distribution rather than the risk distribution would be seriously misguided.

The IPCC, a UN umbrella body bringing together the global community of climate scientists whose flagship reports summarise the latest science and whose executive summaries for policy makers are approved by governments, assessed that a half a degree of difference in average global temperature change amounts to significant impact that rises in a non-linear fashion. Already between 1.5°C vs 2°C it projects a robust difference and significant impact in terms of water stress, food scarcity, heat-related deaths, forest fires, climate poverty, locked-in sea level rise and the loss of nature and ecosystem services on land and sea (see Graph II.3) ([165]). These impacts would also be likely to have knock-on implications such as increased migratory pressures.

([160]) A recent and well-regarded paper, which feeds into the currently ongoing work on the IPCC's Sixth Assessment Report, narrows this range to 2.6°C-3.9°C. See Sherwood et al (2020) 'An Assessment of Earth's Climate Sensitivity Using Multiple Lines of Evidence', *Reviews of Geophysics*, 58:4

([161]) IPCC (2010) Guidance Note for Lead Authors

([162]) Another illustration is that most people would not consider a probability of 'up to 10%' acceptable in the case of an airplane crashing or a bridge collapsing.

([163]) We simulated different types of distribution in an attempt to reproduce figure 2 and were able to closely approximate with a Gamma distribution, with the impact following a function of fourth order.

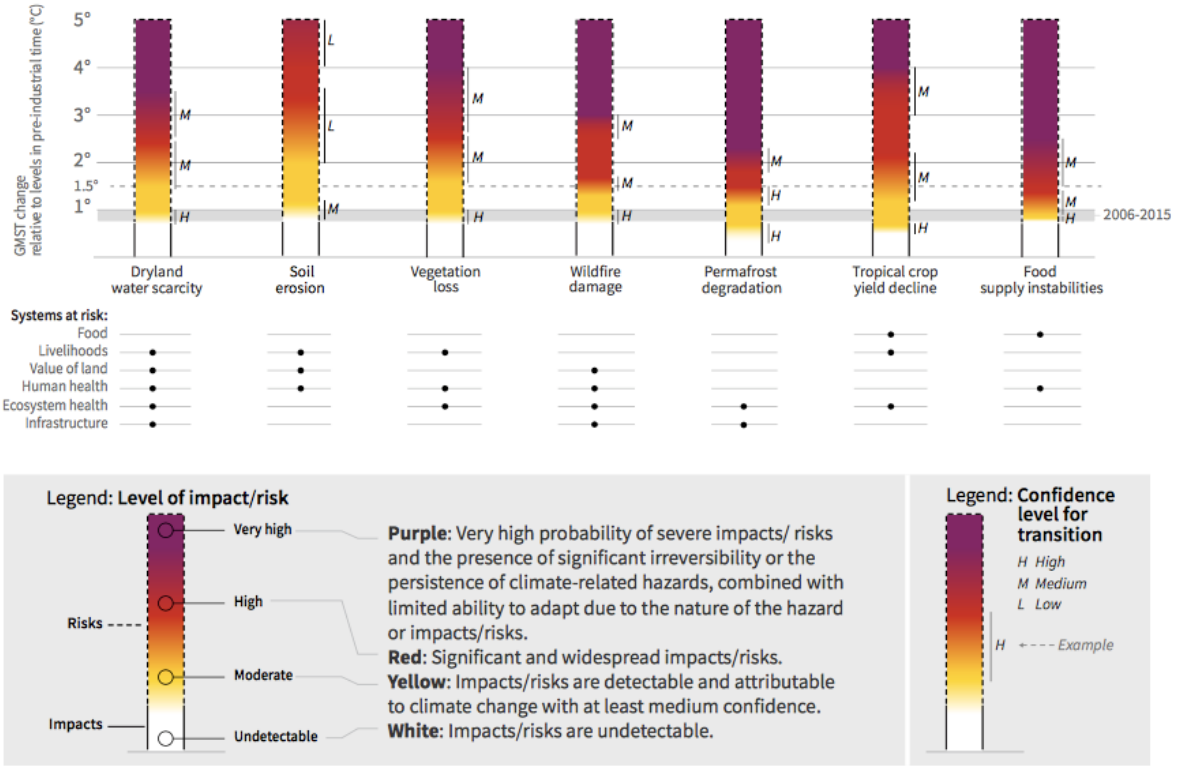
([164]) See King, D. et al (2015) *Climate change: A risk assessment*. Cambridge University Centre for Science and Policy Rep.

([165]) IPCC (2018) *Special Report on Global Warming of 1.5C*. For further context, the global mean cooling that produced the Last Glacial Maximum is estimated to have been around 6°C. Cf. Tierney et al (2020) 'Glacial cooling and climate sensitivity revisited', *Nature* 584, pp. 569–573

Graph II.3: **Example of impacts: food supply risks and other instabilities.**

A. Risks to humans and ecosystems from changes in land-based processes as a result of climate change

Increases in global mean surface temperature (GMST), relative to pre-industrial levels, affect processes involved in **desertification** (water scarcity), **land degradation** (soil erosion, vegetation loss, wildfire, permafrost thaw) and **food security** (crop yield and food supply instabilities). Changes in these processes drive risks to food systems, livelihoods, infrastructure, the value of land, and human and ecosystem health. Changes in one process (e.g. wildfire or water scarcity) may result in compound risks. Risks are location-specific and differ by region.



Source: IPCC Special Report on Climate Change and Land (2019).

Tipping points. The CS as such is not the only source of significant uncertainty surrounding climate change. Tipping points, i.e. 'large-scale discontinuities' in the climate system that are likely to be abrupt as well as irreversible on human timescales have been considered to be high (catastrophic) impact events but of low probability. While the scientific consensus on this point is not complete, leading scientists point to mounting evidence that (i) these events could be more likely than previously thought, (ii) some of these thresholds may already have been crossed, (iii) exceeding tipping points in one climate and ecological system can increase the risk of crossing them in others, and (iv) a global cascade, which would amount to 'an existential threat to civilisation', cannot be ruled out ([166]).

An example that appears perilously close to materialising is the loss of the remaining Arctic sea ice and its ability to reflect incoming solar energy back to space (albedo). A complete disappearance of Arctic sea ice during the sunlit part of the year may have a heating effect equivalent to one trillion tonnes of CO2, as compared to the 2.4 trillion tonnes emitted since industrialisation ([167]). Another example is the release of carbon dioxide and methane from the melting Arctic permafrost and significant parts of the seabed whose estimated

([166]) Seee Lenton et al (2019) 'Climate tipping points — too risky to bet against', *Nature* 575, 592-595. See also Rockström, J et al (2009) 'Planetary boundaries:exploring the safe operating space for humanity', *Ecology and Society* 14(2): 32

([167]) Some research is suggesting that recent trends could lead to an ice-free Arctic as early as the 2020s and others suggest 2030 or substantially later. Baseline calculations tend to assume that cloud cover would remain constant. In comparison, with a total loss of cloud cover, the total added warming could be three times greater. See Pistone, K., I. Eisenmann and V. Ramanathan (2019), 'Radiative Heating of an Ice-Free Arctic Ocean', *Geophysical Research Letters* 46(13), 7474-7480.

impact on the climate in this century varies, ([168]) but where new processes are still being discovered, and where the latest observations and projections include severe changes occurring abruptly ([169]).

A lesser known but no less important tail risk relates to the global rate of species extinction ([170]), which is by now tens to hundreds of times higher than the average rate over the past 10 million years and is accelerating; ([171]) this in turn impacts the resilience of many remaining species. Most models only consider primary extinction ([172]). For example, a scenario-based gridded global model for biodiversity ([173]) suggests a 25-30% decline in plant biodiversity for 4 degrees warming and a 10-20% decline in vertebrate biodiversity, while noting that the exact relationships are uncertain. The rise in average temperature is, of course, not the sole or even the main factor in the current rate of biodiversity decline , which already far outstrips these figures ([174])(the most important factor overall appears to have been habitat destruction, although for some ecosystems such as coral reefs climate change is already the number one culprit).

Taking into account, in turn, co-extinction (the disappearance of consumers following the depletion of their resources) suggests that when critical environmental conditions are breached, even the most resilient organisms are susceptible to rapid extinction. A prominent model in this regard ([175]) found that even extremophile species went extinct close to global biodiversity collapse, which was identified around 5°C heating, and that the transition was abrupt.

Carbon drawdown. The planet would have already warmed far beyond the current 1.1°C if it had not been for oceans, plant mass and soil absorbing about half of the human-induced CO2 emissions. Amplifying the rate and scale of drawing down excess carbon from the atmosphere is, however, not a get-out-of-jail card in case we fall short on policy to reduce emissions, but a necessary part of meeting the Paris targets even in the central scenario (i.e. not taking the fat tail risks from a higher CS or tipping points into account).

We do not currently have technology for cheap, large-scale non-biological carbon sequestration. What is more, our natural carbon sinks may also be increasingly compromised in this function due in large part to climate change itself. The global terrestrial carbon sink has been so far increasing, but tropical forests are now taking up a third less carbon than they did in the 1990s, owing to the impacts of rising temperatures, droughts and deforestation, among other things. The Amazon may turn into a net CO2 emitter by the next decade ([176]). As for the ocean sink, what appears to be clear is that its rate of CO2 absorption varies significantly in ways that we are not currently able to predict ([177]). While overall, Earth system models now suggest that terrestrial and ocean carbon sinks exhibit a *diminishing* marginal uptake of atmospheric CO2 as a function of cumulative uptake and of temperature, many economic models investigated in a recent working paper fail to reflect the

([168]) See Walter Anthony et al (2018) '21st-century modeled permafrost carbon emissions accelerated by abrupt thaw beneath lakes', *Nature Communications* 9(1); Yumashev et al (2019) ' Climate policy implications of nonlinear decline of Arctic land permafrost and other cryosphere elements', *Nature Communications* 10

([169]) See e.g. Teufel, B and Sushama, L (2019) 'Abrupt changes across the Arctic permafrost region endanger northern development', *Nature Climate Change* 9

([170]) The global scientific community as such has just taken the first steps to scope the interlinkages between biodiversity and climate change via an IPCC-IPBES co-sponsored workshop in December 2020, whose report will feed into the 2021 UN Conventions on climate change and on biodiversity.

([171]) IPBES (2019) *Summary for policymakers of the global assessment report on biodiversity and ecosystem services*. The driving factors range from habitat loss and industrial agricultural methods to climate change.

([172]) I.e. they do not take into account the impact of species loss on the potential for other species to go secondarily extinct, due to co-extinctions of dependent species and extinctions that cascade through ecological communities.

([173]) Watkiss,,P., J. Troeltzsch, K. McGlade and M. Watkiss (eds). (2019). 'COACCH: The Economic Cost of Climate Change in Europe: Synthesis Report on Interim Results'. *Policy brief by the COACCH project*. The model calculates local terrestrial biodiversity intactness, and combines the resulting maps to obtain overall mean species abundance values.

([174]) See IPBES (2019) op.cit; WWF (2020) *Living Planet Report 2020 - Bending the curve of biodiversity loss*. Almond, R.E.A., Grooten M. and Petersen, T. (Eds).

([175]) Strona, G and Bradshaw, C (2018) 'Co-extinctions annihilate planetary life during extreme environmental change', *Scientific* Reports 8. The paper is so far uncontested in the literature.

([176]) Hubau et al (2020) 'Asynchronous carbon sink saturation in African and Amazonian tropical forests', *Nature* 579. Forests in parts of Europe are also already severely compromised by drought, invasive insects and other climate change-driven phenomena, with e.g. 98% of trees in Frankfurter Stadtwald already sick or dead (https://www.fr.de/frankfurt/stadtwald-frankfurt-mehr-als-jeder-zehnte-baum-ist-tot-90113352.amp.html?fbclid=IwAR2zASmEoig86jFukWAHdNFC7ryuhgODzQOogIfj9rqKbwDdx6n_c05Tn_I). Cf. B. Schuldt et al. (2020) A first assessment of the impact of the extreme 2018 summer drought on Central European forests. *Basic and Applied Ecology,* vol. 45

([177]) DeVries et al (2019) 'Decadal trends in the ocean carbon sink', Proceedings of the National Academy of Sciences of the United States of America

evolution of science in this regard and [178] still assume *increasing* marginal uptake.

Structural parameter uncertainty. Uncertain structural parameters appear at several levels of the analysis of the economic impact of climate change (e.g. climate sensitivity and how this actually changes climate beyond temperature change (precipitation, long term weather patterns, etc.), feedback loops related to tipping points, damages related to large temperature changes discussed further below). Their interaction induces a critical 'tail fattening' of the (posterior-predictive) distributions of possible outcomes [179]. The relatively high probability of catastrophic outcomes compared to a normal distribution is thus a key feature of climate change.

II.2.2. Costs from rising temperatures

Just as the speed and scale of transmission from higher atmospheric concentrations of greenhouse gases to global surface temperatures is subject to fat-tailed uncertainty, there is also uncertainty about the economic damages higher temperatures will cause. Moreover, the degree to which damages occurring in the future should be discounted has been subject to fierce debate.

II. 2.2.a Damage functions

How will a higher global mean surface temperature affect economic outcomes? Damage functions in the literature are generally formulated in terms of share of GDP [180] lost as a function of temperature change.

The direct economic impact of global warming is likely to depend on the sector of the economy (e.g. agriculture vs. manufacturing), the level of temperature change that has already occurred, the scope of damages taken into account as well as the initial climatic conditions in a particular geographic area. The damage functions typically used in the literature have been heavily criticised. Nonetheless, a discussion of the factors at play and the uncertainties surrounding each of them appears necessary [181].

Not all damages that are plausible can be quantified or modelled, and models vary widely in the scope of damages they include, but always represent at best a partial representation of potential impact and related costs. The damages most commonly discussed in the literature are (the order does not reflect relative importance) [182]:

- *Agricultural output*: [183] A higher atmospheric concentration of CO2 boosts plant growth but affects food quality negatively. Agricultural output in cooler regions may benefit from moderate warming that prolongs the growing season, as long as this impact is not over-compensated by the impacts of increasing draught or other extreme weather events. By contrast, higher temperatures will affect agriculture negatively in areas already most vulnerable to draught and wildfires, in particular as they are likely to be accompanied by reduced rainfall in the same areas. On balance, the literature tends to suggest that a moderate increase of global temperatures leads to an increase of global agricultural output before the impact turns negative at higher temperatures. The strength of the carbon fertilisation effect is however disputed, and estimates of optimal growing temperature for different crops are surrounded by significant uncertainty. Additional uncertainties relate to the impact of increasing temperatures on weather variability

[178] Dietz et al (2020) 'Are Economists Getting Climate Dynamics Right and Does It Matter?', *CESifo Working Paper* No. 8122

[179] Weitzman, M. (2011), 'Fat-Tailed Uncertainty in the Economics of Catastrophic Climate Change', *Review of Environmental Economics and Policy*, 5(2), 275–292.

[180] As often in economic models, GDP is used here as a shorthand for wellbeing. In our simulations, we will also use GDP and its main components, complemented with the employment impact of policy measures.

[181] Farmer, J.D., C. Hepburn, P. Mealy and A. Teytelboym (2015), 'A Third Wave in the Economics of Climate Change', *Environmental and Resource Economics* 62, 329-357 point to lack of evidence about the underlying mechanisms, aggregation issues and a failure to take uncertainty explicitly into account. Pindyck (2013) 'Climate Change Policy: What Do the Models Tell Us?' *Journal of Economic Literature*, 51(3), 860–872.; describes the damage functions in standard IAMs as 'completely ad hoc'. The literature on the economic impact of climate change is massive. For the sake of tractability, the discussion focusses on a selection of well-known IAMs, namely those used by the US Interagency Working Group (DICE, PAGE and FUND), the JRC's Peseta IV model, the ENV-Linkages CGE model used by the OECD as well as the assessment under construction in the COACCH project.

[182] The focus is here on physical phenomena affecting the economy. Indirect channels such as financial stability or inflation may play sigificant roles as well, see Giuzio et al (2019) op. cit., Andersson, M., C. Baccianti and J. Morgan (2020), 'Climate change and the macro economy', *ECB Occasional Paper* 243..

[183] See Stern, N. (2007), *The Economics of Climate Change: The Stern Review*, Cambridge University Press; Ackermann, F. and C. Munitz (2012), 'Climate damages in the FUND model: A disaggregated analysis', *Ecological Economics* 77, 219–224. The range of climate impacts on plant growth has been narrowed down, see Toreti, A., D. Deryng, , F.N. Tubiello et al. (2020), Narrowing uncertainties in the effects of elevated CO2 on crops. *Nat Food* **1,** 775–782;

and the incidence of pests and diseases that may put crop production at risk.

- *Fisheries:* ([184]) Changes to water temperature and salinity as well as the locations in which sea-ice can be found modify stratification and nutrient mixing in the oceans and are likely to lead to changes in species distribution and falling catch in some coastal regions. The impact on fisheries is expected to be most strongly negative in low latitudes, whereas it could be positive in northern Europe.

- *Tourism*: ([185]) Increasing global temperatures are expected to make some tourist regions less attractive (e.g. Alpine ski resorts) and exacerbate water scarcity in arid zones, while other tourist destinations might become more attractive. Impacts could therefore be negative or positive, depending on the region.

- *Economic disruption from storms and river floods*: ([186]) The occurrence of hurricanes directly depends on ocean surface temperature. Their average strength, though not necessarily their frequency is expected to increase with higher temperatures. As the water holding capacity of air increases with temperature (exponentially), the incidence of strong rainfall and flooding is expected to increase. Both mechanisms imply a convex relationship between temperature and storm and flood damage.

- *Damages from sea-level rise and coastal flooding*: ([187]) The cost related to even moderate warming-induced sea-level rises is substantial. The high concentration of economic activities in coastal and low-lying areas implies large damages or substantial costs for flood defences. People will be displaced from unprotected or not sufficiently protected areas.

- *Energy production and use*: ([188]) Warmer average temperatures reduce the energy demand for heating and increase the energy demand for cooling. At the same time, different patterns of wind, cloud cover and precipitations could affect electricity production.

- *Ecosystem services*: ([189]) As explained above, the impact of rising temperatures on ecosystems is likely to be large. The resulting economic damage is complex and so far not well understood. Tol (2002) assumes it is a convex function of climate change.

- *Human health*: ([190]) This includes a variety of channels such as decreased mortality due to extreme cold and higher mortality due to heat waves, but also the spread of malnutrition, diarrhoea and vector-borne diseases, most prominently malaria. An additional channel, generally not covered in models relates to the health impact of interactions between climate-change and air pollution. The aggregate impact depends on whether the reduced mortality from cold waves outweighs the other channels. The transposition of human mortality into a metric of global welfare losses obviously requires assumptions about the economic value of human life that are fundamentally difficult.

([184]) OECD (2015),'*The Economic Consequences of Climate Change*', OECD publishing, Paris. and sources therein

([185]) OECD (2015) op. cit.

([186]) Knutson, T. et al. (2020), Tropical Cyclones and Climate Change Assessment: Part II: Projected Response to Anthropogenic Warming. *Bulletin of the American Meteorological Society* 101, E303–E322; Stern (2007), op.cit.

([187]) Feyen L., J.C. Ciscar, S. Gosling, D. Ibarreta and A. Soria (editors) (2020), '*Climate change impacts and adaptation in Europe: JRC PESETA IV final report*', Publications Office of the European Union, Luxembourg; Heslin, A., N. D. Deckard, R. Oakes and A. Montero-Colbert (2019), 'Displacement and Resettlement: Understanding the Role of Climate Change in Contemporary Migration', in: In: Mechler R., L. Bouwer, T. Schinko, S. Surminski and J. Linnerooth-Bayer (eds) '*Loss and Damage from Climate Change. Climate Risk Management, Policy and Governance*', Springer, Cham.

([188]) Després, J. and M. Adamovic (2020), 'Seasonal impacts of climate change on electricity production', *JRC Technical Report*, Luxembourg.

([189]) IPCC (2014), Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change, Geneva; Van der Geest K. A. de Sherbinin, S. Kienberger, Z. Zommers, A. Sitati, E. Roberts and R. James (2019), The Impacts of Climate Change on Ecosystem Services and Resulting Losses and Damages to People and Society. In: Mechler R., Bouwer L., Schinko T., Surminski S., Linnerooth-Bayer J. (eds) Loss and Damage from Climate Change. Climate Risk Management, Policy and Governance. Springer, Cham. While the loss of biodiversity and climate change have common causes, and interact in various ways, biodiversity loss could have very negative consequences for humanity also in the absence of climate change. Tol, R. (2002), Estimates of the Damage Costs of Climate Change: Part 1: Benchmark Estimates, *Environmental and Resource Economics* 21, 47–73.

([190]) Feyen et al (2020) op.cit., Ciscar, J-C., J. Rising, R. E. Kopp and L. Feyen (2019), Assessing future climate change impacts in the EU and the USA: insights and lessons from two continental-scale projects, *Environmental Research Letters* 14, 084010; Carleton, T. and co-authors (2019),' Valuing the Global Mortality Consequences of Climate Change Accounting for Adaptation Costs and Benefits', *NBER Working Paper* 27599. Burke, M. A. Driscoll, J. Xue S. Heft-Neal, J. Burney and M. Wara (2020), 'The Changing Risk and Burden of Wildfire in the US', *NBER Working Paper* 27423.

These assumptions matter as in some models the estimated impact of mortality has a large bearing on the estimated damages overall.

We next take a closer look at damage functions in a selection of well-known IAMs, models developed recently with a focus on the EU and articles that challenge the IAM benchmark. These models ([191]) differ in the impact channels covered and the way in which they are modelled. For instance, the FUND 3.9 and PESETA IV integrated assessment models as well as the ENV-Linkages computable general equilibrium model and COACCH feature detailed accounts of (some of) the channels discussed above. The level of aggregation is higher in PAGE09, which features a 'kinked' damage function to reflect the possible triggering of a tipping point (e.g. an additional strong sea-level rise from the melting of the Greenland ice sheet). For the more recent versions of the DICE model, the disaggregated analysis of damages was abandoned in favour of an aggregate damage function. The latter is modelled so as to fit damage estimates in the literature, with a 25% additional damages added to correct for channels the literature does not account for.

The model-predicted economic impact of climate change crucially depends on the functional form of the damage function ([192]). As seen above, many impact channels suggest a convex relationship between rising temperatures and economic damages. However, in some areas, in particular agriculture, the impact of a small temperature increase above pre-industrial level may be globally positive. The aggregate damage function based on various estimates collected from the literature in Tol (2018) ([193]) can therefore be described as a piecewise linear function with a 'kink' at dT= 1°. By contrast, Nordhaus and Moffat (2017) ([194]) conclude that the damage function providing the best fit with damages reported in the literature is quadratic. Also Howard and Sterner (2017) ([195]) conclude at a quadratic functional form. However, having extended the sample of surveyed damage estimates, corrected for duplication and omitted variables, they arrive at substantially higher damage estimates (see Table II.1).

A key output of the FUND, PAGE and DICE models is the estimated social cost of carbon, in other words the price of a ton of CO2 that reflects the negative externalities of GHG emissions; Rose et al (2017) ([196]) examine the drivers of differences in the estimated social cost of carbon. Under standardised assumptions, the damage functions in DICE and PAGE are quite similar, for small temperature variations. Above 3°C, the discontinuity incorporated in the PAGE model leads to a faster increase of damages. Among the three, the FUND model stands out, mainly due to the feature that warming up to 5° is assumed to be beneficial to global agricultural output.

The impact estimates considered in these studies cluster around temperature changes of 2-4°C with few estimates for larger dT. As economic damage functions are calibrated with observations that relate to relatively small historical temperature changes and even weather variations, ([197]) it is natural that large uncertainty concerns any extrapolation to damages from stronger temperature variations. Lamperti et al (2018) ([198]) point to the possibility that interactions between heterogeneous agents may amplify the negative macroeconomic impacts of climate shocks substantially beyond what damage functions in

([191]) FUND 3.9 is described in Anthoff, D. and R. Tol (2014), *'The Climate Framework for Uncertainty, Negotiation and Distribution (FUND), Technical Description, Version 3.9'*.. PAGE09 in Hope, C. (2011), 'The PAGE09 Integrated Assessment Model: A Technical Description', *Cambridge Judge Business School Working Paper* 4/2011, DICE 2016R in Nordhaus, W. (2017), 'The social cost of carbon: Updated estimates.' *Proceedings of the U. S. National Academy of Sciences*.. The description of PESETA IV is in Feyen et al. (2020) op. cit. Finally, ENV-Linkages is described in OECD (2015) op cit. and COACCH in Watkiss et al (2019) op. cit..

([192]) Bretschger, L. and A. Pattarki (2019), 'As Bad as it Gets: How Climate Damage Functions Affect Growth and the Social Cost of Carbon', *Environmental and Resource Economics* 72, 5–26.

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

([194]) Nordhaus, W., and A. Moffat (2017), 'A Survey of Global Impacts of Climate Change: Replication, Survey Methods, and a Statistical Analysis', *NBER Working Paper* No. 23646.

([195]) Howard, P. and T. Sterner (2017), 'Few and Not So Far Between: A Meta-analysis of Climate Damage Estimates', *Environmental and Resource Economics* 68, 197–225.

([196]) Rose, S., D. Diaz and G. Blanford (2017), 'Understanding the Social Cost of Carbon A Model Diagnostic and Inter-Comparison Study', *Climate Change Economics* 8(2), 1750009.

([197]) IMF (2020), in World Economic Outlook, Washington; Howard and Sterner (2017) op. cit. A survey of different empirical approaches is in Auffhammer, M. (2018), 'Quantifying Economic Damages from Climate Change', *Journal of Economic Perspectives* 32(4),33–52.

([198]) Lamperti, F., G. Dosi, M. Napoletano, A. Roventini and A. Sapioe (2018), 'Faraway, So Close: Coupled Climate and Economic Dynamics in an Agent-based Integrated Assessment Model', Ecological Economics 150, 315–339.

Table II.1: **Examples of damage functions**

model (author)	dT (°C)(a)	damage (% of GDP) (b)	functional form	method	remarks
Tol (2018)	1	-0,7	piecewise linear	estimated on the basis of point estimates from a literature survey	
	2	0,6			
	6	6,3			
PESETA IV (Feyen et al, 2020)	1,5	0,3	quadratic	several impact channels modelled	estimate for the EU
	3	1,4			
	4	1,9			
PAGE 09 (Hope, 2011a)	3	just under 2%	complex	several impact channels modelled	estimate for the EU
DICE 2016R (Nordhaus, 2016)	3	2,0	quadratic	estimated on the basis of point estimates from a literature survey	
	6	8,2			
ENV-Linkages (OECD, 2015)	1,5	1,0	complex	Examination of different sectoral impacts	Damages by 2060
	4,5	3,3			
COACCH (Watkiss et al, 2019)	2,4	3	complex	Multi-model examination of so far 3 sectors: coastal floods, river floods, transport infrastructure	estimates for EU. RCP 4.5 (0.7 trn EUR pa) and RCP 8.5 (2.6 trn EUR p.a). %age for 2085 based on 1.5% GDP growth.
	4,3	10			
Howard and Sterner (2017)	3	7-8	quadratic	Literature survey, adjusting for duplication and omitted variable bias	global. Excluding catastrophic damages
	3	9-10			as above, but including catastrophic damages
Burke et al (2017)	2	18	close to linear / concave	Impact of observerd temperature variations on labour and agriculture	global. Long-run, differentiated response scenario as reported (ED fig 6).
	4	43			
Weitzman (2012)	6	50	exponential	by assumprion	global
	12	99			

(a) global mean surface temperature change compared to pre-industrial level; (b) loss of GDP compared to no-climate-change baseline by 2100 (unless otherwise stated)
Source: European Commission compilation from the quoted articles.

standard IAMs suggest. Weitzman (2012) ([199]) argues that from the viewpoint of insuring against the possibility of catastrophic outcomes, it would be preferable to consider an exponential damage function. Starting from the impact of annual temperature variations on output in a large sample of countries, Burke et al (2015) ([200]) conclude that the global damage function is close to linear, but much steeper than those used in most IAMs.

The assumed ease and degree of adaptation to climate change has an important bearing on overall estimated damages and is one driver behind differences across damage functions in different models. ([201]). In general, over short periods, path dependency and sunk costs related to capital or skills that are becoming obsolete are likely to hinder adaptation, but substitution becomes easier over longer periods as new capital and skills are accumulated. Behavioural change by individuals could facilitate both adaptation and mitigation ([202]). Smooth adaptation may however be more complicated if the direct damage from climate change varies widely across regions and sectors.

The economic impact of climate change may be felt more strongly by poorer households than richer ones ([203]). It is also is not evenly distributed across space. The largest impact of rising temperatures on economic output are projected for tropical and subtropical regions. This affects the comparability of the estimated damages reported in Table II.1, as damages in the EU (given for PESETA, PAGE and COACCH) would tend to be smaller in relation to GDP than global ones. Also within the EU, negative impacts, in particular from droughts, are expected to be more pronounced in the Mediterranean and Atlantic region than in central and northern Europe ([204]). Globally, the geographical areas where the negative physical impacts are likely to be highest comprise many low- to middle-income countries. There is however

([199]) Weitzman, M. (2012), 'GHG Targets as Insurance Against Catastrophic Climate Damages', *Journal of Public Economic Theory*, 14 (2), 221–244.

([200]) Burke, M., S. M. Hsiang and E. Miguel (2015), 'Global non-linear effect of temperature on economic production', *Nature* 527**,** 235–239.

([201]) Ackermann, F. and C. Munitz (2016), 'A critique of climate damage modeling: Carbon fertilization, adaptation, and the limits of FUND', *Energy Research & Social Science* 12, 62–67; Rose et al (2017) op. cit.; Ciscar et al, (2019) op. cit. , OECD, 2015, op.cit.

([202]) Terzi, A. (2020), 'Crafting an effective narrative on the green transition', *Energy Policy* 147, 111883.

([203]) Islam, S.N. and J. Winkel (2017),' Climate Change and Social Inequality', *UN DESA Working Paper* 152.

([204]) Szewczyk, et al (2020) op. cit. The recent draughts in central and northern Europe underline that temporary deviations from such general trends are well possible, see also Toreti et al. (2019), The Exceptional 2018 European Water Seesaw Calls for Action on Adaptation, *Earths Future* 7(6), 652-663.

disagreement in the literature as to whether a higher level of GDP per capita per se makes countries less vulnerable to the effects of climate-change ([205]).

The relation between temperature increases and economic damage is subject to large uncertainties, possibly even more so than the geophysical factors driving climate sensitivity. This relates both to the degree of knowledge about the factors identified above, omitted economic sectors (e.g. construction and transport) and other omitted factors such as migration, conflict, or disruptions of international trade ([206]).

An important generally omitted factor is ecosystem services. Among the models surveyed here, only the FUND model directly accounts for ecosystem services, but remains limited to the 'warm-glow' effect, i.e. people's hypothetical willingness to pay for the conservation of biodiversity, landscapes etc. A more complete picture requires a firmer understanding of the vulnerability of complex ecosystems in their interaction with human activity and wellbeing beyond their recreational function to include provisioning and regulating functions such as pollination, soil conservation, flood control, water and air purification. Ecosystems accounting is aimed at filling this gap, but is not yet sufficiently developed to provide a quantification of the different impact channels involved ([207]).

More generally, the formulation of damage functions in the models surveyed here may not represent the latest knowledge about climate impacts ([208]). Uncertainty related to threshold effects and nonlinearities in climate sensitivity also affects the estimated damage functions.

([205]) Tol (2018) argues that this is the case, whereas Burke et al (2015) find no evidence that advanced economies faced decreasing damages from temperature variations as they became wealthier.

([206]) Tol, (2002) op. cit., Burke et al, (2015 op. cit..), Pindyck, (2013) op. cit.

([207]) On the assessment of ecosystem services see OECD, 2015, Anthoff and Tol, 2013; Tol, 2002; IPCC, 2014. On ecosystem accounting see Constanzu et al (2014); La Notte, A., S. Vallecillo, C. Polce, G. Zulian and J. Maes (2017), 'Implementing an EU system of accounting for ecosystems and their services: Initial proposals for the implementation of ecosystem services accounts', *JRC Technical Report*, Luxembourg. However, our knowledge of biodiversity and ecosystems remains very limited as pointed out by Mora, C., D. Tittensor, S. Adl, A. Simpson and B. Worm (2011): 'How Many Species Are There on Earth and in the Ocean?', PLoS Biol 9(8): e1001127.

([208]) Rose et al (2017) op. cit; Dietz et al (2020) op. cit.

II 2.2 b Discounting future damages

The damages from climate change are set to occur over a time horizon stretching far into the future. Relatively modest differences in the way future damages are discounted can therefore have a large impact on their calculated net present value. Following the publication of the Stern Report in 2007, the discounting of climate damages and the weighting of future generations' welfare compared to the present generation's have become the subject of fierce debate. This 'Stern-Nordhaus controversy' focussed on differences in the social cost of carbon estimated by the Stern Report, which used the PAGE model, and by Nordhaus (2008), which used the DICE model, and on the sensitivity of policy recommendations to the discount rate used ([209]).

Following the notation in Espagne et al (2016), the parameters that enter the discounting of future outcomes are the pure social rate of time preference (ϱ), the expected long-term growth rate of per capita output (or consumption) (g) and the elasticity of the marginal utility of consumption (α) such that the discount rate (r) is defined as $r=\varrho+\alpha g$.

The assumed long-term growth rate of the world economy (see Table II.2) does not play a major role in the 'controversy'. Conceptually, there is broad agreement that there should be discounting for the expected increase in future generations' consumption possibilities. This may however be more complex if the uncertainty surrounding growth is taken into account ([210]).

The consumption elasticity α is set at 1 in the Stern Report and at 2 in Nordhaus' DICE model. It has been noted that the high aversion of inequality across generations incorporated in the Stern Review's low ϱ may sit at odds with a rather low preference for equality of consumption within a

([209]) Nordhaus, W. (2008), '), 'A question of balance : weighing the options on global warming policies', New Haven, Yale University Press. Espagne, E., F. Nadaud, B. Perissin and A. Pottier (2012), 'Disentangling the Stern/Nordhaus Controversy: Beyond the Discounting Clash', *FEEM Working Paper* No. 61.2012.

([210]) National Academies of Sciences, Engineering, and Medicine (2017), '*Valuing Climate Damages: Updating Estimation of the Social Cost of Carbon Dioxide'*, Washington DC: The National Academies Press.

given generation incorporated in the consumption elasticity α ([211]).

The controversy mostly crystallised on the assumed social time preference rate. Nordhaus argues that it should be chosen in such a way that r equals an observable (market) real return on investment, on the grounds that this is the rate against which economic actors will also evaluate abatement investments. By contrast, Stern argues that, on ethical grounds present and future generations should be treated equally. Pure time discounting should only reflect the risk of the extinction of humankind, (i.e. that future generations may not exist). He therefore sets ϱ=0.1%. The resulting discount rate is r=1.4%. Other authors have suggested that ϱ could be interpreted as a policy variable, indicating the degree to which policy makers prefer the wellbeing of their voters over that of future generations. A more recent survey suggests that 'around 2%' is a discount value that received a lot of support among experts ([212]).

Table II.2: **Examples of discounting parameters in the IAM literature**

$r=\rho+\alpha g$	r	ρ	α	g
Stern (2007)	1,4	0,1	1	1,3
Dasgupta (2007)		0,1	2-4	
Weitzman (2007)	6	2	2	2
Nordhaus (2008)	5,5	1,5	2	2
Hope (2011)	3-3.2	1,0	1,2	1.7-1.9
Anthoff and Tol (2014)		1,0	(1)	
Drupp et al (2018)	'ca. 2'			

Source: European Commission compilation from the cited articles.

This literature review highlights the asymmetric risks around existing quantifications. Omitted channels / variables, the incomplete coverage of non-linearities and recent insights from climate science suggest that the actual damages from global warming will be larger than most point estimates in the literature, probably by a substantial margin. The business-as-usual baseline to which mitigation policy should be compared is unlikely to be a sustainable one, and could well turn out to be unaffordable.

We refrain from formulating our own quantification of damages for the assessment of the European Union's mitigation policy below. First, the literature review suggests that one should consider ranges of possible outcomes rather than point estimates. Second, damages follow the emission of GHG with long lags. Damages that are generally assessed at the horizon of 2100 may not be easy to integrate into our model assessment that focuses on the coming 30 years. Third, we restrict our analysis of mitigation policy to the EU, which accounts for only about 8% of global GHG emissions. Such unilateral climate action policies would have very limited effect on global temperature rise and the corresponding economic damages over our simulation horizon.

II.3. The economic impact of mitigation policies

The analysis in this section focuses on the design of climate mitigation policies. The objective of climate mitigation policy is to limit the increase of global mean temperatures to a level deemed sufficiently safe. To implement the Paris Agreement, the Commission has proposed aiming at zero net GHG emissions by 2050 ([213]).

Our quantitative assessment of climate mitigation policies makes use of selected simulation results from the E-QUEST model. E-QUEST is an extension of the European Commission's standard QUEST model with energy and sectoral disaggregation ([214]). The E-QUEST model used for the assessment is set up for two regions, the European Union (EU) and the rest of the world (R). In each region, the economy consists of

([211]) Dasgupta, P. (2007), 'Commentary: The Stern Review's Economics of Climate Change', National Institute Economic Review 199, 4-7. See also Weitzman, M. (2007), 'A Review of The Stern Review on the Economics of Climate Change', *Journal of Economic Literature*, XLV (September), 703–724.

([212]) A more detailed discussion on the ethical underpinnings of discounting climate damages and the consequences of applying alternative concepts of intergenerational justice in climate models can be found e.g. in the articles by Davidson as well as Caney in Walsh, A., S. Hormio and D. Purves (eds.) (2017), '*The Ethical Underpinnings of Climate Economics*', Routledge. See also Pindyck (2013) op; cit.; Drupp,M., M. Freeman, B. Groom, and F. Nesje (2018), 'Discounting Disentangled', *American Economic Journal: Economic Policy*, 10(4): 109–134.

([213]) European Climate law proposal to achieve EU climate neutrality: https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52020PC0080&from=EN.

([214]) This section largely builds on the detailed E-QUEST model description and its application to analyse the impact of reaching the EU climate targets: Varga, J., Röger, W. and J. in 't Veld (forthcoming) E-QUEST - A multi-region sectoral dynamic general equilibrium model with energy. Directorate General Economic and Financial Affairs, European Commission. Discussion Papers. For the standard QUEST model, see Burgert, M., Roeger, W., Varga, J., in 't Veld, J. and Vogel, L. (2020). A Global Economy Version of QUEST. Simulation properties. European Economy Discussion Papers 126. Directorate General Economic and Financial Affairs, European Commission.

households, firms, a monetary and a fiscal authority. The model distinguishes two types of households, liquidity or not liquidity constrained ones, depending on their access to financial markets. Both household types offer differentiated labour services to firms in three skill levels: low, medium and high-skilled. In each region, firms produce differentiated goods and services for domestic and foreign markets. Production requires labour, general (non-energy) capital, a composite of intermediate goods and a composite of fossil fuel-intensive, 'dirty' and electricity-intensive, 'clean' capital-energy bundle ([215]) .

The main innovation of E-QUEST compared to the standard QUEST model is the modelling of substitution possibilities between the fossil fuel and electricity-intensive capital technologies. The model incorporates two of the most often used channels in energy and climate policy models to capture clean technological progress: i) efficiency improvements in using clean capital and ii) productivity improvements in producing clean capital. The first type of technological progress is modelled through autonomous energy efficiency improvement (AEEI), which implies that the clean energy use (i.e. electricity) per unit of output declines over time. AEEI is a frequently used approximation of energy-saving technological change in computable general equilibrium (CGE) models ([216]). The second type of technological progress is modelled through learning-by-doing in our model. Learning-by-doing has been employed in the literature of energy and climate policy models to account for the simple observation that production performance either in the form of productivity or cost reductions tends to improve with the accumulation of experience. Technology 'learning rates' are now widely employed by researchers and policy analysts to project future trends in the energy and environmental domains ([217]).

We explore six scenarios to study the economic effect of reaching the 2050 climate neutrality target set by the European Union. Taking the most frequently used policy scenarios in the environmental economics literature, we test for the possibility of double dividends, i.e. positive environmental and economic effects from climate mitigation policies through environmental taxes and their recycling.

The first reference case implements regulations, i.e. the government imposes restrictions on the economy-wide use of fossil fuels without any additional carbon taxes ([218]). In the subsequent five scenarios, the government levies carbon taxes on all final and intermediate consumption of fossil fuel in the EU ([219]). We ensure the comparability of the scenarios by imposing the same emission trajectories for each sector in every scenario while reaching an overall 93% cut in emissions by 2050 ([220]). We compare the economic effects of five main recycling options under the carbon taxation case:

- reduction in lump-sum taxes,
- personal income tax (PIT) cuts for low-skilled households only,
- consumption tax cuts,
- reduction in capital taxes (excluding dirty capital) and
- recycling via 'clean' subsidies to support the purchase of clean capital goods.

The scenarios set a logistic emission reduction path and let the model find the solution for the required carbon tax (or the shadow price of carbon in the regulation scenario). The simulated emission path reaches the 2030 targeted reductions of 55% and then reduces emissions further by 93% in 2050

([215]) There are seven aggregated sectors in the model: a fossil fuel and a fuel-intensive capital producing sector, an electricity and an electricity-intensive capital producing sector, a sector manufacturing non-energy related capital goods, an emission-intensive sector and an aggregate of the remaining economic sectors.

([216]) Webster, M., Paltsev, S., and Reilly, J. 2008. Autonomous efficiency improvement or income elasticity of energy demand: Does it matter? Energy Economics, 30(6):2785–2798.

([217]) Rubin, E. S., Azevedo, I.M.L., Jaramillo, P. and Yeh, S. (2015). A review of learning rates for electricity supply technologies, Energy Policy 86(C): 198-218.

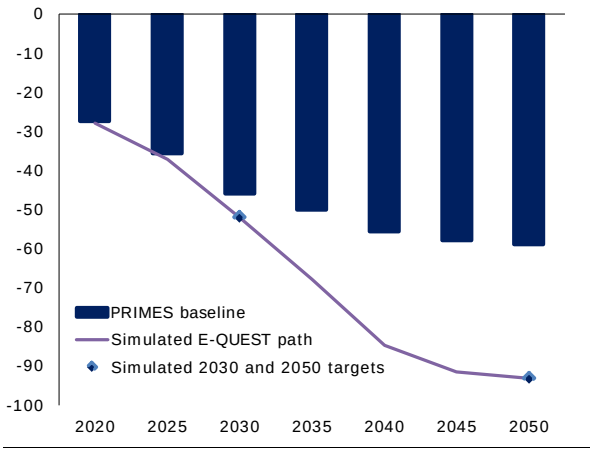
([218]) Technically, we impose a shadow price on emissions without any direct fiscal revenue.

([219]) A cap-and-trade system of controlling greenhouse gas emissions (such as the EU's emissions trading system) works in the same way as carbon taxes in the model. We assume that the government sets the carbon tax as the price of emission allowance to control the level of annual emissions in the domestic economy. The modelling does not represent GHG removals required to achieve overall net zero greenhouse gas emissions.

([220]) Note that the scenarios are equivalent in terms of delivering the same annual emission reductions while using different policy instruments.

relative to its 1990 level. The model takes into account the effect of already existing climate mitigation measures to limit GHG emissions based on the PRIMES energy model simulations ([221]). These underlying PRIMES model simulations form a baseline that already assumes a reduction of about 45% and 58% of EU GHG emissions relative to the 1990 level by 2030 and 2050 respectively (see Graph II.4) ([222]).

Graph II.4: **Emission reductions and targets**



(1) % of 1990 level
Source: PRIMES and E-QUEST simulations.

Graph II.5 shows the macroeconomic effects of the different policies that aim for the EU goal of net zero emissions in 30 years (by 2050). Note that we focus on the direct economic effects of these policies, and we do not model the environmental feedback effects in these simulations. The GDP results confirm that imposing carbon taxes on the use of fossil fuel and using the revenue to reduce the burden of taxation elsewhere is economically more beneficial compared to regulatory measures which do not yield additional tax revenues. Under regulation, GDP losses can reach 2% in the long run by 2050, while losses are typically lower under carbon taxation, with the lowest losses when revenue is used to reduce capital taxes and subsidise clean capital purchases (around -0.6%). Except for our regulation scenario, recyclable tax revenues are gradually increasing up to a peak and diminishing afterwards following a Laffer-curve shape as the more stringent emission reduction requirements command increasing carbon prices. Note that while economists tend to favour environmental taxes over non-market regulatory instruments, such as technology standards or bans on polluting goods, environmental regulations are widely used for their potential benefits, which cannot be captured in standard macroeconomic models ([223]).

The ranking of GDP results by recycling instruments also reflects the ranking of taxes by their distortive effects in the economy. Reducing lump-sum taxes, which are the least distortive, has the least dampening effect on the cost of climate policy. This is followed by consumption taxes (VAT). Labour tax reductions targeted at lower income groups with a higher marginal propensity to consume reduce output losses stemming from carbon taxes further. Taxes on capital are most distortive, and recycling carbon tax revenue to reduce these has larger impact. The most beneficial scenario in terms of GDP effects is the recycling of carbon revenues into subsidies on the purchase of clean capital and capital tax reduction.

Graph II.5 also helps us to understand what drives the difference between the recycling options by decomposing the GDP effects from the expenditures side.

In terms of consumption losses, we can see that subsidies given to households to help them to purchase clean capital provides the biggest cushion against the increasing burden of taxing fuel, which makes the use of dirty energy gradually more costly.

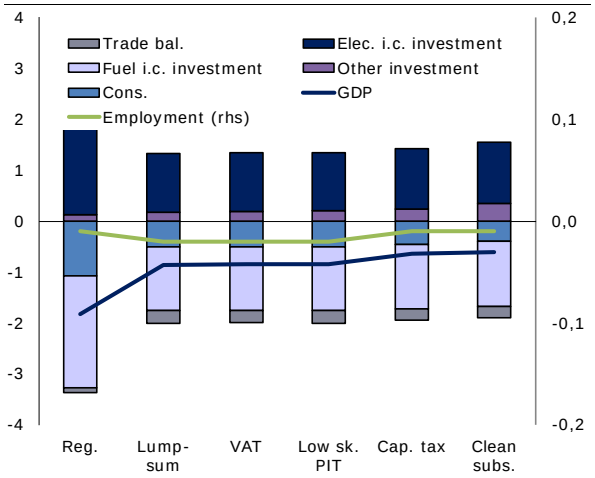
We can see that the capital tax reduction and clean subsidy scenarios, which are the most beneficial from an economic point of view, also lead to higher investment in general capital and clean capital compared to other recycling options.

([221]) E3MLab/ICCS. (2014). PRIMES model. National Technical University of Athens. https://ec.europa.eu/clima/sites/clima/files/strategies/analysis/models/docs/primes_model_2013-2014_en.pdf

([222]) In technical terms, we exogenise the emission path according to the PRIMES model simulation results. The PRIMES baseline accounts for the current policy measures and technology trends. In order to have a policy neutral baseline with the least distortion in the structure of relative prices and taxes, which could influence the economic efficiency of the subsequent scenarios, we use carbon taxes that induce the necessary relative prices for reaching the target and lump-sum tax recycling that mitigates the effect of changing the tax-structure.

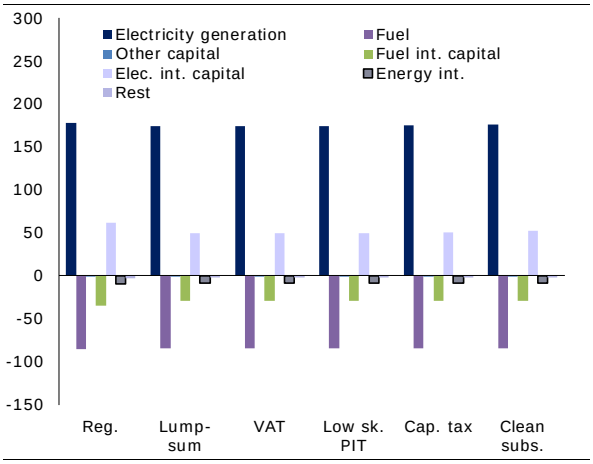
([223]) This can be partly due to the easier legislative procedure or public acceptance of non-market instruments over taxes. See Bovenberg, A., L., and Goulder, H., L. (2002) Environmental Taxation and Regulation. In Handbook of Public Economics, Elsevier, Volume 3, 2002, pp. 1471-1545. Editor(s): Alan J. Auerbach, Martin Feldstein

Graph II.5: **Macroeconomic effect of climate policy scenarios (2050)**



GDP and employment (rhs): % deviation from baseline. Consumption, fuel-intensive investment, electricity-intensive investment, other investment, trade balance: deviation in % of baseline GDP.
Source: E-QUEST simulations.

Graph II.6: **Change in sectoral output**



% deviation from baseline, by 2050.
Source: E-QUEST simulations.

The employment effects are only slightly negative in the long run, because the sectoral shift to electricity-intensive industries can largely compensate for the shrinking labour demand in the fossil fuel-intensive industries.

Graph II.6 shows the required contribution of sectoral output adjustment to the transition towards a carbon neutral economy. While electricity generation more than doubles, fossil fuel supply diminishes by more than 80% relative to the baseline. The shift in energy sources towards electricity mirrors a similar transformation in the capital production sectors from fossil fuel intensive capital to electricity-intensive capital.

At this point, it is worth taking a snapshot of our climate policy measures in the long run by looking at how they perform along the lines of the two possible dividends: their environmental and welfare effects. Goulder (1995) ([224]) surveyed the theoretical and empirical evidence on the double dividend hypothesis and distinguished between the strong and the weak form of the double dividend.

The weak form of the double dividend hypothesis requires that the efficiency costs of a revenue-neutral environmental tax reform are lower if the additional revenues from the environmental taxes are used to cut distortionary taxes compared to the case where these revenues are recycled in a lump-sum fashion. The strong form of the double dividend hypothesis requires that an environmental tax reform improves not only environmental quality but also non-environmental welfare.

We can focus on the GDP, consumption and employment effects of the five main carbon revenue-recycling scenarios, reducing lump-sum taxes, low-skilled labour taxes, capital taxes, VAT, or providing green (clean) subsidies. Note that by the construction of our scenarios, each of these policies yields the same environmental effects, as we impose the same emission reduction path for easier comparison. However, our policies perform differently in terms of economic benefits and welfare. Our first observation is that the weak form of double dividend as defined by Goulder (1995) is easily satisfied. Recycling the revenues by reducing any of the distortionary taxes can improve the GDP, consumption or employment effect relative to our lump-sum scenario. In line with the meta-analysis of Freire-González (2017) ([225]), the strong form of double dividend is much harder to achieve. In terms of GDP or consumption, our policies cannot reach positive effects. In terms of employment, the policies perform somewhat

([224]) Goulder, L. H. (1995). Environmental Taxation and the 'Double Dividend': A Reader's Guide. International Tax and Public Finance 2(2): 157–183.

([225]) Freire-González, J. (2017) Environmental taxation and the double dividend hypothesis in CGE modelling literature: A critical review. Journal of Policy Modeling 40: 194–223.

better, but still slightly negative employment effects arise.

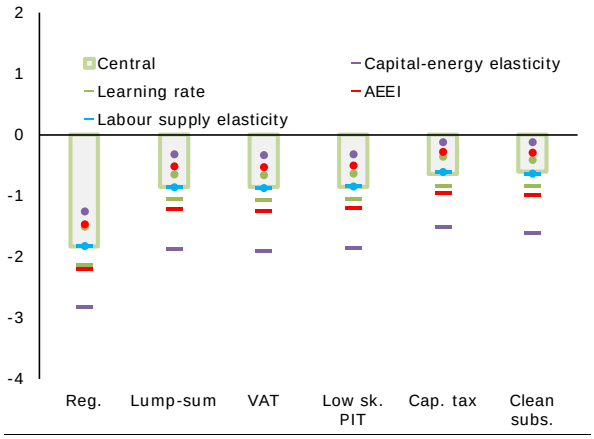
We conclude our analysis by performing a sensitivity analysis with respect to some of the most critical parameters of the model. We take an interval of +/-25% of the original calibrated values for the corresponding parameters shown below, approaching the lower and upper end of the estimates in the relevant literature:

- elasticity of substitution between the clean and dirty capital-energy bundle (6)
- learning-by-doing rate (10%)
- autonomous energy efficiency improvement rate (1% p.a.)
- labour supply (Frisch) elasticity (0.25).

Focusing on the GDP by 2050, Graph II.7 shows the sensitivity of the results using column bars for the central scenarios discussed in the previous sections and coloured markers for the lower and upper bounds for the corresponding parameters. Note that in each case, the larger (smaller) is the parameter value, the more optimistic (pessimistic) is our calibration scenario in terms of the main macroeconomic variables. The graph below offers a number of interesting insights into the sensitivity of our results and also points to the need of future research on the most important parameters determining the policy outcomes.

First, the results show that the elasticity of substitution between clean and dirty technologies plays a crucial role in the magnitude of the GDP results. For each scenario, increasing (decreasing) the substitution possibilities between clean and dirty capacities significantly improves (worsens) the long-run GDP effects. Under the high elasticity case, the clean subsidy and the capital tax recycling scenarios can result in negligible, only slightly negative GDP effects. On the other hand, the output effects can go down to – 3% under the low substitution elasticity case with solely regulation-based climate policy. Similarly, we can also see that both the learning-by-doing rates and the AEEI rates have a significant effect on the GDP results. This shows that the uncertainty surrounding these factors can play an important role. However, our GDP results are robust for the Frisch labour supply elasticity.

Graph II.7: **Sensitivity analysis**



% deviation of GDP from baseline, by 2050.
Source: E-QUEST simulations. The round markers correspond to the upper limit and the horizontal bars mark the lower bound of the respective parameter.

To put these results into perspective, most of the estimated effects of ambitious climate change policies reported in Stern (2007) cluster between -5% to +2% of national and world output by 2050. In most cases, the estimates are small, around 1% or less relative to baseline output ([226]). Our results are also in the range of previous impact assessments analysing the long-term EU climate strategy with estimated effects between -1.3% to +2.2% of EU GDP by 2050 ([227]).

II.4. Conclusion

No region of the world is immune to the negative economic impacts arising from global warming. In the euro area, specific challenges could arise from a differentiated impact, for example between coastal and continental or southern vs northern regions, which could exacerbate economic divergence, as well as posing threats to price stability and financial stability.

([226]) The full range of estimates spans between -15% to +4% of output. This variation in the estimates is driven by the characteristics of the individual models. Models that can rely only on energy conservation tend to show substantial costs because this mitigation option becomes quickly exhausted over time. On the other hand, general equilibrium models with richer mitigation options, revenue recycling possibilities and technological learning point to less negative effects. The E-QUEST model also belongs to this class of general equilibrium models.

([227]) These effects are also reported relative to the baseline without an explicit damage function.
https://ec.europa.eu/clima/sites/clima/files/docs/pages/com_2018_733_analysis_in_support_en_0.pdf.
The most recent 2030 Climate Target Plan was restricted to the 2020-2030 horizon.

The literature on the economic impact of climate change is vast. The overview in this section has looked at the impact of GHG concentrations on global temperatures and the impact of climate change on economic output. Standard IAMs incorporate economic damages caused by GHG emissions that, over the time horizon 2020 to 2100 look limited when compared to global GDP growth over the past decades. The representation of damages in these models is however incomplete. A common theme in the literature is the nature of the limitations of our knowledge about factors that mean that damages could be severely worse than anticipated. Such uncertainty relates for example to the non-linear economic consequences of rising temperatures, and the timing of tipping points beyond which climate change and ecosystem damage become irreversible. Other important mechanisms are left out for lack of knowledge of how to quantify them It therefore appears crucial to highlight the large downside risks. When communicating on model results, the focus should be more on the range of plausible scenarios rather than on point estimates.

Mitigation policy itself does not necessarily come with large costs for the economy as a whole. The model simulations presented here show that mitigation policy under certain conditions affects aggregate economic output and employment only little at the same time as it brings net GHG emissions close to zero by 2050. Obviously, decarbonisation requires massive structural change, represented in the simulations by the phasing out of almost all fossil fuel extraction and the substitution towards renewable energy in the production process. The simulations suggest that this is compatible with a limited impact on aggregate output. The sensitivity analysis highlights that the degree of substitutability of energy sources as well as continued efficiency gains in renewables are important drivers of these outcomes. However, even under more pessimistic assumptions, the cost of mitigation remains manageable.

As we have not integrated a damage function in the simulations, our simulation results do not include the harm avoided thanks to climate mitigation policy. Nonetheless, our findings provide guidance for the implementation of the European Green Deal.

The negative impacts of climate change are non-linear in increasing global temperatures. This in itself justifies ambitious mitigation targets such as the Paris Agreement's temperature goals and Europe's ambition to become climate-neutral by 2050 and the proposal to tighten the intermediate targets for 2030. As omitted mechanisms and incomplete knowledge imply large risks of significantly bigger damages at any level of temperature increase, climate policy needs to also serve a risk management function in parallel with adaptation to climate change impacts that are inevitable even in the best-case scenario.

The green transition will trigger large sectoral shifts in economic activity, with a need for accompanying social and regional policy. In the euro area, the ECB is also pondering adaptations to its monetary strategy in response to the impact of climate change. Policies that help further technical progress in the renewables sector will also ease the transition. The scope and complexity of this endeavour calls for a systemic approach as reflected in the 'green oath' whereby all policy areas are held to do no harm ([228]).

At the same time, the numerous unknowns and risk factors related to the assessment of the economic impact of GHG emissions call for further development of analytical tools (e.g. refinement of 'damage functions') and conceptual frameworks (e.g. understanding the role of services provided by threatened ecosystems in generating material wellbeing).

([228]) Commission Communication 'The European Green Deal', COM(2019)640final.

III. Fiscal policy implications of uncertain fiscal outcomes

By Philipp Mohl and Gilles Mourre

This section analyses the impact of the uncertainty that fiscal outcomes can have on expected fiscal efforts. The findings highlight that discretionary fiscal adjustments are subject to large uncertainty, as measured ex post by the forecast errors in EU countries from 2000, even if the forecasts used are unbiased. Results from panel regressions reveal that Member States frequently do not adjust their expected fiscal effort to uncertain fiscal outcomes in the form of forecast errors. We find that Member States react only late and asymmetrically to forecast errors, relaxing the fiscal effort in case of positive surprises and leaving it unchanged in case of negative ones.

III.1. Introduction

Uncertainty is inherent to economic developments. The Great Recession in 2008/2009 illustrates the effect of unforeseen events on the economy. The risk of contagion effects called into question the very viability of the euro-area project ([229]). However, it does not take a very deep crisis to see that uncertainty is an unavoidable feature of the economy.

Uncertainty also affects fiscal policy. In the short and medium term, much of the uncertainty about fiscal policy comes from shocks to the macroeconomic environment and the impact of these shocks on fiscal variables. ([230]) In the longer term, the main sources of fiscal uncertainty stem from potential growth, implicit interest rates on public debt, health-care or ageing expenditure and contingent liabilities ([231]).

The COVID-19 pandemic clearly highlights the implications of uncertainty for fiscal policy. According to the Commission 2020 autumn forecast, fiscal deficit and public debt are projected to increase considerably in 2020 and 2021. The outlook covers large differences across Member States and is surrounded by a high degree of uncertainty.

Against this background, this section analyses the impact of uncertainty of fiscal outcomes on the expected fiscal efforts. The main objective is to analyse whether and under which conditions Member States react to uncertainty by adjusting their expected fiscal effort. While the analysis is backward looking, its implications are also relevant for the recovery from the COVID-19 crisis.

It is structured as follows. Sub-section 2 gives an overview of the main types of uncertainty indicators, which take different perspectives. Sub-section 3 presents stylised facts of the uncertainty measure used for the analysis, namely the forecast error of the fiscal effort. Sub-section 4 describes the empirical strategy, before sub-section 5 presents the main findings. Finally, Sub-section 6 concludes.

III.2. Uncertainty: different measures and perspectives

While uncertainty is inherently unobserved, four types of indicators have been used to measure it ([232]).

First, dispersion indicators. They mostly focus on the divergence of opinions of forecasters or

([229]) Buti, M. and P. Padoan, (2013), 'How to make Europe's incipient recovery durable: End policy uncertainty', *VOX*, 12 September.

([230]) Belinga, V., Benedek, M., de Mooij, R. and M. Norregaard (2014), 'Tax buoyancy in OECD countries', *IMF Working Paper* No. 14/110, Mourre, G. and S. Princen (2015), 'Tax revenue elasticities corrected for policy changes in the EU', *European Economy. Economic Papers* 18; Mourre, G., Astarita, C. and A. Maftei (2016), 'Measuring the uncertainty in predicting public revenue', *European Economy, Economic Papers* 39; Fioramanti, M., Gonzalez Cabanillas, L., Roelstraete, B. and S. Ferrandis Valterra (2016), 'European Commission's forecasts accuracy revisited: Statistical properties and possible causes of forecast errors', *ECFIN Discussion Paper* 27; Koester, G. and C. Priesmeier (2017), 'Revenue elasticities in euro area countries', *ECB Working Paper* 1989.

([231]) Auerbach, A. (2014), 'Fiscal uncertainty and how to deal with it', Hutchings Center on Fiscal and Monetary Policy at *Brookings Working Paper* 6, 15 December.

([232]) For descriptions of uncertainty indicators see also Vašíček, B. (2018), 'Impact of uncertainty shocks in the euro area', . European Commission (2018), *Quarterly Report on the Euro Area,* Vol. 16, No.3, pp. 25-40; Meinen, P. and O. Roehe (2017), 'On measuring uncertainty and its impact on investment: cross-country evidence from the euro area', *European Economic Review*, Vol. 92, pp. 161-179 or Jurado, K., Ludvigson, S. and S. Ng (2015), 'Measuring uncertainty', *American Economic Review*, Vol.105, No. 3, pp. 1177-1216. To encompass all dimensions, some authors build synthetic indicators combining different measures (European Central Bank (2016), 'The impact of uncertainty on activity in the euro area', *ECB Economic Bulletin* 8.

survey respondents, but also on the divergence of firm-growth rates within industries. Such indicators assume that a high (low) dispersion indicates a high (low) level of uncertainty ([233]). A positive feature of dispersion indicators is that they are typically based on a large number of observations. Nevertheless, some caveats exist. First, agents' opinions may display systematic biases due to financial incentives ([234]). Second, dispersions across respondents may be explained by differences in available information or in their implications ([235]). Third, dispersion may be caused by time lags in the release of surveys, since forecasters rarely make predictions at the same point in time.

Second, stock market volatility indicators. The volatility of stock market data has been frequently used as a proxy for uncertainty. Financial-market data are available at high frequency, which allows measuring their volatility at different periods. Nevertheless, it cannot be ruled out that these indicators change for reasons other than uncertainty, for instance because of changes in risk aversion or economic confidence ([236]). In addition, stock market data can be less relevant in smaller countries.

Third, forecast errors measures. These are based on the difference between forecast and outturn data. They assume that a low (high) deviation between forecast and outturn data of macroeconomic ([237]) or financial markets data ([238]) is a sign of a low (high) level of uncertainty. While it is possible to calculate forecast errors for many variables ([239]), they are typically not available at high-frequency level. Furthermore, it cannot be ruled out that these indicators change for reasons other than uncertainty.

Fourth, news-based indicators. These are indicators that count words related to uncertainty in media sources. The more often these words occur, the higher the degree of uncertainty ([240]). The main caveats with news-based measures are potential biases due to the subjectivity this entails (e.g. availability of media sources, choice of newspapers, search words). Furthermore, there are limitations to data availability, especially for smaller countries.

In the following, we show how uncertainty has evolved in the EU using the types of uncertainty measures presented above (Graph III.1 1). We consider the dispersion of forecasters' opinion (ECB SPF), volatility on the financial market (VSTOXX) and economic policy uncertainty (EPU).

Uncertainty indicators show marked differences, depending on their perspective: economic, financial or political uncertainty ([241]). Such uncertainty measures spike at different points in time and exhibit low correlations. The correlation is even negative between the EPU and the dispersion of macroeconomic forecasts (-0.08), and it only reaches a level of close to 0.3 between the ECB SPF and the VSTOXX.

([233]) Bloom, N., Floetotto, M., Jaimovich, N., Saporta-Eksten, I. and S. Terry (2018), 'Really uncertain business cycles', *Econometrica* , Vol. 86, No. 3, pp. 1031-1065, Bachmann, R., Elstner, S., E. Sims (2013), 'Uncertainty and economic activity: Evidence from business survey data', *American Economic Journal: Macroeconomics,* Vol. 5, No. 2, pp. 217-49, Abel, J., Rich, R., Song, J., J. Tracy (2016), 'The measurement and behavior of uncertainty: Evidence from the ECB survey of professional forecasters', *Journal of Applied Econometrics*, Vol. 31, No. 3, pp. 533-550.

([234]) Jurado *et al.* (2015)., *op.cit.*

([235]) Diether, K., Malloy, C. and A. Scherbina (2002), 'Differences of opinion and the cross section of stock returns', *The Journal of Finance,* Vol. 57, No. 5, pp. 2113-2141; Mankiw, N., Reis, R. and J. Wolfers (2003), 'Disagreement about inflation expectations', *NBER Macroeconomics Annual* 18, pp. 209-248; Vašíček (2018), *op. cit*.

([236]) Bekaert, G., Hoerova, M. and M. Duca (2013), 'Risk, uncertainty and monetary policy', *Journal of Monetary Economics,* Vol. 60, No. 7, pp. 771-788.

([237]) Klomp, J. and J. de Haan (2009), 'Political institutions and economic volatility', *European Journal of Political Economy*, Vol. 25, No. 3, pp. 311-326, Mohl, P.and D. Sondermann (2013), 'Has political communication during the crisis impacted sovereign bond spreads in the euro area?', *Applied Economics Letters,* Vol. 20, No. 1, pp. 48-61, Auerbach (2014), *op. cit.,* Abel, J., Rich, R., Song, J. and J. Tracy (2016), 'The measurement and behavior of uncertainty: Evidence from the ECB survey of professional forecasters', *Journal of Applied Econometrics*, Vol. 31, No. 3, pp. 533-550, Rossi, B., Sekhposyany, T. and M. Souprez, (2017), 'Understanding the sources of macroeconomic uncertainty', *Barcelona Graduate School of Economics Working Papers* 920.

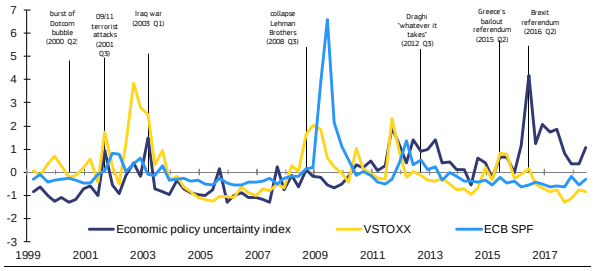
([238]) Brown, K., Harlow, W. and S. Tinic (1988), 'Risk aversion, uncertain information, and market efficiency', *Journal of Financial Economics,* Vol. 22, No. 2, pp. 355-385.

([239]) Jurado *et al.* (2015), *op. cit*.

([240]) Baker, S., Bloom, N. and S. Davis (2016), 'Measuring economic policy uncertainty', *The Quarterly Journal of Economics,* Vol. 131, No. 4, pp.1593-1636.

([241]) For the dispersion of indicators we take data from the ECB's Survey of Professional Forecasters (SPF) and estimate the cross-sectional variance of 1-year rolling forward forecast point predictions of Eurozone GDP growth (Abel *et al.* (2016), op. cit.). In terms of financial-markets measures we use the VSTOXX, which measures the volatility of the EURO STOXX 50, as well as the bond spread between the German and Greek 10-year government bonds. Finally, the news-based measure is shown by the Economic Policy Uncertainty index, which is applied to Europe (Baker *et al.* (2016), *op. cit.*).

Graph III.1: **Evolution of uncertainty indicators for the EU in comparison**



Source: ECB, European Commission, Baker, Bloom and Davis, Bloomberg.

The VSTOXX and the bond spreads measure specifically the uncertainty of financial markets. The VSTOXX increased significantly in reaction to the 9/11 terror attacks, the 2003 Iraq war and the collapse of Lehman Brothers. It decreased progressively after ECB President Mario Draghi's 'Whatever it takes' speech in July 2012 and increased again in 2015 in the context of Greece's bailout referendum.

The economic policy uncertainty (EPU) index focuses on political events. The EPU index showed significant increases in reaction to the 9/11 terror attacks or the Iraq war; two events which also triggered reaction in the financial uncertainty indicators. By contrast, the EPU index did not spike following the fall of Lehman Brothers but it increased following the Brexit referendum, while the measures of financial market and macroeconomic uncertainty (e.g. dispersion of indicators) remained at low levels.

Dispersion in the ECB Survey of Professional Forecasts (SPF) primarily measures macroeconomic uncertainty. This indicator shows a spike of uncertainty right after the collapse of Lehman Brothers. The delay compared to the financial indicators around 2009 and 2012 reflects a difference in their nature: the measure of macroeconomic uncertainty peaked after that of financial uncertainty because risks were first observed on the financial market and their materialisation fuelled the risk of contagion to the real economy. The recent referendums on the UK's membership of the EU and Greece's financial assistance programme were accompanied by increases in measures of political risk but did not trigger sizeable reactions in measures of macroeconomic uncertainty.

III.3. Stylised facts using our uncertainty measure: forecast errors of the fiscal effort

Our key measure for uncertain fiscal outcomes is the forecast error of the fiscal effort. Our analysis focuses on the fiscal effort, as measured by the change in the structural balance, since it is a key indicator of the Stability and Growth Pact (SGP) ([242]). We assess the uncertainty of the fiscal effort with the third type of uncertainty indicator presented above, namely the forecast error (Sub-section 2). Our uncertainty indicator corresponds to the 18-month-ahead forecast error for year *t* and is defined as the difference between the forecast for *t* made in autumn of *t-1* and the actual (outturn) value for *t* as observed in spring of *t+1*. The use of the autumn forecast allows us to take into account Member States' draft budgetary plans. As a result, a positive (negative) forecast error means that the fiscal effort turned out to be smaller (higher) than expected, implying a negative (positive) surprise.

The forecast error is based on Commission forecast reports. We compute the forecast errors for Member States using real-time data from Commission forecast vintages between autumn 2000 and spring 2018. Our analysis shows that Commission forecasts represent an unbiased forecast with satisfactory forecasting properties ([243]). By contrast, forecasts produced by domestic authorities may be overly optimistic in order to avoid potential procedural consequences in case of non-compliance with the targets ([244]). For this reason, we argue that our forecast error indicator represents an *ex post* measure of uncertainty for Member States.

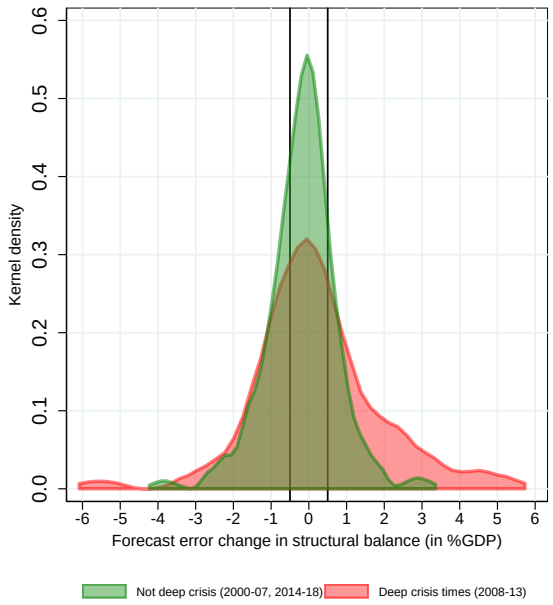
([242]) The structural balance adjusts the overall government balance for the impact of the economic cycle as well as for certain one-off revenues (e.g. sales of telecommunication licences) and one-off capital transfers (e.g. financial assistance to the banking sector). In the preventive arm of the SGP, the required fiscal adjustment is also measured by the expenditure benchmark.

([243]) We ran tests for bias in the Commission's projections, by simply regressing the forecast error on a constant and testing if this constant is statistically different from zero. Our findings show that the forecast of the fiscal effort does not show a bias for country aggregates (EU, euro area, CEEC) and for all 28 Member States apart from Croatia. For Croatia, the number of observations is limited, since it only joined the EU in 2013. The results broadly confirm similar tests (González Cabanillas, L. and A. Terzi (2012), 'The accuracy of the European Commission's forecasts re-examined', *European Economy. Economic Papers* 476, European Commission (2020), 'Performance of spending rules at EU and national level – a quantitative assessment, Report on public finances in EMU', *European Economy, Institutional Paper*, 24 July 2020.

([244]) Frankel, J. and J. Schreger (2013), 'Over-optimistic official forecasts and fiscal rules in the eurozone', *Review of World Economics*, Vol. 149, No. 2, pp. 247-272.

Our results show that the forecast errors of the fiscal effort can be sizeable, not only in times of deep crisis (Graph III.2**)**. It is true that the forecast errors were particularly large during the 2008/2009 Great Recession. During this period, more than 70% of the forecast errors exceeded 0.5 pp. of GDP (see white Kernel in Graph III.2). In addition, the forecast errors were mostly positive, explaining the right-skewed distribution. However, also outside times of deep crisis, sizeable forecast errors exceeding 0.5 pp. occurred in around 50% of cases (see green Kernel in Graph III.2).

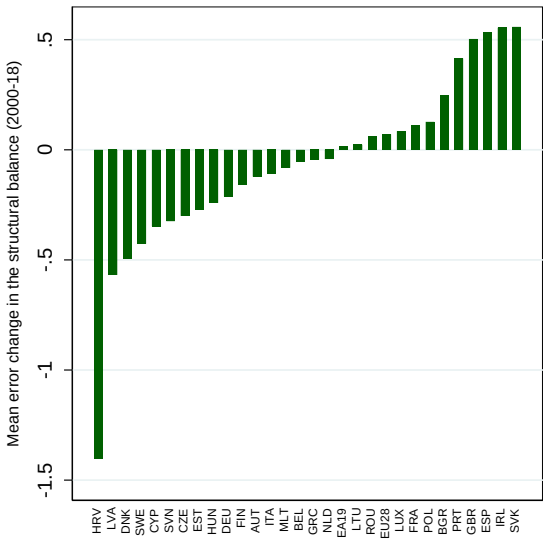
Graph III.2: **Distribution of forecast errors of the fiscal effort (EU-28 Member States)**



(1) Note: Our uncertainty indicator corresponds to the 18-month-ahead forecast error for year t and is defined as the difference between the forecast for t made in autumn of t-1 and the actual (outturn) value for t observed in spring of t+1. A positive (negative) forecast error corresponds to a negative (positive) surprise. The calculations are based on real-time data from Commission forecast vintages from 2000-2019. For data availability reasons, the cyclically-adjusted balance is used before 2006 instead of the structural balance.
Source: Commission forecast from different vintages.

The forecast error of the fiscal effort was non-negligible for many Member States. For the EU as a whole, positive and negative 18-month-ahead forecast errors offset each other over the period 2000 to 2018, resulting in a mean error close to zero. However, at country level, the forecast error seems to be more persistent. Over the entire period, on average around 20 (15) percent of the Member States overestimated the fiscal effort by on average 0.25 (0.5) pp. (Graph III.3). The mean error represents only a rough indicator of the forecast quality, since positive and negative errors can offset each other, thus limiting the size of the error.

Graph III.3: **Mean error of fiscal effort by country**



(1) Note: See footnote of Graph III.2 for more information.

Source: Commission forecast from different vintages.

III.4. Empirical strategy

Using a panel data approach, we analyse Member States' reaction to uncertainty based on an augmented fiscal reaction function. The analysis concentrates on all Member States using real-time data from Commission forecast reports between autumn 2000 and spring 2019.

The analysis is conducted in two steps. As a first step, the key drivers of the expected fiscal effort are determined using a classical fiscal reaction function, which is augmented with the forecast error of the fiscal effort. This allows us to get a first rough idea of whether Member States learn from past uncertainty (i.e. a 'learning effect'). The specification looks as follows:

$$\Delta sb_{i,t+1}^{AF,t} = \beta_1\, cycle_{i,t+1}^{AF,t} + \beta_2\, \mathrm{debt}_{i,t-1}^{AF,t} + \beta_3\, FE\,(\Delta sb_{i,t-1}) + \beta_4\, X_{i,t}^{t} + \vartheta_t + \theta_i + \varepsilon_{i,t} \quad (1)$$

where the superscript t refers to the time of the publication of the Commission forecast report, while subscript t refers to the year to which the figure applies and i stands for the Member State.

For instance, the dependent variable $\Delta sb_{i,t+1}^{AF,t}$ is the expected fiscal effort for year *t+1* as projected in the Commission autumn forecast report of year *t*.

The independent variables are selected in line with the literature ([245]). We control for two key variables used in the fiscal reaction function literature, namely the economic cycle ('cycle' in equation 2), as measured by the change in the output gap, and the government's budget constraint in the form of the debt-to-GDP ratio ('debt'). The setup reflects the rationale of the EU fiscal governance framework, which requires a larger fiscal effort in good economic times and/or in the presence of high public debt for Member States that still need to reach a sound fiscal position (their MTO) ([246]). A key variable of interest is the forecast error of the fiscal effort. Our uncertainty indicator corresponds to the 18-month-ahead forecast error for year *t* and is defined as the difference between the forecast for *t* made in autumn of *t-1* and the actual (outturn) value for *t* as observed in spring of *t+1*. The forecast error of the fiscal effort is denominated in equation 2 as $FE\left(\Delta sb_{i,t-1}\right)$. The remaining independent variables are summarised in vector *X*. They include the forecast error of the output gap, key indicators for EU fiscal rules (dummy variables for Member States who are in EDP and/or have achieved their MTO) and the election year (the percentage share of months of a given year before an election) ([247]). Furthermore, the specification incudes year- (ϑ) and country-fixed effects (θ), while ε represents an error term.

In a second step, we refine our specification to find out if the sign, size and/or persistency of the forecast error matters for the reaction of Member States. Since forecast errors are an unavoidable part of fiscal projections, we do not expect Member States to react to all kinds of uncertainty. However, a myopic disregard of repeated errors or large-scale uncertainty can do serious damage to a Member State's public finances. Therefore, we use the following panel interaction model to find the conditions under which the forecast error becomes significant:

$$\Delta sb_{i,t+1}^{AF,t} = \beta_1\, cycle_{i,t+1}^{AF,t} + \beta_2\, debt_{i,t-1}^{AF,t} + \beta_3\, FE\left(\Delta sb_{i,t-1}\right) + \beta_4\, X_{i,t}^{t} + \beta_5\, FE\left(\Delta sb_{i,t-1}\right).D_{i,t}^{AF,t} + \beta_6\, D_{i,t}^{AF,t} + \vartheta_t + \theta_i + \varepsilon_{i,t} \qquad (2)$$

where *D* represents a dummy variable that is equal to 1 if the forecast error is positive (i.e. representing a negative surprise) and/or large (exceeding 0.25 or 0.5 pp. of GDP) and/or persistent (i.e. repeated forecast errors of up to 3 years). To find out if these elements have an impact on the expected fiscal effort, the dummy variable is interacted with the forecast error. We can then derive the marginal effect, which measures how a marginal change of the forecast error effects the fiscal effort as follows:

$$\frac{\partial\, \Delta sb}{\partial\, \mathrm{FE}(\,\Delta sb)} = \beta_3 + \beta_5\, D_{\mathrm{i,t}} \qquad (3)$$

The equation shows that the marginal effect depends on the value of the dummy variable *D*. The marginal effect is defined as $\beta_3 + \beta_5$ if the dummy variable is equal to 1 (e.g. forecast error shows a negative surprise), whereas it simplifies to $\beta 3$ if the dummy variable is 0 (e.g. forecast error shows a positive surprise) ([248]). In addition, the standard errors for both events can be calculated based on the variance-covariance matrix.

We apply different estimation techniques. In terms of the estimation approach, we apply three different techniques. We first estimate the model with simple LSDV estimations using White heteroscedasticity robust standard errors ([249]). In

([245]) See for instance, Bohn, H (1998), 'The behaviour of U.S. public debt and deficits', *The Quarterly Journal of Economics,* Vol. 113(August), pp. 949-963, Checherita-Westphal, C. and V. Žďárek(2017), 'Fiscal reaction function and fiscal fatigue: Evidence for the euro area', *ECB Working Paper* 2036, Combes, J., Minea, A. and M. Sow (2017), 'Is fiscal policy always counter-(pro-) cyclical? The role of public debt and fiscal rules', *Economic Modelling,* Vol. 65, pp. 138-146, European Commission (2011), 'Public Finances in EMU', *European Economy* 3, September.

([246]) European Commission (2019), 'Vade Mecum on the Stability and Growth Pact – 2019 edition', *Institutional Paper* 101, 2 April.

([247]) Election year is defined as the share of month in a given year before the election (e.g. if the election takes place in October 2019, the value of the variable is 10/12 in 2018 and 5/6 in 2019 and 1/6 in 2018. Please note that we tested a range of alternative control variables e.g. the partisanship (left vs. right). We also tested for the sensitivity of the economic cycle by using the level of the output gap and the real GDP growth rate. However, the results do not change.

([248]) For the specification and interpretation of interaction terms see Brambor, T., Clark, W. and M. Golder (2006), 'Understanding interaction models: Improving empirical analyses', *Political Analysis*, Vol. 14, No. 1, pp. 63-82, Braumoeller, B. (2004), 'Hypothesis testing and multiplicative interaction terms', *International Organization,* Vol. 58, No. 4, pp. 807-820.

([249]) White, H. (1980), 'A heteroskedasticity-consistent covariance matrix estimator and a direct test for heteroskedasticity', *Econometrica*, Vol. 48, No. 4, pp. 817-838.

addition, we provide further evidence by running first-difference and system-GMM regressions in order to control for endogeneity ([250]). We consider the forecast error and the output gap to be endogenous. Due to the small sample size, the set of internal instrumental variables is restricted to up to 2 lags and the matrix of instruments is then 'collapsed' ([251]). We test the validity of the GMM specification with AR(1,2) and Hansen tests.

III.5. Main findings

Our baseline model largely confirms the findings of the fiscal reaction function literature (Table 1). We find strong evidence of pro-cyclical fiscal policy, as shown by the negative and significant coefficient of the change in the output gap. In addition, an increase of the debt-to-GDP ratio tends to lead to a fiscal tightening. Moreover, election years appear to be significantly linked to a loosening of the fiscal effort. The initial years of the Great Recession (2008-09) seem to have resulted in a significant loosening of the fiscal adjustment. Finally, Member States that have achieved their MTOs seem to set looser fiscal adjustment plans, while there is no evidence that an EDP affects the expected fiscal effort. The findings are robust to the estimators used (columns 1-5) ([252]).

A rough first assessment indicates no significant learning effect (Table 1). To get a rough first idea whether Member States learn from past episodes of uncertainty, we augment the model with the forecast error of the fiscal effort. Since the consequences of increased uncertainty may only kick in after repeated forecast errors have occurred, we assess the impact of time lags in greater detail. We run our empirical analyses by adding the lagged forecast error in a stepwise fashion, beginning with a lag of 1 year (column 3) and ending up with specifications comprising the forecast error with a lag of up to 2 (column 4) and 3 years (column 5). The results indicate that an increase (decrease) in the forecast error does not have a statistically significant impact. The findings of the other independent variables remain broadly unchanged.

Table III.1: **Regression results: augmented baseline model**

	LSDV	SYSGMM			
	(1)	(2)	(3)	(4)	(5)
Δ OG (t+1)	-0.324***	-0.460***	-0.345***	-0.330***	-0.393***
	(-4.962)	(-3.145)	(-3.325)	(-3.136)	(-3.598)
Public debt (t)	0.009***	0.006***	0.006***	0.003	0.006***
	(2.732)	(3.652)	(2.878)	(1.149)	(4.506)
Crisis dummy (2008-09)	-0.778***	-0.763**	-3.060***	-2.256***	-1.955***
	(-3.528)	(-2.432)	(-4.743)	(-4.940)	(-6.338)
Election year (t+1)	-0.000	-0.001***	-0.002***	-0.001**	-0.001***
	(-1.549)	(-2.622)	(-3.770)	(-2.358)	(-3.648)
MTO achievement (t)	-0.279***	-0.179**	-0.166	-0.251***	-0.106
	(-3.140)	(-2.333)	(-1.628)	(-2.704)	(-1.364)
EDP (t)	0.098	0.136	0.006	0.168	0.068
	(1.325)	(1.631)	(1.061)	(1.366)	(0.817)
Forecast error OG (t-1)	-0.048	-0.005	-0.170**	-0.075	-0.025
	(-1.250)	(-0.083)	(-2.174)	(-1.207)	(-1.030)
Forecast error ΔSB (t-1)			-0.003	0.012	0.068
			(-0.060)	(0.179)	(1.491)
Forecast error ΔSB (t-2)				0.066	0.031
				(1.384)	(0.720)
Forecast error ΔSB (t-3)					0.030
					(0.910)
# countries	28	28	28	28	28
# observations	410	410	399	371	343
Wald time dummies	0.000	0.000	0.000	0.000	0.000
Forecast error ΔSB (size)			-0.003	0.078	0.129
Forecast error ΔSB (p-value)			0.952	0.858	0.136
AR(1) (p-value)		0.004	0.005	0.007	0.023
AR(2) (p-value)		0.455	0.363	0.58	0.788
Hansen (p-value)		0.520	0.476	0.274	0.245
# instruments		24	30	31	32

(1) Estimations are based on the least square dummy variable estimator using heteroskedasticity-robust standard errors (LSDV). In addition, the use of system-GMM (SYS-GMM) estimators follows Blundell and Bond (1998), where we consider the output gap and the forecast error variables to be endogenous. Due to the small sample size, the set of internal instrumental variables is restricted to up to 2 lags and the matrix of instruments is then 'collapsed'. The standard errors are corrected following Windmeijer (2005). AR(1,2) and Hansen tests confirm the validity of the GMM specifications (Roodman, 2009a, b). Note that the coefficients and standard errors of the forecast error cannot be interpreted if the variable is included in the regression with several lags (columns 3-5). As a consequence, we report the size of forecast errors coefficients (row 'forecast error ΔSB (size);) We then use a simple Wald test to check whether this short-term elasticity is statistically different from zero ('forecast error ΔSB (p-value)'). ***, ** and * denote statistical significance at 1, 5 and 10% respectively.
Source: European Commission.

Robustness tests broadly confirm the main findings. First, we shorten the sample to re-run the regressions for the period since 2005. The reason for this is that the structural balance has been used in fiscal surveillance only since 2005, while the cyclically-adjusted balance was used earlier than that ([253]). Second, we assess the sensitivity of our findings by using different estimation techniques as described above. Overall, our key findings do not change much in both cases.

([250]) Blundell, R. and S. Bond (1998), 'Initial conditions and moment restrictions in dynamic panel data models', *Journal of Econometrics,* Vol. 87, No. 1, pp. 115-143.

([251]) The standard errors are corrected following Windmeijer, F. (2005), 'A finite sample correction for the variance of linear efficient two-step GMM estimators', *Journal of Econometrics*, Vol. 126, No. 1, pp. 25-51.

([252]) We also tested for a broad range of additional independent variables (such as the current account balance, openness, ageing), which, however, turned out to be not statistically significant.

([253]) The structural balance corresponds to the cyclically-adjusted balance excluding one-offs and certain temporary measures.

We then revise our empirical strategy to find out if Member States learn from past episodes of uncertainty. A myopic disregard of repeated or large-scale uncertainty can do serious damage to the public finances. In order to take this factor into account, we assess the sign, size and persistence of the forecast error in greater detail. We distinguish between negative surprises (i.e. positive forecast errors) and positive ones (i.e. negative forecast errors). We also test if large or very large negative or positive surprises (0.25 pp. or 0.5 pp. of GDP) had an impact. Finally, we test if repeated (large) negative or positive surprises had an impact on Member States' expected fiscal effort.

Our findings of the refined test of the learning effect can be summarised as follows (Table 2):

- ***Sign of the forecast error***: Our results show that neither negative surprises (i.e. a *positive* forecast error) nor positive surprises of the fiscal forecast (i.e. a *negative* forecast error) have a statistically significant impact on the expected fiscal effort.

- ***Size of the forecast error***: Similarly, *large* or *very large* negative surprises do not cause a significant effect on the expected fiscal effort if they occur only once. This finding holds, irrespective of the sign (positive or negative) and the size (0.25 pp. or 0.5 pp. of GDP) of the forecast error. Similarly, the occurrence of one (very) large forecast error in the past (up to three years) has no statistically significant impact on the expected fiscal effort.

- ***Persistence of forecast errors***: We assess up to three lags to assess the impact of persistent forecast errors. We find evidence that persistent forecast errors have an impact on the expected fiscal effort. The strength of the impact depends, however, on the size of the forecast error: Overall, we find only a weak impact in case of negative surprises, but a strong one for positive ones. To be more precise, in case of negative surprises, only a *repeated and very large negative* surprise (i.e. exceeding 0.5 pp. of GDP) leads to a statistically significant impact in the form of a fiscal tightening. It is important to note, however, that this is a rather rare event that only occurs in around 3% of all observations since 2000 (13 out of 399). The main result is only valid in case of three very large negative surprises that are repeated in a row. By contrast, we cannot find significant results if the very large negative surprise occurred only 2 years in a row or in 2 out of 3 years. At the same time, repeated positive surprises have a rather strong impact, resulting in a fiscal loosening.

III.6. Conclusions

This section finds that Member States tend to react only very late and asymmetrically to the uncertainty surrounding the fiscal effort. We show that uncertain economic outcomes in the form of the forecast error of the fiscal effort have been an integral part of fiscal projections in the EU since 2000. Nevertheless, the results from panel regressions reveal that Member States frequently do not adjust their expected fiscal effort to economic shocks. We find that Member States only late and asymmetrically react to forecast errors, relaxing the fiscal effort in case of positive surprises and leaving it unchanged in case of negative ones.

Table III.2: **Regression results conditional on forecast characteristics**

		Type of surprise	
		Negative	**Positive**
Sign		0,08	0,01
Size	Large	0,05	-0,02
	Very large	0,01	-0,03
Per-sistence	Repeated		
	• 2 years in a row	-0,02	-0.16*
	• 3 years in a row	0,02	-0.20**
	Repeated and large		
	• 2 years in a row	-0,11	-0.02**
	• 3 years in a row	-0,07	-0.49**
	Repeated and very large		
	• 2 years in a row	0,15	-0.27**
	• 3 years in a row	0,19*	-0,30

(1) Forecast errors of the fiscal effort (i.e. the change in the structural balance) are considered to be large (very large) if they exceed 0.25(0.5) pp. The table shows the size and significance level of the marginal effect, which measures the impact of a marginal increase of the forecast error if the forecast characteristic (sign, size, persistence) is fulfilled (see equation (3)). The findings are based on the same sample and estimation techniques as described above. A reading example of the quantitative assessment: a negative surprise tends to have a small positive impact on the expected fiscal adjustment (the size of the coefficient is 0.08), which is, however, not statistically significant at the 10% level. ***, ** and * denote statistical significance at 1, 5 and 10% respectively.

Source: European Commission.

IV. Economic benefits of the euro

By Paul Brans, Ulrich Clemens, Christina Kattami and Eric Meyermans

Abstract: This section analyses how euro area Member States and their citizens have benefited from the euro since its launch more than 20 years ago and to what extent the expected benefits of its introduction have materialised. The adoption of the euro has facilitated cross-border transactions, especially in product and financial markets, thereby increasing price transparency and competition. However, barriers limiting consumer choice and full price competition, such as the incomplete Single Market, remain. Medium-term price stability across the euro area has been achieved since the launch of the euro; and increasingly integrated financial markets have also provided citizens and firms with more opportunities to share risks. At the same time, however, lower transaction costs and elimination of nominal exchange rate risk had a stronger impact on cross-border financial flows than on intra-euro trade in goods and services which led to an unsustainable accumulation of debt in some Member States in the run-up to the global financial crisis. Overall, the section concludes that the euro can only reach its full beneficial potential once the economic and monetary union (EMU) architecture is completed ([254]).

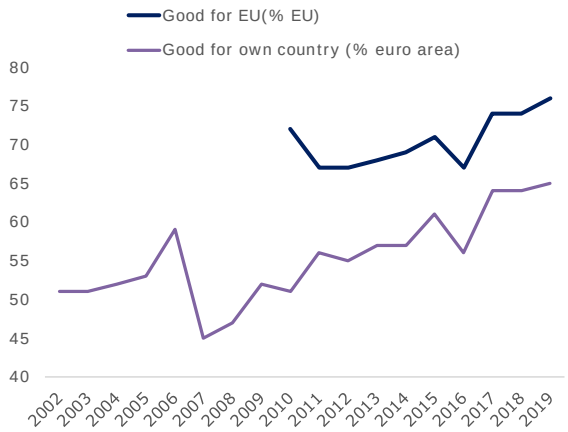
IV.1. Introduction

The introduction of the euro marks one of the most ambitious undertakings in the history of European unification. The changes it brought are in many cases beyond economic analysis only. Indeed, a common currency may present many textbook benefits, but the euro's eventful life prompts us to examine the theory more thoroughly. It may also provide a reminder in times of crisis, such as the current COVID-19 crisis, that while institutional reform is necessary to reap the full benefits of the euro, the common currency has improved the lives of European citizens regardless.

As such, this section will describe how the euro area Member States and their citizens have benefited from the adoption of the euro, based on a literature review. At the same time, it highlights those areas where the euro could not fulfil expectations, thus calling for continued reform efforts and deepening of the Single Market.

The euro was launched on 1 January 1999. By mid-2020 the euro had become a currency used daily by about 340 million citizens of the euro area. It is also the second most used currency around the world and another 60 countries and territories, representing 175 million people, have pegged their own currencies, either directly or indirectly, to the euro ([255]).

Graph IV.1: **The impact of the euro on one's own country and on the European Union (Flash Eurobarometer survey)**



(1) A positive reply to the questions 'Having the euro is a good or a bad thing for your country (% - EURO AREA)' and 'Having the euro is a good or a bad thing for the EU (%)'.
Source: Flash Eurobarometer 481.

According to a recent Flash Eurobarometer survey ([256]), 65% of respondents across the euro area stated that they thought the euro was good for their own country – the highest score since the survey was launched in 2002 – while 76% of respondents across the euro area were of the opinion that the euro was good for the EU – see Graph IV.1. In addition, beyond the freedom and democracy that the EU provides its citizens with,

([254]) The authors wish to thank an anonymous reviewer and ECB colleagues Virginia Di Nino, Ettore Dorrucci, Michael Ehrmann, Michael Fidora, Peter McQuade, Mario Porqueddu, Daniel Sousa Carvalho, Georg Strasser, Guido Wolswijk and Christoph Zwick for useful comments on earlier drafts. The views expressed are the author's alone and do not necessarily correspond to those of the European Commission.

([255]) For more details see https://europa.eu/euroat20/the-euro-in-numbers/

([256]) European Commission Flash Eurobarometer 481, November 2019.

the euro has been considered to be the most important element of a European identity ([257]).

A daunting research challenge

At its launch, the expectations of the potential economic benefits of the euro were high. It was generally expected that a single currency would bring price and exchange rate stability, foster intra-euro area trade and provide a shelter against currency crises, and that more efficient capital markets would allow capital to flow across borders to its most efficient use and promote cross-border risk sharing ([258]).

At the same time, it was also expected that the introduction of the euro would strengthen the incentives for structural reforms such as labour market reforms along 'flexicurity'-principles, while other developments such as an accelerated expansion of global value chains might not have been fully anticipated.

However, since then quantifying these benefits and costs turned out to be challenging, as the most important benefits such as those arising from increased cross-border trade and capital flows accrue only gradually, while other costs and benefits are one-off and have an immediate impact, such as transition costs to the new currency ([259]).

Moreover, when assessing empirically the euro's impact, it is not always possible to disentangle the effects of the adoption of the euro from other developments such as the deepening of the Single Market or the effects stemming from the self-reinforcing interactions between the two.

Outline of the section

Building on previous reviews of the benefits of the euro ([260]), this section is structured as follows. The second subsection examines how the adoption of the euro complements the functioning of the Single Market by lowering transaction costs and reducing nominal exchange rate uncertainty for households and firms. This benefits consumers as well as producers, as it reduces the price search cost, pushes prices closer to marginal costs and increases the efficient allocation of resources. Such benefits are not always available under a flexible nominal exchange rate regime, as flexible exchange rates often violate the purchasing power parity conditions in the wake of volatile financial market shocks ([261]).

The third subsection highlights how the adoption of the euro strengthened price stability through a credible common monetary policy that reduced upward biases in inflation expectations. It argues also that although the irreversible fixing of the nominal exchange rate has eliminated the benefits of nominal exchange rate adjustments, nominal exchange rates have become less effective and relevant in the wake of ongoing structural changes such as the expansion of global value chains and increasing foreign exchange balance sheet exposure of households and firms. The subsection furthermore discusses some areas where pre-euro expectations were not met, for example, increased wage flexibility and Member States' structural reform efforts.

The fourth subsection explores in more detail the extent to which the single monetary policy and the elimination of competitive nominal devaluations promoted intra-euro area trade and foreign direct investment (FDI). This subsection provides also a brief overview of the benefits associated with a stronger international currency status of the euro.

The fifth subsection describes some missing elements in the well-functioning of the economic and monetary union (EMU). The last subsection draws some conclusions.

All in all, the analysis suggests that while the micro-economic channels such as lower transaction costs were to a large extent in line with the findings reported in the literature prior to the launch of the euro, the macro-economic channels turn out to be less in line with what was expected. For instance, the elimination of nominal exchange rate flexibility seems to have had a stronger impact on intra-euro area financial flows than on intra-euro trade flows,

([257]) Parlemeter 2016, Special Eurobarometer of the European Parliament, November 2016.

([258]) See for instance Emerson, M., Gros, D., Italianer, A., Pisani-Ferry, J. and H. Reichenbach (1992), *One Market, One Money: An Evaluation of the Potential Benefits and Costs of Forming an Economic and Monetary Union*, Oxford: Oxford University Press

([259]) For instance the one-off costs for shops to create new price lists denominated in euro.

([260]) See, for instance, ECB (2008), '10th Anniversary of the ECB', *ECB Monthly Bulletin.*

([261]) See, for instance, Bergin, P. and L. Ching-Yi (2012), 'The Dynamic Effects of a Currency Union on Trade', *Journal of International Economics*, Vol. 87, No. 2, pp. 191–204.

Table I.1: **Potential and actual economic benefits of the euro**

Effect			Impact	Realised benefits
Direct effects	Lower transaction costs		Elimination of costs associated with currency conversion and cross-border payments· Strengthening of firms' productivity and competitiveness	significant
	Elimination of exchange rate volatility		Reduced uncertainty fosters export and investments Reduced foreign exchange balance sheet exposure helps to diversify risks and stabilise domestic consumption	significant
	Lower inflation bias		Reduced loss of purchasing power for non-indexed income and wealth Reduced "shoe-leather" costs Beneficial effect on innovation Lower inequality	significant
Intermediate effects		Price convergence on product and capital markets	Lower prices and more choice for consumers Lower resource allocation inefficiencies Increased portfolio diversification, reducing savings and income volatility More uniform costs of funding strengthen competition in the Single Market	moderate
		International trade	Increased trade volumes due to reduced exchange rate uncertainty and transaction costs	significant
		Capital flows and financial market integration	Increased financial market integration due to lower currency risk and transaction costs, e.g. increased intra-euro area FDI. Increased shock absorption capacity and higher potential growth due to increased cross-border risk-sharing opportunities.	significant limited
		Cross-border labour mobility	Reduce unemployment and support aggregate demand in countries affected by idiosyncratic shocks	limited
		Incentives to conduct national structural reforms	Reforms improve well-functioning of markets and increase countries' shock absorbtion capacity	limited

(1) The shoe-leather cost measures the opportunity costs of holding money when nominal interest rates increase in response to anticipated inflation.
Source: Author's representation.

and in the run-up to the global financial crisis financial flows acted as a source of instability rather than promoting sustainable growth.

Table IV.1 provides a brief summary of the benefits stemming from selected channels associated with the adoption of the euro, such as lower transaction costs and less exchange rate volatility.

This section complements the second issue of the special 2019 Quarterly Report on the Euro Area (QREA) edition that provided an overview of developments since the launch of the euro in 1999 in terms of economic performance, institutional developments and further efforts needed ([262]).

IV.2. Complementing the Single Market

The euro complements the well-functioning of the Single Market by reducing transaction costs through systemic innovations such as the single euro payments area and by eliminating nominal exchange rate volatility within the euro area. In

([262]) Available at https://ec.europa.eu/info/publications/quarterly-report-euro-area-volume-18-no-2-2019_en

turn, these developments increase price transparency and market integration, which have a strong potential to increase societal welfare.

IV.2.1. Lower transaction costs

Prior to the adoption of the euro, the coexistence of multiple national currencies implied substantial resource costs in the conduct of cross-border payments ([263]). A common currency naturally eases the payment process between its Member States, as it (i) eliminates the cost to convert currencies, (ii) saves on operational costs associated with handling currencies and (iii) increases the incentives and opportunities to simplify the execution of cross-border payments for firms ([264]) as well as households ([265]).

A first step towards capitalising on these inherent benefits of a single currency was the 2001 EU Regulation on cross-border payments in euro ([266]), which eventually gave rise to further harmonisation and integration of European payment systems under the Single Euro Payments Area (SEPA) initiative.

The direct benefits of SEPA for European citizens include a single system for both domestic and cross-border bank transfers, which allows charging an account directly in one country for services provided in another country. Similarly, it allows people who are working or studying in another SEPA country to use an existing account in their home country to receive their salary or pay bills in the new country. Already by 2006, SEPA had helped to reduce the cost of transferring money in euros between euro area countries on average by 90% compared to 2001 ([267]).

At the same time, SEPA also strengthens euro area firms' productivity and competitiveness. More specifically, it helps firms to create more efficient euro cash-management infrastructures, enhances cash pooling, enables more efficient clearing and adoption of e-invoicing and helps to establish an integrated market for electronic payments in euros by credit card, debit card, electronic bank transfer or direct debit. In addition, significant direct gains are made by automating and streamlining activities and by unlocking liquidity and credit lines required for clearing transactions ([268]).

Overall, a fully operational SEPA has been estimated to yield a recurring annual benefit of EUR 22 billion due to increased price convergence and process efficiency ([269]), a cost-saving example that reaffirms one of the most straightforward benefits of the euro. In turn, these gains should also directly benefit all citizens to the extent that they are passed on to consumers.

IV.2.2. Elimination of intra-euro area exchange rate volatility

Prior to the adoption of the euro, nominal exchange rates of what were to become euro area Member States showed strong volatility ([270]) with,

([263]) For instance De Grauwe (2012), *The Economics of Monetary Union*, Oxford University Press, reports that various surveys suggest that prior to the introduction of the euro, banks' commissions on exchanging currencies constituted about 5% of their revenues. The European Commission at http://europa.eu/rapid/press-release_MEMO-19-1170_en.htm?locale=en reports that by end-2019 a transaction in euro from a non-euro area Member State to a euro-area Member State was priced between EUR 15 and EUR 24 regardless of the transaction amount, while a transaction within the euro area may be free of charge or cost only a few cents.

([264]) International transactions imply a broad range of costs, see for instance Anderson, J. and E. van Wincoop (2004), 'Trade Costs', *Journal of Economic Literature*, Vol. 42, no. 3, pp. 691-751.

([265]) For instance, households that engage in intra-EA tourism or cross-border shopping do not have to convert and hold different currencies.

([266]) Regulation (EC) No 2560/2001 of the European Parliament and of the Council on cross-border payments in euro forbid payment service providers from imposing different charges for domestic and cross-border payments or ATM withdrawals in euro within the EU.

([267]) See for instance European Commission (2006), Commission staff working document on the impact of Regulation (EC) 2560/2001 on bank charges for national payments, SEC (2006) 1783.

([268]) See PricewaterhouseCoopers (PwC) (2014), 'Economic analysis of SEPA Benefits and opportunities ready to be unlocked by stakeholders'.

([269]) Of which EUR 13.2 bn to the corporate sector, EUR 2.9 bn the public sector and EUR 5.9 bn to the banks. Estimate reported by PwC (2014), *op cit.*

([270]) On the empirical relevance of volatility in the foreign exchange market before the launch of the euro, see, for instance, Goodhart, C. (1989), 'News and the foreign exchange market', *LSE Financial Markets Group Discussion Paper*, No 71, Goodhart, C. and L. Figliuoli (1991), 'Every minute counts in financial markets', *Journal on International Money and Finance*, Vol. 10, pp. 23–52, and Faust, J., J. Rogers, E. Swanson and J. Wright (2002), 'Identifying the Effects of Monetary Policy Shocks on Exchange Rates Using High Frequency Data', *Board of Governors of the Federal Reserve System, International Finance Discussion Papers* No. 739. In addition, foreign exchange traders themselves may also be a source of a rich dynamic in the foreign exchange markets if their strategies are based on trial and error in an uncertain world. See, for instance, De Grauwze, P and P. Grimaldi (2012), *The Exchange Rate in a Behavioral Finance Framework*, Princeton University Press. Moreover, nominal exchange rates may overshoot their equilibrium value when rigidities in product prices hinder full price adjustment, with exchange rate fluctuations compensating for this lack of product market flexibility. See Dornbusch (1976), 'Expectations and Exchange Rate Dynamics', *Journal of Political Economy*, Vol. 84, No. 6, pp. 1161–1176.

for instance, strong depreciations (up to 15% vis-a-vis the ECU on a yearly basis) of the Italian lira and strong appreciations (up to almost 10%) of the Deutschmark – see Graph IV.2. Such volatility may generate important feedback loops to the real economy, for instance through a lower propensity of firms to export, higher exchange rate hedging costs and lower incentives for cross-border portfolio diversification.

With the adoption of the euro, nominal exchange rate volatility between Member States was fully eliminated; this in turn also led to decreased real effective exchange rate volatility in most euro area Member States ([271]), and in particular in Finland, Portugal, Italy and Spain (see Graph IV.3), leading to increased intra-euro area trade and cross-border investment as detailed in subsection IV.4.

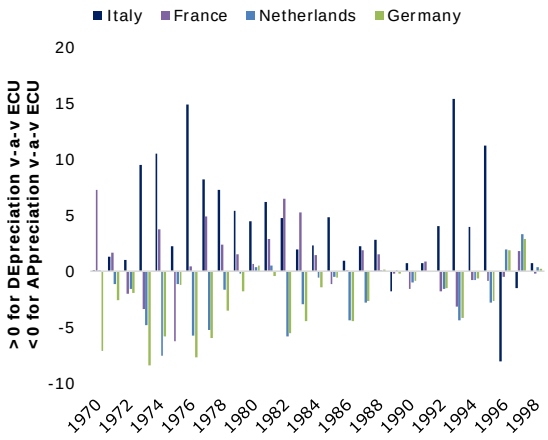
Available empirical research suggests that a one standard deviation decrease in real effective exchange rate volatility is associated with a 1.7 to 2.3% increase in real GDP growth ([272]), highlighting the beneficial effects of the common currency on Member States' economic growth.

IV.2.3. Price convergence in product markets

An important effect of the systemic innovations in cross-border payments and the elimination of nominal exchange rate uncertainty is price arbitrage and the subsequent convergence of prices across countries, which is associated with notable gains in product as well as financial markets.

In product markets, price convergence ([273]) across the Member States that joined the euro area before 2002 (i.e. EA11 ([274])) accelerated during the second half of the 1990s – see Graph IV.4. This acceleration was triggered by the further deepening of the Single Market and the Maastricht convergence criteria. However, this price convergence petered out as of 1999, reflecting to a large extent persisting cross-country price differences of non-standardised goods such as cars ([275]), for which sellers differentiate the retail or wholesale price across markets ([276]). Nevertheless, the further enlargement of the euro area (EA-19) reinforced overall price convergence across the euro area.

Graph IV.2: **Nominal exchange rate fluctuations (vis-a-vis the ECU)**
1970-1998
Selected group of countries



Percent change in nominal exchange rate vis-a-vis the ECU
Source: AMECO database.

([271]) The real effective exchange rate summarises, in one indicator, movements in (1) nominal exchange rates between a Member State and the rest of the euro area, (2) nominal exchange rates between a Member State and the rest of the world, as well as (3) inflation differentials between a Member State and both the rest of the euro area and the rest of the world. The introduction of the single currency eliminated the nominal exchange rate volatility between a Member State and the rest of the euro area, and this contributed to a reduction in the volatility of the real effective exchange rate (ceteris paribus).

([272]) See for instance Janus, T. and D. Riera-Crichton (2015), 'Real Exchange Rate Volatility, Economic Growth and the Euro', *Journal of Economic Integration*, Vol. 30, No. 1, pp. 148-17.

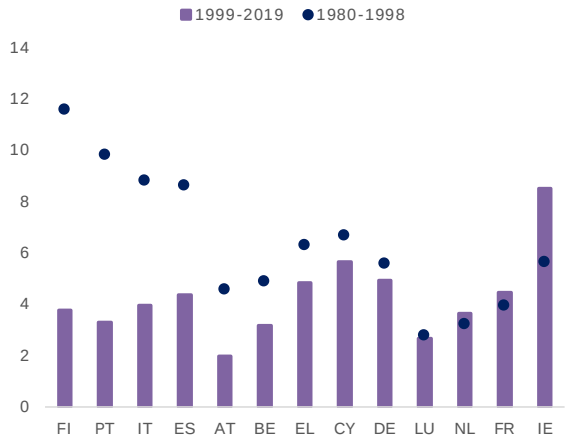
([273]) As measured by the coefficient of variation of price level indices which expresses the price level of a given country relative to a group of countries like EA-12 or EA-19. Price level convergence is to be distinguished from inflation convergence, which is discussed in the next subsection.

([274]) EA-11 includes EA-12 except LU – a small country with a disproportional impact on the indicator value.

([275]) For instance Dvir, E. and G. Strasser (2018), 'Does marketing widen borders? Cross-country price dispersion in the European car market', Journal of International Economics 112(C), pp. 134-149 report evidence for price differentiation in the European market for new passenger cars between 1993 and 2011, based on, e.g., regulatory (fuel tax), market (market power, market size) and climatic differences.. Other studies do not find significant price differences for standard goods sold through online retail outlets. See for instance Cavallo, A., Neiman, B. and R. Rigobon (2014), 'Currency unions, product introductions, and the real exchange rate', *Quarterly Journal of Economics*, Vol. 129, No. 2, pp. 529-595.

([276]) Furthermore, the stalling price convergence and even slight divergence among EA-12 over the past decade is actually largely driven by two Member States.

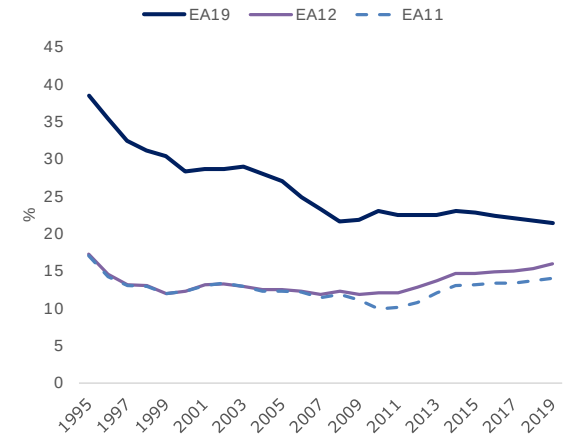
Graph IV.3: **Real effective exchange rate volatility**
(standard deviation)



Source: IMF IFS database.

All in all, the overall impact of adopting a single currency on product market price convergence is quite significant, with available studies ([277]) estimating that price dispersion is about 30 to 50% lower for countries in a currency union than for those with a fixed exchange rate.

Graph IV.4: **Price convergence Actual individual consumption**



(1) Coefficient of variation of price level indices. The price level index expresses the price level of a given country relative to a group of countries like EA-12 or EA-19. EA-11 is EA-12 excluding Luxembourg.
Source: Eurostat.

([277]) For instance Cavallo et al. (2014), *op cit.* study price developments in euro and non-euro EU countries as well as the US and countries using dollars. See also, Buti, M. and A. Turini (2015), 'Three waves of convergence. Can Eurozone countries start growing together again?', VoxEU.

IV.2.4. Price convergence in financial markets

Similarly, the adoption of the euro has also had an important impact on transaction costs in the financial markets. For instance, the costs for cross-border purchases of a euro bond or equity are estimated to have decreased since the launch of the euro by around 31% and 27%, respectively ([278]).

Besides directly benefitting savers over time through lower portfolio management expenses, these lower transaction costs should also help citizens to hold a more diversified portfolio of financial assets, implying that their savings and income from these savings will be less volatile overall. At the same time, however, this positive diversification effect has been partly offset by the relative increase in transaction costs for assets outside the euro area, which induced residents to invest relatively less in equities from outside the euro area ([279]).

Lower transaction costs also promote price arbitrage in financial markets, which (in combination with other structural reforms) helps to establish a more uniform cost of funding for firms across the currency area - thereby strengthening competition in the Single Market.

However, in the absence of adequate micro- and macro-prudential supervision, as was the case during the run-up to the global financial crisis, heightened capital mobility may amplify emerging instabilities and create significant negative spillover effects ([280]). Against this background, a number of measures, such as the establishment of the European Systemic Risk Board as well as the Single Supervisory Mechanism and Single Resolution Mechanism under the Banking Union, have been taken to address such vulnerabilities.

IV.3.Fostering macroeconomic stability

Membership of a currency union with a credible independent monetary authority benefits its

([278]) These reductions include lower transaction costs due to a harmonisation of legal systems across the euro area. See for instance Coeurdaciera, N. and P. Martin (2009), 'The geography of asset trade and the euro: Insiders and outsiders', *Journal of the Japanese and International Economies*, Vol. 23, No. 2, pp. 90-113.
([279]) See for instance Coeurdaciera and Martin (2009), *op cit.*
([280]) See for instance Allen, F, T Beck, E Carletti, P R Lane, D Schoenmaker, and W Wagner (2011), '*Cross-Border Banking in Europe: Implications for Financial Stability and Macroeconomic Policies*', Centre for Economic Policy Research

Member States, as it lowers a country's inflation bias that may arise from the desire to push unemployment below its natural rate so that it is unable to commit to a low inflation rate in a credible way.

At the same time, Member States lose control over their domestic interest rate and nominal exchange rate, though such control in practice already had been limited for most Member States given their exchange rate commitment. Moreover, it is argued below that in a modern economy characterised by expanding global value chains and increasing foreign exchange balance sheet exposure to diversified risks, nominal exchange rates lose part of their effectiveness as an adjustment channel. However, such developments also put a stronger burden on internal adjustment mechanisms, such as wage setting.

Even so, the global financial crisis showed that when the business and financial cycles are not synchronised across euro area Member States, a common monetary policy may become less effective. Hence, it should remain a policy requirement to promote upward convergence towards resilient economies across the euro area ([281]), as this is crucial (but not sufficient) to improve the functioning of the Economic and Monetary Union and optimise the benefits of the euro ([282]).

IV.3.1. Price stability

Prior to the adoption of the euro, several Member States exhibited high and volatile inflation rates (Graph IV.5). While difficult to quantify, high inflation has several adverse effects such as 'shoe-leather costs' ([283]), a loss of purchasing power of non-indexed income ([284]), less innovation ([285]) and a reduction in net wealth if not anticipated ([286]). High inflation can furthermore reinforce social inequalities, as low-income households typically are less able to protect themselves against the erosion of their savings and income through financial instruments and other investments.

During the first 10 years following the euro's launch, Member States experienced lower inflation rates close to the European Central Bank's (ECB's) price stability objective of euro area inflation below, but close to, 2% in the medium term. For instance, average annual inflation ([287]) between 1980 and 1998 was 7% in Spain, 11.9% in Portugal and 15.3% in Greece compared to 2.9% in Spain, 2.6% in Portugal and 3.2% in Greece between 1999 and 2009.

While the decline and stabilisation of inflation also had a strong global dimension, the fact that the European Central Bank operates independently, under the primary objective of price stability, operationalised via a numerical formulation of price stability, likely has lent credibility to the institution and helped anchor inflation expectations in the euro area ([288]). By comparison, prior to the single currency, different monetary policy regimes existed in the individual Member States, with some Member States attaching less weight to price stability and favouring instead the achievement of output above its long-run potential.

However, since 2013, inflation in the euro area as a whole has been for the most part below the ECB's price stability objective. This limits the room for adjusting relative nominal unit labour costs of current account deficit countries but also limits the

([281]) See for instance Giudice, G., J.Hanson and Z. Kontolemis (2018), Economic Resilience in EMU, *Quarterly Report on the Euro Area*, Vol. 17, No.2, pp. 9-15.

([282]) See for instance Berti, K. and E. Meyermans (2018), 'Sustainable convergence in the euro area: A multi-dimensional process', *Quarterly Report on the Euro Area*, Vol. 16, No.2, pp. 9-23 .

([283]) I.e. the opportunity costs of holding cash when nominal interest rates increase in response to anticipated inflation. For instance, Calza, A. and A. Zaghini (2015), 'Shoe-leather costs in the euro area and the foreign demand for euro banknotes', *ECB Working Paper Series* No. 1824, estimate that between 2002 and the summer of 2007, the shoe-leather cost was about 0.08% of annual GDP per annum, while at the peak of the crisis it had risen to 0.22% of GDP. With overnight interest rates approaching 0% in subsequent years, shoe leather cost in the euro area were consequently close to zero.

([284]) Or income indexed only with a significant time lag, such as pension benefits.

([285]) For instance, using euro area and US data, Chua, A., Cozzi, G., Lai, C.-C. and C.-H. Lia (2015), 'Inflation, R&D and growth in an open economy', *Journal of International Economics*, Vol. 96, No. 2, pp. 360-374 estimate that a 1 percentage point increase in the inflation rate decreases the R&D share of GDP by about 0.4%. This outcome reflects the fact that R&D investments are more severely affected by liquidity requirements (i.e. cash in advance) than investments in physical capital and that inflation erodes the holding of money balances.

([286]) See for instance Table 1 in Fischer, S. and F. Modigliani (1978), 'Towards An Understanding of the Real Effects and Costs of Inflation', *NBER Working Paper* No. 303 for a summary of the real effects of inflation.

([287]) For the sake of comparison with pre-euro times, we use national CPI data instead of the Harmonised Index of Consumer Prices (HICP), to which the ECB's price stability objective refers to.

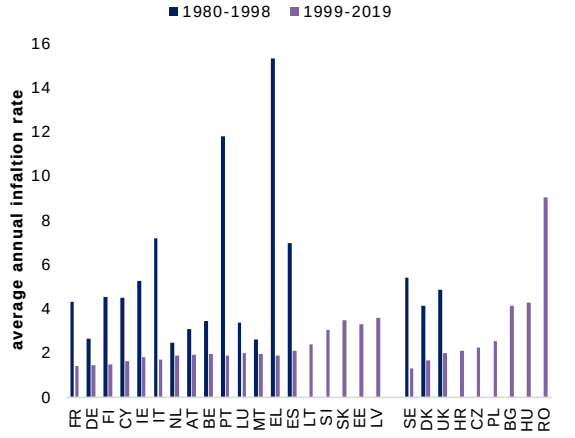
([288]) For instance, Alesina, A. and R. Barro (2002), 'Currency unions', *Quarterly Journal of Economics*, Vol. 117, No. 2, pp. 409–436 argue that when the inflation target set by national monetary authorities lacks credibility, rational economic agents will discount this in their price setting, and the actual inflation will be higher than the target rate.

room for deleveraging by both public and private debtors across the euro area ([289]).

IV.3.2. Limited benefits of nominal exchange rate flexibility

When a country becomes a member of a currency union, it can no longer adjust independently its nominal exchange rate if hit by an idiosyncratic shock ([290]). This may then pose a stronger adjustment burden on other parts of the economy, such as wages ([291]).

Graph IV.5: **Average annual inflation rate**



(1) No inflation rate for the 1980-1998 period for Member States joining the EU in 2004 or later.
Source: Authors' estimate based on AMECO database.

However, ongoing structural developments have made the nominal exchange rate a less effective adjustment tool. These developments relate to factors such as (i) the ongoing integration of domestic production tasks into global value chains, (ii) increased foreign currency balance sheet exposure, (iii) non-linear exchange rate pass-through and (iv) the ineffectiveness of national monetary policy to stabilise the nominal exchange rate in an interdependent world. Moreover, as discussed above, adopting the euro also eliminates nominal exchange rate fluctuations stemming from financial market shocks –that may generate important feedback loops to the real economy, especially in the short-to medium- run ([292]).

Nevertheless, with irreversibly fixed nominal exchange rates and a high degree of wage and price rigidity, a larger part of the adjustment burden shifts to quantities such as employment and output ([293]).

(i) Expanding global value chains ([294])

First, classical textbook analysis assumes that countries produce goods and services domestically, and that all production factors are remunerated in domestic currency. In such an environment, a country's international price competitiveness is improved unambiguously by a nominal exchange rate depreciation in the short term ([295]).

However, with falling transaction and coordination costs ([296]), patterns of international trade have changed in a profound way, giving rise to global value chains (GVCs) where the production process gets more fragmented and tasks get spread across several countries ([297]). In a GVC, a firm imports intermediary goods and services, creates value added and subsequently exports its output to the next chain of the GVC. Generally speaking, in the case of GVCs, exchange rate fluctuations have an ambiguous impact ([298]). That is, a depreciation will increase the cost of intermediary imports, while at the same time making the output more competitive in export markets. Moreover, as the euro area Member States are more involved in regional rather than global supply chains ([299]), fluctuations of

([289]) I.e., – to the extent this lower inflation was not expected when contracts were settled.
([290]) See for instance Friedman, M. (1953), *Essays in Positive Economics*, University of Chicago Press.
([291]) The same type of burden shift onto other nominal macroeconomic variables occurs also under alternative exchange rate regimes, like hard pegs or a fixed exchange rate, as was the case under the European Exchange Rate Mechanism prior to the adoption of the euro.
([292]) See for instance Hooper, P. and S. Kohlhagen (1978), 'The Effect of Exchange Rate Uncertainty on the Prices and Volumes of International Trade', *Journal of International Economics*, Vol. 8, pp. 483-511..
([293]) See for instance various issues of European Commission, 'Labour Market and Wage Developments in Europe'.
([294]) For a comprehensive analysis of the implications of GVCs for the euro area, see the ECB Working Group on Global Value Chains (2019), 'The impact of global value chains on the euro area economy', *ECB Occasional Paper* No. 221.
([295]) Provided that such depreciation is not retaliated by a devaluation of the trading partners' currency.
([296]) Driven by the ongoing digital revolution as well as the creation of euro-wide standards.
([297]) See for instance Baldwin, R. (2016), *The Great Convergence: Information Technology and the New Globalization*, The Belknap Press of Harvard University Press.
([298]) See for instance Schmitz, M., Fidora, M. and Gunnella, V. (2017), 'The impact of global value chains on the macroeconomic analysis of the euro area', Economic Bulletin, No. 8 and Georgiadis, G., Georgios, Gräb, J. and M. Khalil (2019) 'Global value chain participation and exchange rate pass-through', ECB Working Paper, No. 2327.
([299]) ECB Working Group on Global Value Chains (2019), *op.cit.*

national exchange rates within the area would especially be ineffective, while fluctuations of the euro vis-a-vis other exchange rates may produce real effects.

Even so, independently of GVC developments, a rising share of intermediary imports in exports observed across euro area Member States ([300]) also reduced the impact of nominal exchange rate adjustments on firms' competiveness.

It remains to be seen whether the increased trade tensions of recent years and the disruptive impact of COVID-19 on GVCs ([301]) will lead to some repatriation of production capacities and thus a weakening of GVCs.

(ii) More foreign exchange balance sheet exposure

Moreover, the capacity of national currencies to help absorb idiosyncratic shocks via a depreciation can furthermore be seriously undermined if domestic residents hold a significant amount of unhedged liabilities denominated in foreign currency ([302]).

In this case, a strong depreciation would significantly weaken the balance sheets of domestic banks, households and firms. As a result, distressed agents will save more, thereby reducing domestic demand that may offset any gains in foreign demand for goods and services induced by the depreciation.

By contrast, cross-border bank credit and transactions within a currency union are settled in the common currency, which means that it does not entail any foreign exchange balance sheet exposure but may help to diversify risks and stabilise domestic consumption ([303]) ([304]).

(iii) Non-linear exchange rate pass-through

Furthermore, the presumed opportunities stemming from a simple linear relationship between nominal exchange rates and competitiveness are less straightforward in practice. For instance, exporting to foreign markets may involve irrecoverable sunk costs such as expenditures for marketing, R&D, and the development of distribution networks. As such, sunk costs may make exports less responsive to nominal exchange rate adjustments – both in terms of entering and leaving the export markets ([305]).

Moreover, in non-perfectly competitive markets, like those resulting from the presence of investment sunk costs, firms operate pricing to market and tend to absorb the impact of exchange rate movements with changes to their cost markup.

(iv) More effective monetary policy coordination

In addition, since the launch of the euro, the Member States of the euro area have primarily been hit by common shocks, such as the great financial crisis and the COVID-19 pandemic. In such circumstances, a single currency and common monetary policy enable Member States to counteract more effectively common shocks than national monetary policies would.

Furthermore, while a loss of price competitiveness may widen a country's external imbalances, research ([306]) suggests that strong domestic demand growth fuelled by excessive credit growth has also been an important factor driving external imbalances in the past; and that external adjustment in deficit countries was achieved

([300]) See OECD (s.a.), 'Import content of exports' at https://www.oecd-ilibrary.org/trade/import-content-of-exports/indicator/english_5834f58a-en

([301]) See for instance Seric and Winkler (2020), 'COVID-19 could spur automation and reverse globalisation – to some extent' VoxEU.

([302]) As has been the case for several Eastern European countries. See, for instance, European Systemic Risk Board (2011), 'Recommendation of the European Systemic Risk Board on lending in foreign currencies', ESRB/2011/1.

([303]) See, for instance, Kontolemis, Z., Meyermans, E. and C. Uregian (2020), 'Consumption smoothing and the role of banking integration in the euro area', *Quarterly Report on the Euro Area*, Vol. 9, No. 2, pp.7-26.

([304]) Empirical analysis indeed suggests that a domestic currency with its exchange rate fixed to a foreign currency that has the status of an international currency, increases the residents' propensity to borrow in this currency, as the fixed exchange rate decreases balance sheet risks from currency depreciation.

([305]) Indeed, if these sunk costs were made with a view to export to foreign markets when the currency was depreciated, then firms may find it profitable to continue to export to that market when the exchange rate appreciates, i.e. trade hysteresis. See for instance Baldwin, R., and P. Krugman (1989), 'Persistent Trade Effects of Large Exchange Rate Shocks', *Quarterly Journal of Economics*, Vol. 104, pp. 634-55.

([306]) See for instance Comunale, M. and J. Hessel (2014), 'Current account imbalances in the Euro area: Competitiveness or financial cycle?', *De Nederlandse Bank Working Paper* No. 443

primarily through demand compression, rather than expenditure switching ([307]).

Moreover, available research suggests that whenever capital is freely mobile on a global scale, the global financial cycle constrains national monetary policies regardless of the exchange rate regime ([308]).

Nevertheless, while business cycles across Member States may be more synchronised with a common currency, their amplitude may diverge strongly as Member States' capacity to withstand shocks differs notably ([309]). This shows that the effectiveness of a common monetary policy can be strengthened by promoting convergence in Member States' capacity to withstand shocks and by completing the banking union and capital market union with a view to strengthening cross-border risk sharing ([310]) .

(v) Higher adjustment burden on quantities

At the launch of the euro, the expectation was that increased wage flexibility ([311]) as well as labour mobility ([312]) would facilitate domestic adjustment in the absence of nominal exchange rate flexibility.

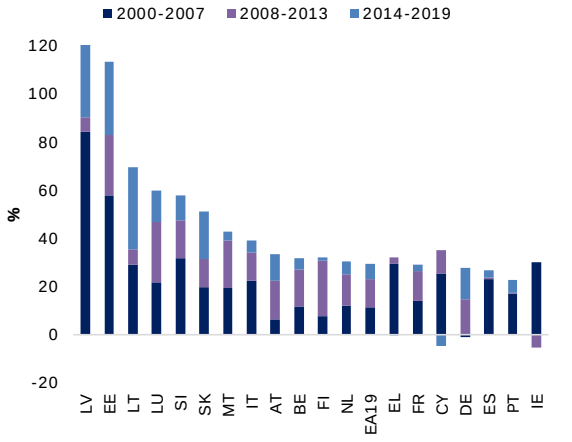
However, while in the run-up to euro adoption several Member States witnessed notable wage moderation, the adoption of the euro does not seem to have accelerated labour market reforms ([313]). As such, nominal unit labour cost growth behaved as a source of imbalances in the euro area in the run-up to the crisis. Several Member States, including Greece, Ireland, Portugal and Spain, recorded very strong nominal unit labour cost growth, while others, such as Germany and Austria, recorded very low or even slightly negative unit labour cost growth (see Graph IV.6) ([314]).

These developments distorted international competitiveness, contributing to unsustainable external imbalances that warranted sharp downward adjustments in unit labour costs. However, rigid wages hindered such a correction, and adjustment occurred mainly in terms of quantities such as employment and output ([315]).

IV.3.3. Incentives for structural reforms

Another expectation of the euro's launch was that joining EMU would facilitate cross-border risk sharing and would create more incentive for national structural reforms enabling Member States to better withstand asymmetric shocks.

Graph IV.6: **Nominal unit labour cost - cumulative growth**



(1) I.e. 2014-2019 cumulative growth not shown - break in series.
Source: Authors' estimates based on Eurostat, National Accounts.

However, the emergence of exceptionally low real interest rates during the first 10 years following the

([307]) See for instance Lane, P and G. Milesi-Ferretti (2012), 'External adjustment and the global crisis', *Journal of International Economics*, Vol. 88, No. 2, pp. 252-265.
([308]) See for instance Rey, H. (2018), 'Dilemma not trilemma: the global financial cycle and monetary policy independence', NBER Working Paper 21162.
([309]) See for instance Franks, J., Barkbu, B., Blavy, R., Oman, W. and Schoelermann, H. (22018), 'Economic Convergence in the Euro Area: Coming Together or Drifting Apart?', *IMF Working Paper* No 18. De Grauwe, P. and Y. Ji (2016), 'Flexibility versus Stability A difficult trade-off in the eurozone', *CEPS Working Document* No. 422.
([310]) See for instance Meyermans, E., Uregian, C., Van Campenhout G. and D. Valiante (2019), 'Completing the Capital Markets Union and its impact on economic resilience in the euro area', *Quarterly Report on the Euro Area*, Vol. 18, No. 4, pp. 27-39.
([311]) Wage flexibility entails two components, i.e. relative wage flexibility and absolute wage flexibility. The former is key for domestic resource reallocation, while the latter is key for competitiveness vis-à-vis the rest of the world.
([312]) Sectoral labour mobility is a channel mainly to increase productivity or accommodate a shift in preferences and technologies. Cross-border labour mobility is a channel mainly to absorb a local lack of aggregate demand.
([313]) Alesina, A., Ardagna, S. and V. Galasso (2008), 'The Euro and Structural Reforms', *NBER Working Paper* 14479.
([314]) Such developments during the early years of EMU were to a large extent driven by booms in domestic aggregate demand, fuelled by the easy availability of cheap credit for consumption and construction in some Member States See for instance Gros D. (2010), 'Europe's Competitiveness Obsession,' *CEPS Commentary.*
([315]) See for instance Izquierdo et al. (2017), 'Labour market adjustment in Europe during the crisis: microeconomic evidence from the Wage Dynamics Network survey', *ECB Occasional Paper* No. 192,

adoption of the euro was coupled – in some vulnerable countries – with credit bubbles, fiscal profligacy and misallocation of resources, and allowed countries to progress less vigorously with their structural reform efforts than originally expected ([316]).

In turn, the persisting long-standing structural weaknesses in some Member States prevented them from taking full advantage of these favourable financing conditions in a sustainable manner. That is, the incomplete architecture of euro financial markets facilitated excessive capital flows to the periphery countries to finance non-productive expenditures such as consumption and investments in residential buildings. These capital flows not only weakened the incentives to reform but were also unsustainable. In consequence, many of the potential benefits of the euro were lost.

IV.4. Effects of better market functioning and macroeconomic stability

At the launch of the euro, there was a general consensus that the common currency would improve market functioning. It was expected that the euro would increase trade volumes and change their composition, that it would direct capital to its most efficient use across the euro area and that it would support cross-border labour mobility ([317]). These developments would not only strengthen the euro area's growth potential, but would furthermore improve the resilience of the euro area economy given that, for instance, cross-border factor mobility is an important channel for absorbing idiosyncratic shocks in a currency union. In addition, a common monetary policy would also be more effective in the pursuit of price stability, as it allows monetary authorities to internalise better intra-European spill-overs and eliminates the spill-overs caused by currency substitution, with the German mark playing the role of the safe-haven currency.

Moreover, stronger cross-border trade, investment and employment opportunities in the wake of the euro's adoption were expected to have a domino effect on other EU Member States wanting to join the euro area. In turn, this euro area enlargement strengthened the incentives for incumbent members to remain in the area.

Overall, the available evidence suggests that there certainly have been improvements in intra-euro area trade, increased investment and capital flows, as well as some (albeit still limited) degree of labour mobility ([318]). However, markets did not always adjust to the extent expected, as briefly highlighted in the following subsections ([319]).

IV.4.1. International trade

First estimates ([320]) of the euro's impact on trade suggested an increase of about 5% following the launch of the common currency. However, as more data became available, results became more ambiguous, with estimates ranging from negligible ([321]) to increases in the intra-euro area trade by about 20%. ([322]) A recent meta-analysis reports the gains in trade between 2% and 6% ([323]).

([316]) See Fernandez-Villaverde, J., Garicano, L. and T. Santos. (2013), 'Political Credit Cycles: The Case of the Euro Zone', *NBER Working Paper* No 18898, and Franks et al., *op. cit.*, as well as Del Hoyo, J.L., Dorrucci, E., Heinz, F. and S. Muzikarova, 'Real convergence in the euro area: a long-term perspective', *ECB Occasional Paper* No. 203, December 2017.

([317]) See for instance Emerson et al. (1992), *op. cit.*

([318]) The lowering of transaction costs has a smaller impact on trade than on financial transactions where even hundredths of a percent cost savings can have a large impact, as argued by for instance Gros D. (2017), 'One Market, One Money – A Mistaken Argument (post factum)?', *CEPS Policy Insight* No 2017/05.

([319]) Here, it is important to recall that estimating the impact of the euro on market functioning poses important identification challenges such as distinguishing between the effects of the euro and the further deepening of the Single Market.

([320]) See for instance Baldwin, R., DiNino, V., Fontagné, L., De Santis, R. and D. Taglioni (2008), 'Study on the Impact of the Euro on Trade and Foreign Direct Investment', *European Commission Economic Papers* No. 321. See also Rose, A.(2000), 'One money, One Market: Estimating the effect of common currencies on trade', *NBER Working Paper* No 7432, p.10, which found a very strong positive effect of currency unions (approximately 200%) on bilateral trade, using gravity-based, cross-sectional data.

([321]) See for instance Figueiredo, E., L. Lima and G. Schaur (2016), 'The effect of the Euro on the bilateral trade distribution', *Empirical Economics*, Vol. 50, pp. 17–29. See also Berger, H., and V. Nitsch (2008), 'Zooming out: The trade effect of the euro in historical perspective', *Journal of International Money and Finance*, Vol 27, No.. 8, pp.1244-1260.

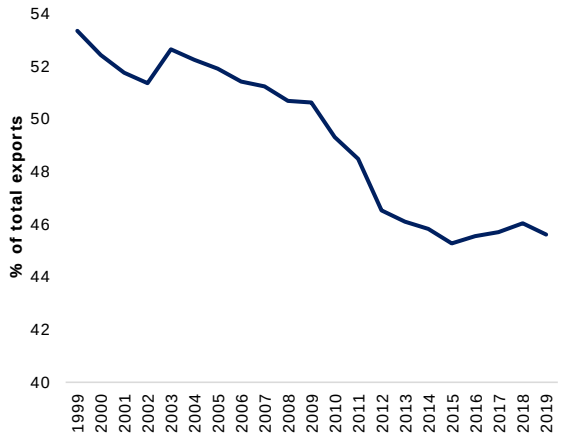
([322]) See for instance Kunroo, M., Sofi, A. and N. Azad (2016), 'Trade implications of the Euro in EMU countries: a panel gravity analysis', *Empirica*, Vol. 43, pp. 391–413.

([323]) See, Polak, P. (2019), 'The Euro's Trade Effect: A Meta-Analysis', *Journal of Economic Surveys*, Vol. 33, No. 1, pp. 101-124. Nevertheless, the issue is far from settled in the academic literature. For example, Rose, A (2016), 'Why Do Estimates of the EMU Effect on Trade Vary So Much?', *CEPR Discussion Paper* No. 11532 claims based on a meta-analysis that the euro trade effect is economically and statistically large, at about 50%. Rose (2016) suggests that the econometric results are to a large extent affected by the nature of the datasets used, as, for instance, the EMU effect is much stronger when the sample includes more than just EMU countries, as well as by identification problems as, for instance, global economic integration intensified at the same time.

Available studies also suggest strong differences across sectors and countries ([324]) as well as differences between intra- and extra-euro area trade ([325]) whereby the share of intra-euro area exports in total exports decreased notably from the euro's launch until 2015 (see Graph IV.7).

All in all, available research ([326]) seems to suggest an increasing heterogeneity in terms of production and specialisation across countries which may allow them to exploit better their comparative advantages. However, the same research also indicates that a lack of structural reforms hinders several Member States to exploit this potential to the fullest extent.

Graph IV.7: **Intra-euro area exports of goods – as % of total exports**



(1) 'Goods' covers all movable property including electricity
Source: Eurostat (International trade in goods (ext_go_agg)).

IV.4.2. Stronger capital flows and financial market integration

The elimination of the exchange rate risk through the introduction of the euro - together with legal and regulatory convergence - was an important factor supporting financial integration across the euro area ([327]). Financial integration was expected to strengthen the euro area's capacity to absorb shocks and promote potential growth by broadening the scope and opportunities for cross-border risk sharing ([328]).

Stronger opportunities for cross-border risk sharing

Well-functioning financial markets provide domestic consumers access to a more diversified income portfolio, not only consisting of labour and capital income from domestic assets but also income from foreign assets. In addition, cross-border retail-banking integration should enable credit flows supporting domestic consumption and investment even if local banks are adversely affected by a country-specific shock. Furthermore, well-integrated financial markets strengthen the transmission of the common monetary policy, which is crucial to stabilise the economy in the face of a common temporary aggregate demand shock.

Over the past 20 years, the euro has acted as a catalyst in the financial market integration process. For instance, available evidence suggests that investor holdings are biased toward their own currencies and that, except for large firms, most firms issue debt mainly in local currency ([329]). This home bias stems from factors such as the high fixed costs associated with borrowing in a foreign currency and exchange rate volatility ([330]). Thus, the common currency increased the available investment opportunities from an investor perspective and broadened the investor base from an issuer perspective. Indeed, studies analysing foreign direct investment (FDI) flows between 1985 and 2012 suggest also that euro area

([324]) See Felbermayr, G., Groschl, J., and I. Heiland (2018), 'Undoing Europe in a New Quantitative Trade Model', *IFO Working Papers* 250-2018

([325]) With the former being more sensitive to relative prices than the latter, see Bayoumi, T., Harmsen, R., and J. Turunen (2011), 'Euro Area Export Performance and Competitiveness', *IMF Working Paper* 11/140.

([326]) See for instance Mongelli, F., Reinhold, E. and G. Papadopoulos (2016), 'What's so special about specialization in the euro area? Early evidence of changing economic structures', *ECB Occasional Paper*, No. 168.

([327]) See for instance Kalemli-Ozcan, S, E Papaioannou, and J. Peydró (2010), 'What Lies Beneath the Euro's Effect on Financial Integration?' Journal of International Economics, Vol. 81, No. 1, pp. 75-88; Lane, P. (2006), 'Global Bond Portfolios and EMU', *International Journal of Central Banking*, Vol., No. 2, pp. 1-24 and Grochowska, A. and A. Hild (2019), 'Financial Union: Integration and Stability', *Quarterly Report on the Euro Area*, Vol. 18, No.2, pp. 7-41.

([328]) In a currency union, risk-sharing via financial markets is a crucial element to stabilise an economy, as it allows domestic consumption and investment to be de-coupled from domestic income and output in the face of idiosyncratic shocks. See for instance Kontolemis, Z., Meyermans, E. and C. Uregian (2020), *op cit.*, providing an empirical assessment of the impact of cross-border bank integration on consumption smoothing.

([329]) See for instance Maggiori, M., B. Neiman, and J. Schreger (2018), 'International Currencies and Capital Allocation', *Becker Friedman Institute Working Paper* No. 2018-30.

([330]) For instance, Fidora, M., M. Fratzscher and C. Thimann (2007), *op. cit.* estimate that a reduction in monthly real exchange rate volatility from its sample mean to zero reduces bond home bias by up to 60 percentage points, while it reduces equity home bias by only 20 percentage points.

membership has had an incremental positive effect on intra-euro area FDI growth, ([331]) with, on average, the adoption of the euro increasing FDI flows from other euro area Member States by 73.7% ([332]).

Capital misallocation and excessive debt levels

As such, the adoption of a common currency increased access to cross-border finance across the euro area. However, in the first decade of the euro, cross-border financial flows also gave rise to the cross-border financing of private consumption and non-productive investments such as residential buildings in several southern Member States, which was mainly driven by the lack of domestic financial market depth and liquidity ([333]).

Moreover, available research suggests that financial interlinkages within the euro area played a more prominent role in transmitting shocks than international trade. While a country is more likely to run a deficit if its major financial partners run surpluses (and vice versa), countries are more likely to run a current account surplus if their trade partners run a surplus ([334]).

At the same time, financial markets failed to discipline public borrowing, as risk premia for some sovereign borrowers did not reflect decreasing debt sustainability ([335]). This resulted in sharp adjustments in risk premia at the onset of the global financial crisis, which induced strong budgetary corrections in several Member States with high public debt levels ([336]).

IV.4.3. Cross-border labour mobility

Although the elimination of nominal exchange rate flexibility also increased the need for stronger movement of labour to absorb shocks and promote potential growth, ([337]) there is no evidence that suggests that the launch of the euro had a positive effect on labour mobility ([338]).

When an economy is hit by an idiosyncratic shock, cross-border labour mobility ([339]) should not only reduce unemployment in the home country but it may also increase domestic aggregate demand if part of the wages earned abroad is transferred to the home country and is used for domestic consumption. In turn, this may improve the fiscal position as unemployment benefits decrease and indirect tax revenues on domestic consumption increase ([340]). Moreover, if the migrant workers strengthen their skills and competences working abroad, the home country may benefit from a permanent increase in national productivity once the cross-border workers return ([341]).

However, available evidence suggests that cross-border labour mobility was a weak channel to offset the loss of nominal exchange rate flexibility in the face of shocks during the global financial crisis ([342]).

([331]) Brouwer, J., Paap, R. and Viaene, J.-M., 'The trade and FDI effects of EMU enlargement', *Journal of International Money and Finance*, Vol. 27(2), 2008, pp. 188-208; De Sousa, J. and Lochard, J., 'Does the Single Currency Affect Foreign Direct Investment?', *The Scandinavian Journal of Economics*, Vol. 113(3), 2011, pp. 553-578.

([332]) Carril-Caccia, F. and E. Pavlova (2018), 'Foreign direct investment and its drivers: a global and EU perspective', *Economic Bulletin Articles* 4.

([333]) See for instance Brunnermeier, M. and R. Reis (2019), 'A Crash Course on the Euro Crisis', *NBER Working Paper* No. 26229.

([334]) Hobza, A. and S. Zeugner (2014), 'Current accounts and financial flows in the euro area', *Journal of International Money and Finance*, Vol. 48, Part B, pp. 291-313.

([335]) See for instance Monteiro, D. and B. Vašíček (2018), 'A retrospective look at sovereign bond dynamics in the euro area', *Quarterly Report on the Euro Area*, Vol. 17 No. 4, pp. 1-16.

([336]) See for instance Meyermans E. (2019), 'Does market discipline enter governments' fiscal reaction functions in the euro area?', *Quarterly Report on the Euro Area*, Vol. 18 No. 1, pp. 7-26.

([337]) Farhi, E. and I. Werning (2014), 'Labor Mobility Within Currency Unions', *NBER Working Paper* No. 20105.

([338]) Cross-border labour mobility could increase as wages are denominated in euro and thus easier to compare, and less subject to unexpected exchange rate fluctuations.

([339]) Three types of labour mobility can be distinguished: i) long-term labour mobility, where citizens move their residence to a foreign country for at least 1 year to take up work or seek work, ii) cross-border mobility, where citizens reside in one country but are employed or self-employed in another and who, for this purpose, move across borders regularly, and iii) posted workers where employees who are regularly employed in one Member State are sent to another Member State by the same employer to work there for a limited period. For more details, see European Commission (2018), '2018 Annual Report on intra-EU Labour Mobility'.

([340]) See for instance Alcidi, C. and D. Gros (2019), 'EU Mobile Workers: A challenge to public finances?', contribution for informal ECOFIN, Bucharest, 5-6 April, 2019 .

([341]) However, cross-border labour mobility may reach its limits as an adjustment mechanism if it is associated with a major brain drain which could weaken the sending country's potential growth. In the past, high-skilled workers were most inclined to cross borders in several Member States.

([342]) See for instance Huart, F. and M. Tchakpalla (2015), 'Labour Mobility in the Euro Area During the Great Recession', mimeo. Confirming research on labour mobility done prior to the launch of the euro, such as Decressin, J. and A. Fatas (1995), 'Regional Labor Market Dynamics in Europe', *European Economic Review*, Vol. 39, No. 9, pp. 1627–1655.

Nevertheless, while cross-border labour mobility in the euro area is currently rather limited, it is expected to increase in the future as further structural reforms are implemented. Such reforms include, for instance, the further expansion of trans-European networks and the further modernisation of social security coordination rules covering areas such as sickness, maternity/paternity, family, old-age, unemployment and other benefits that are the exclusive responsibility of the national authorities ([343]). This once again illustrates the complementarity of the euro and structural reforms.

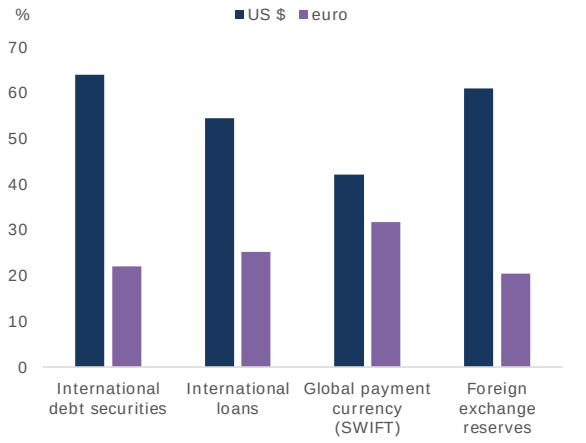
IV.4.4. International currency status

The euro has been a stable currency since its inception. This supports the attractiveness of the euro for worldwide use in trade and finance. For instance, in 2019, 61% and 62% of extra-euro area exports of goods and services were invoiced in euro, while for imports this share was 51% and 52% respectively ([344]).

It would be beyond the scope of this section to elaborate on all the benefits of the international reserve currency status of the euro ([345]) ([346]). From a microeconomic perspective, such a status has a direct advantage for firms and households, as it lowers transaction and hedging costs ([347]) and reduces balance sheets' sensitivity to exchange rate fluctuations because domestic firms and households need to borrow and lend less in foreign currency.

Furthermore, individual euro area Member States have to keep much lower foreign exchange reserves than if they had stayed outside the euro. This saves not only on the administrative costs to manage such reserves, but also on the opportunity costs related to the holding of low yielding reserves ([348]).

Graph IV.8: **The role of the euro in the international monetary system - 2019Q4**



Source: ECB (2020), 19th annual review of the international role of the euro.

Meanwhile, a further internationalisation of the euro combined with a move to multiple currencies for the settlement of international commodity prices could bring more stability to the prices in euro of imported intermediary inputs such as oil. This may then lessen the impact of exogenous shocks arising in foreign exchange markets on the euro area economy

At the same time, however, this could also have implications for the conduct and transmission of monetary policy in the euro area ([349]). For example, empirical research suggests that an increase in the share of the euro as an invoicing currency for extra-euro area imports of 10 percentage points would lower exchange rate pass-through to import prices by almost 7 percentage points ([350]).

IV.5.Strengthening the EMU architecture

The global financial crisis and the subsequent European debt crisis highlighted the incomplete nature of the EMU architecture and that Member

([343]) See for instance European Commission (2016), 'Questions and Answers on the revision of social security coordination rules'
([344]) See ECB (2020), The international role of the euro, June 2020.
([345]) See, for instance Gräb, J. and A. Mehl (2019), 'The benefits and costs of the international role of the euro at 20', Special feature 3 in ECB (2019), The international role of the euro.
([346]) See also European Commission (2018), 'Towards a stronger international role of the euro', COM(2018) 796 final and European Commission (2021), 'The European economic and financial system: fostering openness, strength and resilience', COM(2021) 32 final
([347]) A higher share of invoicing in local currency lowers the exchange rate risk and reduces the need for financial hedging.
([348]) See for instance Roger S. (1993), 'The management of foreign exchange reserves', *BIS Economic Papers*, No 38 and IMF (2015), Assessing reserve adequacy—specific proposals.
([349]) See for instance Cœuré, B. (2019), 'The euro's global role in a changing world: a monetary policy perspective', speech delivered at the Council on Foreign Relations, New York City, 15 February 2019.
([350]) See ECB (2015), 'The role of currency invoicing for the international transmission of exchange rate movements', in ECB (2015), 'The international role of the euro', Frankfurt am Main, July.

Sates' capacity to withstand shocks differs strongly. As such, the social and economic divergences between euro area members intensified sharply during the global financial crisis and this divergence was far from corrected when the recent COVID-19 pandemic broke out ([351]).

At the same time, policy responses at the euro area level were less effective in the absence of an appropriate balance between risk sharing and risk reduction. This led to an overly reliance on monetary policy for stabilisation purposes and an inappropriate policy mix, especially in the likely presence of a lower bound for policy interest rates ([352]).

Moreover, adjustment in the face of common shocks remains asymmetric as surplus countries face fewer constraints ([353]) In addition, in a currency union, with no national central bank acting as lender of last resort and no common fiscal stabilisation capacity, national financial markets may be vulnerable to a self-fulfilling flight to-safety ([354]).

Such developments severely hinder the euro area's capacity to exploit fully the benefits of the single currency; and they carry also the risk to weaken citizens' support for the euro ([355]).

All in all, addressing these challenges calls for stronger progress in completing a genuine Financial Union, achieving a more integrated Economic and Fiscal Union, and strengthening euro area institutions and accountability ([356]).

IV.6. Conclusions

In 1999, EMU was created with the expectation that it would bring significant benefits to the citizens of its Member States.

This section took a closer look at the main micro- and macroeconomic channels through which Member States were expected to benefit from the euro. While there is still scope to extend this review, the findings already highlight that measuring a country's benefits from the euro's adoption by a single statistic is not feasible, as it involves a complex set of interactions whereby the euro is part of a whole package of complementary reforms and policies such as the deepening of the Single Market, the completion of the Banking Union and Capital Markets Union and other institutional and governance reforms.

Thus, completing the architecture of the Economic and Monetary Union is urgently needed to allow its citizens to benefit from the euro's adoption to the fullest extent ([357]). In this respect, recent experiences with the EU's recovery plan in the wake of the COVID-19 pandemic, especially the Recovery and Resilience Facility (RRF) and Support to mitigate Unemployment Risks in an Emergency (SURE), seem to provide an opportunity for a further harmonised direction of economic and fiscal policy. This needs to be complemented by ambitious structural reforms at Member State level.

([351]) See for instance European commission (2020), 'Analysis of the euro area economy', Commission Staff Working Document, COM(2020) 746 final.

([352]) See for instance Buti, M., Deroose, S., Leandro, J. and G. Giudice (2017), 'Completing EMU', VoxEU

([353]) Buti et al. (2020), *op cit.*

([354]) See De Grauwe, P. and Y. J. (2013), 'Self-fulfilling crises in the Eurozone: An empirical test', *Journal of International Money and Finance*, Vol. 34, pp. 15-36

([355]) European Commission (2017), 'Reflection Paper on the Deepening of the Economic and Monetary Union'

([356]) Buti et al. (2020), *op cit.,* and Buti, M., Jollès, M. and M. Salto (2019), 'The Euro — A Tale of 20 Years: What Are the Priorities Going Forward?', *Intereconomics,* Vol. 54, pp. 65–72, Sondermann, D. (editor) (2019), 'Economic Structures 20 Years into the Euro', *ECB Occasional Paper* No. 224.

([357]) See also Draghi M. (2018), 'Europe and the euro 20 years on', speech delivered at Laurea Honoris Causa in Economics by University of Sant'Anna, Pisa, 15 December 2018.

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