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Pablo Garcia, Pascal Jacquinot, Crt Lenarcic,
Matija Lozej, Kostas Mavromatis

Global models for a global pandemic: the impact of COVID-19 on small euro area economies

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Abstract

This paper analyses the effects of the COVID-19 pandemic shock on small open economies in a monetary union with an application to the euro area. Accounting for a high degree of openness and a strong dependence on intra and extra union trade, we focus on the size and the direction of international spillovers – both from the shock itself and from the ensuing fiscal response. To do so, we use a unified modelling framework: The Euro Area and the Global Economy (EAGLE) model. Furthermore, within this general framework, we assess the extent to which specific modelling features shape the dynamic responses to the COVID-19 pandemic. The main messages are as follows. First, fiscal spillovers from the rest of the monetary union do matter. Second, the effective lower bound amplifies the size of the spillovers. Third, the design of wage negotiations leads to wage subsidies having negative international fiscal policy spillovers. Fourth, import content of government spending interacts with the effective lower bound, strongly affecting the size and sign of spillovers. Fifth, when households have finite lifetimes, the responses of output and inflation are amplified compared to the case with infinitely lived households. Finally, a next generation EU instrument is more effective when financed using a tax on consumption.

JEL Classification: C53, E32, E52, F45.

Keywords: *DSGE Modelling, International Spillovers, Monetary Union, Euro Area, COVID-19*

Non-Technical Summary

This paper analyses the effects of the COVID-19 pandemic shocks on small open economies (SOE) in a monetary union, with an application to the euro area. We focus on the size and the direction of the spillovers stemming from the shock itself, and from the fiscal policies that were used to fight it. Though our models share the same backbone (the EAGLE model), they have specific features (e.g., active role of public expenditure, household planning horizon, frictions on the labour market, import content of public expenditures). We can thus explore how these particular modelling choices affect the transmission and spillovers of the COVID-19 pandemic. We can exploit the global dimension of the EAGLE model to assess the importance of direct and indirect international spillovers. For direct spillovers, shocks spill out directly from the rest of the EA (REA), which is the largest trading partner of all modelled SOEs. For indirect spillovers, these arise from other two foreign regions, either the rest of the world or the US.

Calibrating the various versions of the model for Ireland, Luxembourg, the Netherlands and Slovenia, it is shown that a very significant fraction of the 2020 decline in economic activity in those SOEs resulted from foreign factors, related to either trade or to fiscal policies. This result is not surprising for small open economies. However, we find that the effective lower bound, the specific design of fiscal measures, and the monetary union framework all play an important role. We provide a rationale for these outcomes. The interaction of fiscal policy with the effective lower bound is key.

We also find important fiscal spillovers from the rest of the monetary union. The unprecedented fiscal measures taken by euro area countries boosted aggregate demand in the whole continent, which, according to our models, has had non-trivial effects in the small economies studied here. In addition, we explore the macroeconomic effects of the recently approved Next Generation EU program.

1 Introduction

The COVID-19 pandemic produced an unforeseen global crisis. Faced with this health versus recession trade-off, most of the governments decided to lock down economies and therefore shutting down most non-tradable sectors, but also temporarily tradable sectors. When an economy is very open, the immediate impact of such action is worsened by the existing large inter-relations across countries and trade linkages, especially when the size of the economy is small. This mechanism highlights the importance of understanding the role of international spillovers and the transmission of global shocks to domestic economies. The question is even more acute for countries in a monetary union, where a common monetary policy and local fiscal reactions are typical. To alleviate the effects of the shock, governments typically react by running large fiscal stimuli that can also, at a certain point, spill over to the main trade partners. At the same time, public expenditures in some small open economies can have a significant import content. Thus, international spillovers have an important fiscal component. Of particular interest is the novelty in the measures taken in response to the COVID-19 pandemic, which was the implementation of an extraordinary fiscal package at the EU level, the so-called the Next Generation EU (NGEU), aiming at supporting countries facing large public deficits.

The existing literature on the transmission and the macroeconomic effects of the pandemic has mainly focused either on closed economy models, abstracting from the analysis of the international spillovers of the shock itself and the policies adopted to counteract its effects (see Eichenbaum et al. (2020), Guerrieri et al. (2020)), or on models for a monetary union with two regions that are symmetric in size (Bartocci et al., 2020). Importantly, little is known as regards the impact of pandemic shocks on small open economies that are part of a monetary union. Their stronger dependence on intra- and extra-union trade makes them more vulnerable to fluctuations in global demand. At the same time, their higher degree of openness, compared to that of larger member states, makes them more vulnerable to fluctuations in the terms of trade and/or exchange rate fluctuations triggered by the first and second order effects of a pandemic shock. For the same reason, such countries can be expected to be more susceptible to the effects of fiscal policy measures taken by their trading partners, which implies that such spillovers have more weight than in large and less open countries from the policy perspective. This paper fills this gap in the literature by analysing the effects of the COVID-19 pandemic shocks on small open economies (henceforth SOEs) in a monetary union, namely the euro area.

We focus on the size and the direction of the **international spillovers** stemming from the shock itself, and from the ensuing fiscal response. We use versions of the Euro Area and Global Economy (EAGLE) model (Gomes et al., 2012) which is a dynamic general equilibrium model (DSGE) of the euro area within the global economy. Featuring a detailed trade matrix, tradable and non-tradable sectors, the EAGLE provides a rich environment to assess the international spillovers of the COVID-19 pandemic. We calibrate the various versions of the model for a number of small open economy member states, namely Ireland, Luxembourg, the Netherlands and Slovenia.[1] Note that we use a significantly more unified modelling framework than has typically been the case in cross-country comparisons using DSGE models (e.g., Kilponen et al. (2019)). This implies greater comparability between simulations in the paper and is its main advantage compared to similar studies. Because the models we use share the same backbone, we can also assess how specific modelling features shape the dynamic responses to the COVID-19 pandemic.

We find significant spillover effects in each of the modelled SOEs, either from within EA or form outside EA. The rest of the EA (REA) represents the largest trading partner of all modelled SOEs. Consequently, the direct international spillover effects mostly stem from this region (intra euro area effects). However, we also find large international spillover effects that arise from other two foreign regions, either the rest of the world (RW) or the US, and which transmit to the domestic SOE both directly and via the REA (extra euro area effects).

We also assess **fiscal spillovers**, as such an environment provides a textbook example of a large-scale countercyclical fiscal policy intervention.[2] Each SOE has its own particular fiscal response, while the fiscal response of the REA is uniform across all the EAGLE model versions and is based on European Commission projections. The results not only show significant effects

[1] We pick the economies that are small, yet diverse in the structure of their economies (e.g., in terms of trade direction we have economies with more extra-EA trade and more intra-EA trade; in terms of production more manufacturing-oriented and more service-oriented; old members very integrated into the EA and recent joiners). This covers practically all cases and helps us to explain why some channels are more important for some countries than for the others. At the same time, it serves as a robustness check for our findings.

[2] A strand of the literature covers the effects of fiscal shocks on business cycles. We mention only a few studies here. Caggiano et al. (2015) study the state dependent fiscal multipliers of the US economy. Cugnasca and Rother (2015) investigate the impact of fiscal consolidation and multipliers in the EU. Kilponen et al. (2019) estimate output multipliers for alternative fiscal instruments by simulating 15 structural models within the EA. Recently, Arigoni et al. (2020) provide an analysis of different fiscal shocks, while studying the multiplier effects in the case of a large-scale fiscal stimulus package in a larger economic crisis, such as the COVID-19 pandemic.

stemming from the domestic fiscal stimulus, but also spillovers from the fiscal stimulus in the REA. Importantly, these spillovers depend on the fiscal instrument and may not be expansionary if the measures undertaken are aimed at the supply-side and there is a binding effective lower bound in the monetary union. We show that in the same situation, spillovers from demand-side measures can be quite significant. In addition, we explore the macroeconomic effects of the recently approved **Next Generation EU** program. Our simulations show the importance of the instrument used to finance the EU budget.

An interesting debate raised by the COVID-19 shock is whether by negatively affecting one sector, it can create a shortage of demand because spending does not shift to another sector (Guerrieri et al., 2020). This can be interpreted as **spillovers across sectors**. The idea is that when a negative shock is concentrated in one sector, then the effect on the other sectors depends on two parameters, the intertemporal elasticity of substitution and the elasticity of substitution across sectors. When for instance a negative supply shock affects a single sector, this makes the goods in that sector more expensive (if they are unavailable, their shadow price increases) relative to other sectors. This raises the cost of the overall consumption basket, shifting consumption to future periods. At the same time, this change in relative prices induces substitution away from goods of the affected sector towards goods of unaffected sectors. A shortage of demand occurs when the intertemporal elasticity of substitution exceeds the cross-sectoral elasticity of substitution and when the central bank cannot reduce the real interest rate to prevent consumption shifting towards the future. This has been labelled as a "Keynesian supply shock." However, we find that **the conditions that enable Keynesian supply shocks to occur do not have much influence on the aggregate outcomes**, at least not within the framework of global models and the relatively symmetric shock compositions used to mimic the effects of the pandemic.[3]

This paper relates to the growing literature analysing the macroeconomic effects of the pandemic. Angelini et al. (2020) estimate the effects of the COVID-19 pandemic by combining two models: the large-scale semi-structural ECB BASE model (Angelini et al., 2019) and the SIR (Susceptible-Infectious-Recovered) model that incorporates predictive dynamics, based on the Kermack and McKendrick (1927) mathematical epidemiological model. Eichenbaum et al. (2020) and Toda (2020) also adopted the SIR model approach. They find that people's decision to cut back on consumption and work reduces the severity of the epidemic, but negatively

[3] Results are available upon request.

contributes to the size of the resulting recession. On the empirical side of the literature, Barro et al. (2020) and Correia et al. (2020) compare the effects of the COVID-19 pandemic with the so-called “Spanish flu” pandemic in the 1918-1920, while Jordà et al. (2020) compare it to the “Black Death” pandemic.

From the modelling perspective, few studies attempt to use DSGE models to analyse the COVID-19 pandemic.[4] Eichenbaum et al. (2020) take a simpler DSGE model and combine it with a SIR model, while Mihailov (2020), building on Galí et al. (2012) assesses the macroeconomic effects of the COVID-19 lockdown based on three scenarios in the United States, Germany, France, Italy and Spain. Several papers propose simulating the COVID-19 shock as a combination of existing structural shocks, which is an approach we adopt. These are Primiceri and Tambalotti (2020), Gomme (2020), and Bartocci et al. (2020).

Our contribution to the literature is threefold. First, a common model setup calibrated to various SOEs. To the best of our knowledge this is the first paper that analyses the macroeconomic effects of the pandemic on SOEs in a monetary union setting. Moreover, we contribute to the literature by providing insights as regards the spillovers from regions outside the monetary union. Second, we exploit detailed international and fiscal environments allowing to properly measure international and fiscal spillovers. To that end, the rich set of fiscal instruments available in the various versions of the model deployed allows us to account for asymmetries in the fiscal response, not only within but also outside the monetary union; Third, we provide an original manner to replicate the first wave of the COVID crisis by exploiting the open economy features in the dynamic stochastic general equilibrium models.

The paper is structured as follows. In section 2, we present the scenario of the first wave of the COVID-19 pandemic outbreak. We also discuss the fiscal measures implemented in response to the first wave of the COVID-19. In section 3, we present the common features of all versions of the EAGLE model, discuss country-specific features of individual EAGLE model extensions and review their calibrations. In section 4, we report the results and additional analyses. Section 5 discusses international and fiscal spillovers. Section 6 examines the implications of the European fiscal transfers (New Generation EU funds). Section 7 concludes.

[4] For empirical estimates of the COVID crisis see Chudik et al. (2020), using a threshold multi-country model, or Kohlscheen et al. (2020), using a GVAR. Both show the importance of spillovers.

2 Crisis scenario and fiscal measures

Using the approach of Primiceri and Tambalotti (2020), Gomme (2020), and Bartocci et al. (2020), among others, we model the COVID-19 shock as a mixture of structural shocks. In this section, we provide the rationale for the chosen shocks and align the shocks with the empirical evidence.

2.1 Stylized facts

The COVID-19 pandemic ravaged the world economy. The global nature of the pandemic coupled with the sharp decrease in international trade suggests the existence of important international spillovers.

First, we look at the global growth dynamics of output and CPI inflation in the main global regions, i.e. the EA, the US and the RW in the top panels of Figure 1. The COVID-19 pandemic had a negative effect on an unprecedented scale. Real GDP growth in all regions collapsed in the second quarter of 2020. Changes in CPI inflation were also sudden and significant.

The middle panels in Figure 1 present the dynamics of key macroeconomic variables in the EA. Unlike during the global financial crisis (GFC), it was aggregate consumption that plummeted in the second quarter of 2020. The substantial collapse of investment is also worth noting. This decline in aggregate demand, caused mainly by lockdowns and social distancing measures, is essential to understand the fall in GDP. At the sectoral level, and as opposed to the trends during the GFC, the decline in non-tradable output is larger than its tradable counterpart, since the non-tradable sector is primarily represented by service activities, which were most affected during the lockdown.

At the country level, similar patterns emerge. The bottom two panels in Figure 1 compare the EA dynamics with those in Ireland, Luxembourg, the Netherlands and Slovenia. CPI inflation and output in all these economies feature similar paths. The left panel shows the evolution of both output growth and CPI inflation in those SOEs. The negative effects of the COVID-19 pandemic are similar to those in global regions shown in the top panels of the figure. A large drop in output is observed in the second quarter of 2020, while a decline in inflation is also visible but less significant.

The observations made above provide the rationale to use the EAGLE model, since its solid theoretical structure and a large variety of shocks will allow us to model the sudden movements described above. In the following sections, we present the data treatment and the model setup in more detail.

2.2 Data treatment

The COVID-19 pandemic differs from the usual economic shocks embedded in macroeconomic models. However, a formal framework is essential to understand its unprecedented macroeconomic effects as well as to guide policy actions. Our approach constructs the COVID-19 shock from the more familiar shocks that usually drive the business cycle in macroeconomic models.

This requires three important factors. First, we must define the combination of shocks that will form the COVID-19 crisis. Since the pandemic pervades all the macro-economy, we opt to combine supply and demand shocks. Specifically, we consider:

- Negative preference shocks. By reducing the weight households place on current utility from consumption relative to future one, these disturbances generate a significant increase in the savings to output ratio.

- Reduction in habit formation. Lockdowns, travel restrictions, and social distancing measures created obstacles to consumption. Thus, we temporarily reduce the level of consumption to which households are accustomed, generating a sudden and steep fall in aggregate consumption similar to the one experienced in the first quarter of 2020.

- Negative investment technology shocks. The economy becomes less efficient at transforming the flow of investment into the stock of capital, triggering a collapse in real investment.[5]

- Cost-push shocks to tradable and non-tradable goods. These supply side disturbances help us in two respects. First, they offset the huge downward pressure on inflation from the demand shocks, allowing the model to better approximate observed inflation dynamics. Second, they allow tradable prices to fall further than non-tradable prices, as observed in the data.

- Reduction in non-tradable inputs in the consumption basket. This shifts consumption away from non-tradable goods (consistently with the effects of the lockdown) and at the same

[5]The negative investment technology shock can also be viewed as a proxy for modelling the financial effects of the pandemic.

time lowers tradable output less than non-tradable output, as observed in the data.[6]

The second key factor concerns the propagation of the COVID-19 pandemic over time. Although the on-going vaccination campaign has raised hopes of an eventual end to the pandemic, most institutions do not predict a very fast recovery. For example, projected 2022 world GDP stands 4% lower than its pre- COVID-19 projection (IMF, 2021). In light of this evidence, we allow our synthetic COVID shock extend over the first four quarters of the simulation. As will become clear, this modelling approach fits the gradual improvement in the economic outlook.

The third ingredient in the procedure is the size of the synthetic shock. This is tricky, for both the pandemic and its macroeconomic consequences are constantly changing. That said, our goal is to focus on economic intuition, not to generate sharp quantitative predictions - the following heuristic procedure provides us with a set of suitable empirical targets:

- We start with the 2020 economic forecasts prepared in autumn 2019. These projections are not polluted by the pandemic, as they date from before the first coronavirus outbreak was detected in Wuhan, China.
- We then compare this vintage of forecasts with the ones prepared in spring 2020, once the COVID-19 pandemic had ravaged the world and its economies.
- Lastly, we assume that differences between those projections are only due to the pandemic and the fiscal response.[7]

We focus on the key macroeconomic variables for which different forecast vintages are readily available, namely the annual growth rate of GDP, private consumption, private investment, and the GDP deflator. In the RW bloc, we limit our attention to the annual growth rate of GDP. Table 3 presents our empirical targets. As seen in the table, economies across the world are seeing steep falls in activity together with significant declines in prices. Such co-movement across regions and variables suggests a dual nature for the COVID-19 shock: it affects both supply and demand in an interconnected environment.

A point here deserves further comment. Forecast vintages on sectoral prices and quantities are not readily available and comparable across countries. Therefore, we calibrate the sectoral

[6] The only exception is the Netherlands, where tradable output fell by approximately the same extent as nontradable output.

[7] This is the same assumption underlying narrative identification strategies and event studies (Zeev (2018), and Antolín-Díaz and Rubio-Ramírez (2018))

shocks to be consistent with the following outcomes: (i) the fall of domestic tradable prices is twice as large as that of non-tradable prices; (ii) the decline of domestic tradable output is half as large as that of non-tradable output. These dynamics are, loosely speaking, common to all economies.[8]

2.3 Fiscal measures

As mentioned earlier, the 2020 Spring Forecast incorporates fiscal packages implemented to cushion the economic fallout. For our exercise to be consistent, we must take these fiscal measures on board. This is not straightforward, for (i) the data is not always clear, and (ii) some policy actions do not have a model counterpart (e.g., public guarantees). That said, Table 5 reports the fiscal measures considered in our baseline exercise.

Recall that our aim is to analyse the first wave of the pandemic, where many fiscal measures were either not yet implemented or not taken up by the firms and households (e.g., guarantees). Because of this, and to achieve comparability between countries, we cast the fiscal measures in terms of direct government spending and transfers (or subsidies) to firms and households. A common feature of all countries is an increase in direct government consumption (mostly health expenditure-related) and an increase in transfers to households and firms (transfers or subsidies).

For **Ireland**, the direct government expenditure increase of 1 p.p. GDP comes from government increase in resources for the health sector (EUR 2 bn, of which 1bn has been implemented and 1bn approved within the first quarter of the pandemic). The various income support measures for households have been modelled as a transfer (negative tax) on households of 2 p.p. GDP. While the exact uptake of this scheme is difficult to estimate as it depends on the uptake, the number is roughly in line with the initial estimates of the Central bank of Ireland (Central Bank of Ireland (2020); for ex-post estimates, see Conefrey et al. (2020)).

For **Luxembourg**, the direct government expenditure increase of 0.3 p.p. GDP stems from the purchase of medical equipment and infrastructure. In addition, income support measures to households (paying partial employment benefits and covering employees leave for family reasons) reached 3 p.p. GDP. In our experiments, these are modelled as lump-sum transfers. Likewise, financial aid to firms reached 1.2 p.p. GDP. These are modelled as a decrease in social security

[8] For example, in Luxembourg, the services component of HICP fell 1% in 2020 relative to its long run average, while the goods component fell 2.1%. In contrast, hours worked in services during the first half of the year declined by 6.5% relative to their long run average, while hours worked in the tradable sector only declined by 3.3%.

contributions.[9]

In the **Netherlands**, the first support package amounted to 5.1% of GDP. The package consists of measures some of which cannot be depicted in the model due to the fact that they were either directed to sectors that are non-existent in the model or intended for aspects that the model abstracts from. Among the various measures adopted, expenditure for healthcare (e.g. healthcare support, bonuses to healthcare workers, medical supplies and other medical expenses) amounted to 0.31% of GDP. Other government expenditures amounted to 0.46% approximately.[10] Both these types of expenditures are considered as government consumption and amount thus to 0.77% approximately. Subsidies and transfers to households amounted to 1% approximately. Subsidies and transfers to firms (e.g. transfers and subsidies to self employed, Tozo, NOW, transfers to various sectors etc.) amounted to 3.64% of GDP approximately.[11]

In the case of **Slovenia**, the direct government consumption increase of 0.6 p.p. GDP represents the purchases of medical equipment and health infrastructure as a response to the COVID-19 pandemic outbreak. Additionally, the government equally disbursed 2.8 p.p. GDP of income support measures between households and firms and are modelled as transfers (negative tax). Lastly, social benefits amount to 0.8 p.p. GDP and are modelled as a decrease in social security contributions. The structure of fiscal measures follows the structure set in Arigoni et al. (2020).

Finally, we assume that monetary policy in the euro area is constrained by the effective lower bound (ELB) during the first three years of the simulation.

3 Modelling environment

3.1 Models setup

All models are based on (versions of) the Euro Area and Global Economy (EAGLE) model. It is a multi-country dynamic general equilibrium model of the euro area developed by a team composed of staff from the Bank of Italy, Bank of Portugal and ECB and as such is an ESCB

[9] This was the fiscal package considered by the BCL in the June 2020 projection exercise (Banque Centrale du Luxembourg (2021)).

[10] Other government expenditures vary from intermediate consumption, to operating costs of new scheme to guarantee trade credits to emergency daycare during the period of closed schools.

[11] Support package NOW (Noodmaatregel Overbrugging voor Werkgelegenheid) is intended for the provision of wage cost reimbursements to entrepreneurs while Tozo (Tijdelijke overbruggingsregeling zelfstandig ondernemers) is a temporary bridging measure for self-employed professionals.

project (Gomes et al. (2010) and Gomes et al. (2012)). Similarly to the ECB's New Area Wide model (NAWM, Coenen et al. (2008)) or the IMF's Global Economy Model (GEM, Laxton and Pesenti (2003)), the EAGLE is micro-founded and features nominal price and wage rigidities, capital accumulation, international trade in goods and bonds. The EAGLE is a global extension of the NAWM and as such shares the same theoretical setup. The introduction of two sectors (tradable and non-tradable), the monetary union and the enhanced fiscal bloc are the main differences with the original NAWM.

The central bank sets the domestic short-term nominal interest rate according to a standard Taylor-type rule, by reacting to increases in consumer price inflation and real activity, both defined at the euro area level. Remaining countries, the US and the rest of the world, have their own nominal interest rates and nominal exchange rates.

On the fiscal dimension, government consumption and investment play a non-trivial role in affecting the optimal decision-making of the private sector (as in Leeper et al. (2010), Coenen et al. (2013), and Clancy et al. (2016)).[12] Government capital stock affects the production process. Government spending on consumption and investment goods is specified as a fraction of steady-state nominal output, as is standard in the literature (Baxter and King (1993), for example). Moreover, in each country, the public debt is stabilized through a fiscal rule that induces the endogenous adjustment of fiscal instruments.

More disaggregated, Luxembourg (LU) (Moura and Lambrias (2018) and Garcia Sanchez and Moura (2019)) also considers **public employment**. To generate plausible fiscal multipliers, LU and SI allow high **import content of government expenditures**, implying Government spending multiplier to be lower. Finally, the Luxembourgish version of the EAGLE features **cross-border workers**, who in the data represent 45% of employment in the data. Labour services supplied by resident and cross-border workers are different, so that domestic firms need both inputs for production.

In the case of Ireland model features a labour market that is modelled using **search-and-matching frictions** in all blocs (Mortensen and Pissarides (1999)).[13] Households supply workers to a continuum of labour firms, each employing one worker. Labour firms hire workers by posting vacancies. Using hired workers, labour firms produce labour services, which they sell to firms in the intermediate tradable and non-tradable sectors. Labour firms also negotiate wages and

[12] For details, see the Technical Appendix (available upon request).

[13] Based on Jacquinot et al. (2018). For details, see the Technical Appendix (available upon request).

hours worked with households. The model has sticky wages following Hall (2005), and a labour market where employees can move between tradable and non-tradable sectors without friction, but movements from unemployment to employment are subject to search frictions. Separations are exogenous. Households and labour firms are subject to labour taxes (households pay wage taxes and labour firms pay social security contributions). Importantly, because households care about net wage income (after-tax) and firms care about total labour cost (including taxes), changes in taxes are taken into account when wages are negotiated. This channel turns out to be important for the way fiscal measures are transmitted across the economies in the model.

3.2 Overlapping generations in EAGLE

The Dutch version of the EAGLE introduces an **overlapping generations structure** that applies to all four regions.[14] This affects the effective planning horizon of households. Consequently, households, have no bequest motive and the usual Ricardian equivalence breaks down. Borrowing from Blanchard (1985) and Yaari (1965), it is assumed that each period households face a probability of death. Agents discount the far future more heavily, thus placing more weight on current fluctuations in disposable income, as well as medium-term discounted wealth, while individual behaviour is similar to that of the representative agent. As a result, Ricardian equivalence breaks down, implying that changes in lump-sum taxes matter and entail non-negligible wealth effects.

To save space, only the home household's maximization problem is presented. Households die with probability $1-\delta$ each period and every period a newborn generation i represents a fraction $1-\delta$ each of total population, where $0 \leq \delta \leq 1$. In other words, δ captures the probability of survival from one period to the next. Therefore, $\sum_{t=0}^{\infty} \delta^t = \frac{1}{1-\delta}$ represents the average household lifetime. As pointed out by Smets and Trabandt (2012), an alternative and empirically more plausible interpretation of $1-\delta$ is that it reflects the effective planning horizon of households. Here, we adopt the planning horizon interpretation as in Smets and Trabandt. Households have no bequest motive and the usual Ricardian equivalence breaks down. Households in all four regions derive utility form consumption and disutility from supplying labour to domestic firms. They are also assumed to have external habits in consumption. In what follows we present the equations for the home country only in order to save space. Similar conditions hold for the rest of the three regions. Under the Blanchard-Yaari structure, the utility function of the representative

[14] For details, see the Technical Appendix (available upon request).

household in each generation i receives the following form:

$$U_t^i = \frac{1-\kappa}{1-\sigma}\left(\frac{C_t^i - \kappa\, C_{t-1}}{1-\kappa}\right)^{1-\sigma} - \frac{\left(N_t^i\right)^{1+\zeta}}{1+\zeta} + \beta\,\delta\,U_{t+1}^i \tag{1}$$

where κ is the degree of habit parameter, σ is the degree of relative risk aversion, ζ is the inverse of the Frisch elasticity of labour supply, C_t^i is generation i's private consumption while C_t is aggregate consumption. N_t^i is generation i's labour supply. Notice that in the utility function above the survival probability, δ, enters the utility function of generation i in discounting the future. Households in the home country trade in two assets, namely a one period home government bond and a one period foreign government bond issued in the US. The latter is subject to a risk premium shock. The aggregated home Euler equations (abstracting from capital for simplicity) in home and foreign bonds receive the following form:

$$\beta\,\frac{R_t}{\Pi_{t+1}}\frac{\Lambda_{t+1}}{\Lambda_t} = \frac{1-\delta}{\delta\;\mu_{t+1}\Pi_{t+1}}\Lambda_{t+1}\;\left(b_t + q_t^*\;b_t^* + m_t\right) + 1 \tag{2}$$

$$\beta\left(1-\Gamma_{b^*}(\cdot)\right)\frac{R_t^{US}}{\Pi_{t+1}}\frac{\Lambda_{t+1}}{\Lambda_t}\frac{S_{t+1}^{H,US}}{S_t^{H,US}} = \frac{1-\delta}{\delta\;\mu_{t+1}^*\Pi_{t+1}}\Lambda_{t+1}\;\left(b_t + q_t^*\;b_t^* + m_t\right) + 1 \tag{3}$$

In the equations above, Λ_t denotes the marginal utility of consumption in period t. Π_t is gross inflation and R_t is the short-term interest rate on one period domestic bonds which coincides with the policy rate of the central bank. b_t denote real bond holdings issued at home, b_t^* denote real bond holdings issued in the US which carry price q_t^*. m_t are real money holdings. Note that in this setup money holdings become net wealth. In equation (3), R_t^US is the short-term interest rate on one period bonds issued in the US, which coincides with the policy set by the Fed. $S_t^{H,US}$ denotes the nominal exchange rate defined as the domestic currency (euro) price of one dollar. Note that home households pay a premium in adjusting their holdings of bonds issued in the US. This is captured by function $\Gamma_b^*(.)$, which is a convex function in foreign bond holdings.[15] Finally, the terms μ_{t+1} and μ_{t+1}^* in both equations are recursive discounting terms.

Observation of the two aggregate Euler equations reveals that bond and money holdings have real effects, through their direct impact on consumption. When households have finite lifetimes, their bond holdings become net wealth. This means that, after aggregation, fluctuations in their holdings affect consumption smoothing, regardless of the fiscal instrument (i.e. distortionary or

[15] This function guarantees stationarity.

non-distortionary) used for debt stabilization. This effect is absent in infinite lifetimes which explains why changes in lump-sum taxes leave private consumption unaffected. Clearly, the infinite lifetimes version of the two Euler equations above can be obtained by setting $\delta = 1$. In this case, the asset portfolio terms disappear. In the benchmark calibration and the corresponding scenarios presented in sections 4 and 5 below, we calibrate the survival probability $\delta = 0.99$, which corresponds to 25 years of effective planning horizon approximately.[16]

3.3 Calibration

This section describes the main sources of heterogeneity across the various versions of the EAGLE model. All models share the same structure, with two important exceptions: finite-life agents in The Netherlands and frictions à la Mortensen-Pissarides in Ireland. In terms of parameter values, Luxembourg is calibrated to be much more open.

Table 1 reports the implied great ratios at the steady state and shows that trade is the main source of heterogeneity across countries. Shares of domestic demand components in nominal GDP are broadly in line with the noticeable exception of LU where the consumption share represents around 30%, about half the share in other countries. Private investment and public expenditures are around 20% of GDP. When the split is available, public consumption represents by far the largest item in total expenditures of the general government. As said, large differences come from import shares: quite low for NL (below 25%), extremely high for LU (almost 185%) while IE and SI are in the middle (75% and 70% respectively). For most countries (NL, IE and SI), import content is larger for consumption goods than for investment goods. This is the opposite for LU. The import content of exports is also significantly larger in LU compared to other blocs (145% against 35% for IE and 30% for SI), reflecting the larger degree of openness of the Luxembourgish economy. On the fiscal side, discrepancies are a bit more muted. VAT revenue is approximatively between 15% (SI) and 18% (IE) of GDP. The tax burden is generally larger on workers (labour income taxes and social contributions) than on firms, except for SI (around 13% against 14%). The last row of the table shows region expressed as shares of world GDP.

Table 2 gives a brief overview of key structural parameters. Again, all blocs are identical, except NL where households have a finite-life horizon. Other countries share the same

[16] Mavromatis (2020) estimates a closed economy DSGE with a Blanchard-Yaari structure using Bayesian techniques and finds 95% posterior interval values for the survival probability between 0.956 and 0.995 approximately.

household preferences specification (logarithmic utility function separable in consumption and leisure). Among the key parameters that are similar across models: the quarterly discount factor set to imply an annualised steady-state real interest rate about 3%, the Frisch elasticity equal to 0.50 and the habit persistence parameter between 0.6 and 0.7. The share of rule-of-thumb households is 25% in all economies. On the supply side, the production technology for intermediate goods is identical (Cobb-Douglas with capital and labour) although public capital is productivity-enhancing in IE, LU and SI. Regarding the final-goods production technology (CES), substitutability between domestic and imported tradable goods is much higher than that between tradable and non-tradable goods, as established by the empirical literature. In fact, the elasticity of substitution between tradable and non-tradable goods is equal to 0.5 against 2.5 (1.5 for LU) for the elasticity between domestic and imported tradable goods. On the nominal side, mark-ups in the tradable goods sector (proxied by the manufacturing sector, 50%) are always lower than those in the non-tradable goods sector (proxied by the services sector, 20% or 30%); while mark-ups in the labour market are set around 30% (as already mentioned, labour market in the IE bloc is set in a different fashion). Real and wage rigidities are in the same ballpark. Price rigidities (Calvo parameter) are another important source of heterogeneity (indexations are the same). Tradable goods prices are stickier in NL and LU. Non-tradable goods prices are stickier in NL and SI.

4 Benchmark simulations

4.1 Baseline scenario

Figures 2 to 6 present the dynamic effects of the synthetic COVID shock in Ireland, Luxembourg, the Netherlands and Slovenia. Note that our baseline scenario is in line with the strong and persistent contraction in economic activity observed in the data.[17] We first explain the main transmission channels that underlie the dynamic responses of all economies, and then we turn to country-specific issues.

Three mechanisms shape these dynamic responses. The leading force is the combination of domestic demand shocks. Specifically, the negative preference shocks cause households to postpone consumption, as the weight they place on current utility falls. This, together with

[17] As noted above, our empirical targets are based on data projections available in the spring of 2020. The revision of these estimates is not a problem, as our goal is to provide intuitions and delve into the underlying economic mechanisms.

the reduction in habit formation, leads to a collapse in aggregate consumption. In addition, the negative investment shocks make the economy less productive at transforming investment into capital, thereby penalizing investment. These three shocks lead to a steep decline in aggregate demand, whose effects ripple through the whole economy via standard channels.

The second important mechanism is international trade. As the global economic activity collapses, so do exports from domestic economies to the rest of the euro area and beyond. This reduction in exports compounds the damages caused by domestic shocks, as all four domestic economies are very small and open (see Table 1).

The third mechanism is the effective lower bound (ELB). As the economy comes to a standstill, inflation falls.[18] This raises the real interest rate, because monetary policy is constrained by the ELB in the short run. The rise in the real rate slows spending through an inter-temporal substitution effect, depressing activity further.

The simulation also yields important sectoral differences. Non-tradable output falls much more than tradable output, although the difference in the behaviour of sectoral prices is the opposite. These phenomena, which are in line with the data, derive from the cost-push shocks and the reduction in non-tradable goods share in the consumption basket.

In all cases, the shocks lead to a substantial deterioration in employment. In some cases, this is compounded by wages being stickier than prices and strong indexation of nominal wages, resulting in an increase in the real wage (SI, Figure 6). In the Irish case (Figure 2), we can also report the reactions of the key labour-market related variables (Figure 3). The COVID shock sharply lowers vacancies in the first year, which leads to a strong reduction in workers' probability of finding a job (and an increase in the probability that the few remaining vacancies will match with a worker). Even though the number of vacancies recovers, and a significant fraction of workers is re-hired in the second year (an increase in the number of matches), this is not sufficient and higher unemployment persists for a long period of time.[19]

As for fiscal policy, the expansionary measures taken by all economies, combined with the contraction in output, account for the noticeable increase in the debt burden.

All told, our baseline simulation generates plausible paths for both quantities and prices

[18] Two competing forces shape inflation dynamics. On the one hand, the fall in aggregate demand pushes inflation downwards. On the other hand, the cost-push shocks to tradable and non-tradable goods push inflation upwards. Following the calibration of the synthetic COVID shock, the demand effect dominates, so that inflation falls.

[19] The persistence of unemployment might be even higher if the pandemic triggered a permanent structural change in the economy.

based on standard economic mechanisms. To see this point more clearly, the last two columns of Table 4 compare the main empirical targets with the model's ability to match them. Obviously, not all items are exactly on target. But broadly speaking, the baseline simulation is in the right ballpark.

4.2 Finite versus infinite lifetimes

In this section, we take the model with the Blanchard-Yaari structure and compare it with the case where lifetimes are infinite. In Figure 7, we display the responses of output and annualized inflation in the Netherlands and the REA. In each panel, we compare the responses from the Blanchard-Yaari version of the model to those from the same model with infinitely lived households. The responses under the Blanchard-Yaari version of the model correspond to the benchmark scenario presented in the previous subsection. To generate the responses under infinite lifetimes, we run the same experiment setting $\delta = 1$. The shocks are those described in the benchmark scenario.

When households have finite lifetimes, the responses of output and inflation are amplified in both regions. In fact, output contracts by 3 percentage points more in both regions. Finitely lived households discount the future more heavily and care more about medium-run fluctuations in their disposable income and wealth. Instead, infinitely lived households smooth the effects of the adverse shocks, reducing their private consumption by less. As a result of the larger drop in private consumption, finitely lived households also expect an even larger drop in medium-run inflation, which is reflected in annualized inflation declining more. Given that the economy is at the ELB in the first 12 quarters, a larger drop in inflation leads to higher real interest rates than under infinitely lived households. As a result, the present value of lifetime wealth falls further, adding to the negative effects on private consumption and output. Finally, the model with infinite lifetimes is also subject to the forward guidance puzzle, as forward guidance tends to have a very strong effect on household inflation expectations. This explains the milder decline and the faster overshooting of inflation in the two regions.

5 International and fiscal spillovers

5.1 International spillovers

This subsection analyses international spillovers from the three foreign blocs to the four domestic economies. Specifically, we assess how domestic output and inflation would have responded to the COVID shock if either the rest of the monetary union, the US or the rest of the world had been immune to the pandemic. To this end, we first define the following statistic:

$$\mu(i,t)^x = X_t^{Bas} - X_t^i. \tag{4}$$

Here X_t^{Bas} is the variable of interest (e.g., Dutch output) at time t in the baseline scenario, and X_t^i is its counterpart in a hypothetical scenario where bloc $i = \{REA, US, RoW\}$ is not hit by the COVID shock. Both X_t^{Bas} and X_t^i are expressed in either percentage deviations or percentage differences from the deterministic steady state.

Figures 8 - 11 convey a clear message: international spillovers matter for both output and inflation. That is, they account for a significant portion of the decline in economic activity in all domestic economies. However, there are some important nuances regarding the interaction of government spending with the effective lower bound and the way that wage subsidies are treated in wage negotiations. In each particular case, we explain the mechanisms that cause the differences.

There are three key channels that govern international spillovers in all the economies we analyse. First, there is a direct demand channel. Even if prices remain unchanged, a fall in the economic activity of the main trading partner has a detrimental effect on the economy that exports to this trading partner. Second, the reaction of prices, and in particular the exchange rate in the case of extra-monetary union trade, can either mitigate or alleviate the consequences of the decrease in foreign demand. Here the binding ELB in the euro area plays an important role, as it causes the euro to appreciate and hence works in a negative direction. Trade direction therefore matters more when the monetary union is bound by the ELB. Third, when government spending has an important import component, the (absence of) government spending expansion in the main trading partners can play an important role, especially if this implies that the economy that exports to such area is pushed to the ELB by the absence of fiscal action. We now turn to illustrate these channels in particular countries.

For **Ireland** (Figure 8), the effects of spillovers reflect the structure of its foreign trade, which differs from that of the other countries in this paper in that it is much more open to non-EA regions. In line with this, the spillovers from the rest of the world, which includes the UK, are the strongest, amounting to about 1 p.p. of GDP (i.e., Irish output would drop by 1 p.p. less if there was no shock in the RW), followed by the spillovers from the US (0.9 p.p. of GDP), and by the spillovers from the rest of the euro area (0.3 p.p. of GDP). The structure of foreign trade, however, must be considered together with the movements in relative prices. When there is an effective lower bound for the euro area, but not for the US and the RW, the euro appreciates, because the non-euro blocs are able to lower their interest rates in response to the shock. If the US or the RW are not hit by the shock, the real exchange rate for Ireland appreciates less, which implies that exports to regions not affected by the shock are less affected by the relative price (in addition to more resilience in the quantity demanded). This exchange rate channel is much less powerful in trade with the REA, because the nominal exchange rate is fixed and the real exchange rate only reflects relative changes in goods prices, which are sluggish due to nominal frictions in price setting.

In terms of inflation, the appreciation of the nominal exchange rate lowers inflation due to lower import prices and reduces foreign demand. The latter affects domestic production and labour demand, resulting in lower wages and lower marginal costs, which spill over to lower inflation. Wages in Ireland are relatively flexible on average, compared to other countries (even though this may not be the case for all types of employees, see Lydon and Lozej (2018)). Moreover, lower wages spill over to all sectors of the economy due to the ability of the marginal workers in tradable and non-tradable sectors to move between sectors. The result is that the negative inflation effect of the decrease in marginal costs compounds the effect of nominal appreciation. This is why, when there is no shock in the RW (to which Ireland is most exposed), the drop in inflation is substantially reduced. For trade with the rest of the euro area, the nominal exchange rate effect is absent. However, the global shock causes an appreciation of the euro even if the shock is not present in the rest of the euro area, and this induces a recession in the entire monetary union. The expected future path of the euro interest rate is higher, as part of the area has not been hit by the shock, so the appreciation is stronger This is the main reason why inflation in Ireland falls by slightly more when the rest of the euro area has not been affected by the shock.

In **Luxembourg** (Figure 9), the strongest spillovers come from within the monetary union. This comes as no surprise, for the rest-of-the-euro-area bloc is, by far, its major trading partner, accounting for roughly 70% of its exports. Luxembourg also features the strongest negative spillovers: on impact, the decline in output in the absence of euro area shocks is 0.6% instead of 7.6%.[20] The large export to GDP ratio (close to 190%) provides the main explanation for this result. In addition, it was expected that output spillovers from the rest-of-the-world bloc are much larger than those from the US. Exports to the US account for roughly 4% of Luxembourg exports, whiles exports to the rest of the world account for 26%.

In terms of inflation, the bottom left panel in Figure 9 reveals sizeable spillovers and provides an interesting insight. In the absence of strong output spillovers, the fall in aggregate demand in Luxembourg is not enough to offset the inflationary pressures coming from the negative supply shocks (i.e., cost-push shocks). That is why Luxembourg inflation is higher without foreign shocks.

For the **Netherlands** (Figure 10) the paradox of a deeper contraction in output is observed when the rest of the euro area is not hit the global shock. This is triggered by the stronger real effective exchange rate under this counterfactual scenario.[21] Given the strong dependence of the Dutch economy on international trade, the stronger appreciation harms its exporting sector, and thus output. Therefore, it seems that the rest of the euro area, when hit by the global shock, acts as absorber which allows for a milder real effective exchange rate appreciation in the benchmark scenario. As a result, the exporting sector is hit less in the benchmark economy than in the counterfactual scenario, which leads to a milder contraction. As regards the contribution of the rest of the regions, the US seems to have a non-negligible spillover in the Dutch economy. The spillover from the US economy amounts to 0.9 p.p. of GDP (i.e., Dutch output would drop by 0.9 p.p. less if there was no shock in the US) and it is almost double the spillover from the rest of the world.

As regards inflation, the stronger appreciation of the real effective exchange rate when the global shock is absent in the rest of the euro area leads to a deeper decline in inflation. Despite price stickiness, this result suggests a non-negligible exchange rate pass-through to Dutch prices. Obviously, the amplified response of inflation is further fuelled by the sharper decline in output in the export sector. Spillovers to inflation from the other two regions are small to negligible.

For **Slovenia** (Figure 11), the largest spillover comes from the rest of the euro area, but the

[20] In reality, it is unlikely that EA shocks account for 92% of the fall of Luxembourg GDP. However, our exercise should be seen as a pedagogical device highlighting the importance of international spillovers. We do not intent to provide precise quantitative estimates.

[21] As we show in section 5.3, this result is sensitive to the presence of the effective lower bound

sign of this spillover is the opposite of what would be expected. This results from how fiscal policy is modelled. Recall that the model allows for import-content of government spending. That is, part of foreign government purchases are imported to Slovenia – an example are pharmaceuticals and private consumption subsidized by the government (for instance, the cash-for-clunkers scheme in Germany, where car parts of cars bought with the subsidy are produced in Slovenia). When the REA shock is switched off, government spending in this bloc is also switched off, and with it some of the positive effect it has on the Slovene economy. When the interest rate is constrained by the effective lower bound, this can have dire consequences, as the lack of demand lowers domestic inflation and increases the domestic real rate. This occurs because the spillover effect of the fiscal stimulus from REA overshadows the (negative) spillover effect of the REA economy excluding the fiscal part (this can be seen in the top-right panel of the figure, where fiscal spillovers from the REA are high, and in the bottom-right panel, showing a relatively high contribution of the REA fiscal policy to domestic inflation in Slovenia). The higher real rate significantly reduces domestic consumption, which magnifies the spillover (we show that this effect is not present when there is no effective lower bound). Spillovers from the US and the RW are smaller and have the expected sign, as both trading partners account for roughly 30% of exports and the fiscal spillovers are small. What we can also observe is that domestic fiscal stimulus matters. On impact, it accounts to almost a 3 p.p. lower output drop. On the other hand, fiscal stimulus from the REA provides even more support to the domestic economy in the first year. Note that this does not imply that the import-content of Slovene goods in government spending in the REA is large (in fact, it is small). But the size of the REA is so big relative to the size of Slovenia that even a small fraction is sufficient to generate strong direct spillovers.

5.2 Fiscal spillovers

We now explore the role of fiscal policy in shaping dynamic responses to the synthetic COVID shock. As in the previous subsection, we compare the paths of output and inflation in the baseline scenario with their counterparts in a hypothetical scenario where either the domestic economy or the rest-of-the-euro-area does not implement any fiscal measure.

The right panels in Figures 8 - 11 present the effects of domestic fiscal policy (see Table 5) during the first three years of the simulation. Although there are significant differences across countries, two key findings emerge. First, domestic fiscal policy generally has mild effects on both quantities and prices. For instance, fiscal support in **Luxembourg** boosts output by 0.5%

in the first year, while it leaves inflation unchanged. Moderate effects mainly reflect import leakages in SOEs, as the import content of consumption, investment and exports, and in some cases even government spending tends to be high (see Section 3). This insight is consistent with the empirical literature on fiscal multipliers, which finds that small open economies feature smaller multipliers (Ilzetzki et al., 2013). Second, the effects of spillovers depend on the fiscal policy measure. If such measures are supply-side oriented, they may improve the performance of the domestic economy (in the absence of the ELB), but this may come to some extent at the expense of the trading partners. This can be seen in the right panels in Figures 8 - 11, which also report fiscal spillovers from the rest-of-the-euro-area bloc. As was mentioned above, this bloc increases transfers to households by 4.5% of ex-ante annual GDP and increases government consumption by 2.2% of ex-ante annual GDP.

In light of the evidence above, it makes sense that fiscal spillovers are significant. This important fiscal package worth 6.7% of ex-ante annual GDP boosts aggregate demand in the rest of the monetary union, especially consumption demand by non-Ricardian households, which in turn fosters domestic exports, and hence domestic output. The ELB amplifies these spillovers, as monetary policy does not respond to these fiscal stimuli.

Domestic fiscal policy in **Ireland** (Figure 8) is calibrated on the initial response of the government to the first wave of the pandemic. Domestic fiscal policy has predictable expansionary effects, for two reasons. First, government consumption directly stimulates domestic output. Second, a subsidy to households' wages keeps their after-tax income higher and at the same time prevents firms to sever employment relationships. The latter happens because, with the wage-bargaining framework, the subsidy to households' wages becomes part of the match surplus that is negotiated between households and firms. Households are willing to accept lower wages, because due to the wage subsidy, their take-home income remains unchanged (or its decline is limited) even if they accept the wage cut. In this way, firms benefit from lower wage costs and preserve more employment relationships. Since firms become more internationally competitive given lower wage costs, this also helps to preserve jobs. Lower wage costs due to the wage subsidy and hence lower marginal costs are also the reason why a substantial fraction of the upward pressure on inflation due to government spending is neutralized. In a wage bargaining framework a wage subsidy to households effectively becomes in part a supply-side measure that lowers inflation. This is an important insight, because in the presence of the ELB this channel reduces the fiscal multiplier somewhat through the increase in the real interest rate.

The wage subsidy mechanism outlined above also operates in other blocs of the model. In the rest of the euro area, the fiscal package is tilted towards wage subsidies (as it is in Ireland), so it mainly favours domestic producers by lowering their marginal costs. Irish exporters would therefore become more competitive if the rest of the euro area did not subsidise wages, which would result in a lower fall in output in Ireland. However, subsidizing wages in the rest of the euro area is a double-edged given the effective lower bound, because it further reduces inflation and increases the real interest rate. This further dampens consumption and investment in the rest of the euro area. This latter channel is the more important reason why the fiscal policy spillovers from the rest of the euro area to Ireland are negative. Again, this is only the case because the fiscal package is tilted towards wage subsidies and these directly lower firms' marginal costs in the wage bargaining framework. For other fiscal measures, such as government spending, the spillovers are positive. From an empirical perspective, investigation of fiscal policy spillovers must consider the fiscal instrument used and its transmission channels.

In the **Netherlands**, fiscal policy in the first year leads to a milder contraction of output by 2 percentage points less than in the case of no domestic fiscal support. The fiscal measures, even though to large extent in a lump-sum form, are effective in mitigating the recession. Obviously, finite lifetimes contribute to that, to a large extent. The impact of the necessary future consolidations is now discounted heavily, raising thereby the multipliers of the adopted fiscal measures. Importantly, the effectiveness of domestic fiscal measures is quite persistent mitigating the recession up to 0.5% three years later. As regards inflation, the effects are visible from the first year, where inflation drops by approximately 0.6% less than in the no fiscal support scenario. Owing to price stickiness, the effects of expansionary fiscal measures build up gradually until they start to dissipate again.

Looking at the spillovers of fiscal measures in the rest of the euro area, their impact is quite substantial in the Netherlands. Given the high degree of openness of the Dutch economy and thereby its strong dependence on external demand, the expansionary fiscal measures in the rest of the euro area alleviate the impact the pandemic shock substantially. Importantly, the persistence of the spillovers from the rest of the euro area is high.

Due to the direct import-content of government spending in the **Slovenian** version of the model (Figure 11), it is difficult to separate the pure fiscal and the pure international effect, and we have discussed both together in the previous section.

5.3 Spillovers when monetary policy is more accommodative

So far, the effective lower bound (ELB) has constrained the nominal interest rate in the monetary union, preventing the central bank from responding to the COVID shock. This subsection relaxes this assumption: a standard Taylor rule will now determine the response of the nominal interest rate to changes in inflation and output.

With a binding ELB, the nominal interest rate in euro area is higher than in the US and in the rest-of-the-world bloc. Therefore, the euro appreciates in both real and nominal terms, putting additional downward pressure on domestic exports, and hence on domestic output. This does not happen when the ELB is not binding, as the euro-area central bank can lower interest rates, which closes (most of) the gap between interest rate in the EA and in the US or the RW.

As in subsection 5.1, we measure spillovers as the difference between the paths of output or inflation in the baseline scenario (i.e., global shock) and their paths in the hypothetical scenario. Comparing Figures 12 - 15 with Figures 8 - 11 reveals that a binding ELB amplifies output spillovers from the US and the rest-of-the-world.[22]

For **Ireland** (Figure 12), removing the binding ELB lowers some of the spillovers from the US and the RW compared to the benchmark case. This happens because when euro area monetary policy can respond and mitigate the recession this prevents a strong appreciation of the euro relative to other currencies. Fiscal spillovers from the REA are still somewhat negative, for the reasons explained above (wage subsidies are taken into account during wage negotiations and firms pay lower wages). However, the spillovers are somewhat less negative when the ELB is not binding, because the lower inflation caused by falling wages does not interact with the ELB.

In addition, the binding ELB also amplifies spillovers from the rest-of-the-euro-area bloc to **Luxembourg** (Figure 13). The fall in the nominal rate boosts aggregate demand in the whole euro area and supports domestic exports. Since, as mentioned already, Luxembourg is a very small and very open economy, this increase in trade volume has significant positive effects.

The impact of the binding ELB is also significant in terms of fiscal spillovers from the rest-of-the-euro-area bloc to Luxembourg. For instance, with a binding ELB, fiscal measures in the rest-of-the-euro-area bloc raise Luxembourg output by 2.5% during the first year of the pandemic (without the binding ELB, that number is 1.6%). This result is intuitive. The large fiscal package implemented in the rest of the monetary union supports aggregate spending and puts upward

[22] In line with Alloza et al. (2020).

pressure on euro area inflation. A standard Taylor rule responds to these developments with a less accommodative policy stance, mitigating the increase in spending and penalizing domestic exports.

For the **Netherlands** (Figure 14), removing the effective lower bound changes the sign of the spillovers from the rest of the euro area. Dutch output now contracts more when the rest of the euro area is also hit by the global shock. Again, given the strong dependence of the Dutch economy on international trade, this result is largely driven by the evolution of the real effective exchange rate. The latter initially depreciates before appreciating by more in the medium run, when the rest of the euro area is also hit by the global shock. The stronger medium-run appreciation of the real effective exchange rate leads to a shaper decline in the output of the Dutch export sector, which explains the deeper recession compared to the case where the global shock does not hit the rest of the euro area.

But what explains the initial short-run depreciation and the subsequent strong and persistent appreciation of the real effective exchange rate? In the absence of the effective lower bound, the decline in euro area inflation leads to a drop in the interest rate which by itself depreciates the euro and hence the real effective exchange rate (due to price stickiness). The sharp decline in inflation implies a sharp drop in the interest rate in the short run which. Given interest rate smoothing, this implies a long-lasting increase in the medium run until the policy rate reverts to its steady state value. This persistent increase in the interest rate, in the medium-run, engineers a persistent appreciation of the real effective exchange rate. This effect is considerably weaker when the rest of the euro area is not hit by the global shock.

Removing the ELB makes spillovers from the rest of the world stronger than those from the US. Obviously, this is related to the interactions between the monetary policy stance and the developments in the bilateral real exchange rate. However, spillovers remain considerably smaller than those from the rest of the euro area. Finally, similar patterns are observed in inflation.

For **Slovenia** (Figure 15), removing the effective lower bound leads to international spillovers with the expected sign and magnitude. It also changes the strong dependence of the Slovene economy on the fiscal stimulus from the REA region, which overwhelms the effects of the spillover from the non-fiscal part of the REA economy. Because the European Central Bank reacts to the shock by lowering the nominal (and real) interest rate, this stimulates private consumption in Slovenia and in the REA, and it also breaks the interaction between the REA fiscal stimulus and the effective lower bound. Consequently, if the effective lower bound is absent, then the negative spillover from the REA accounts for around 0.7 p.p. of Slovenian GDP. A similar mechanism works for the other two regions (US and RW). The additional monetary accommodation also increases the effect on output of the domestic fiscal stimulus, which now exceeds 3 p.p. in the first year, while the effect of the fiscal stimulus from the REA decreases significantly. The effect of the REA fiscal stimulus on inflation is also much smaller than in the case when the effective lower bound is binding.

All in all, this subsection emphasizes the importance of the monetary policy stance in determining the economic impact of the pandemic.

6 Long-term bonds and Next Generation EU

Following the sharp contraction of European economies during the pandemic, the European Council agreed in July 2020 to launch the Next Generation EU (NGEU) instrument. NGEU is a coordinated fiscal response to the crisis aiming to be an exceptional temporary recovery measure. In practical terms, NGEU allows the European Commission to issue debt to finance grants and loans to EU Member States, with the disbursement of funds focusing on the countries most affected by the crisis.[23]

Against this background, we consider an extended version of the model that features a supranational fiscal authority in the euro Area.[24] The European fiscal authority issues long-term bonds and collects lump-sum or VAT taxes from households in the home country and in the REA.[25] Long-term bonds are modelled as perpetuities following Woodford (2001). The duration of these bonds is 10 years. The fiscal authority sells the bonds to Ricardian households at home and in the REA. For the long-term interest rate to deviate from the union wide short-term rate set by the union central bank, it is assumed that long-term bonds are subject to transaction costs. We model transaction costs as a function that is increasing in the GDP share of outstanding long-term debt issued by the supranational fiscal. Lump sum or VAT taxes imposed on home and REA households increase with the share of outstanding long-term debt but are weighted by the size of the region that the household belongs to. This ensures that tax incidence falls more

[23] See also Bańkowski et al. (2021) for more details on the implementation.

[24] For details, see the Technical Appendix (available upon request).

[25] An alternative and more realistic assumption would be local governments to impose lump-sum taxes of households the proceeds of which are then rebated to the fiscal authority, as in Bartocci et al. (2020). Given that households are infinitely lived, and local government debt is stabilized through lump-sum taxes, the two approaches have exactly the same wealth effects.

on households that reside in the bigger region.

The supranational authority uses the resources raised by issuing long-term debt either to provide support to the non-tradable goods sector or to finance part of member states' outstanding debt. The two scenarios are considered separately. In both cases, it is assumed that the supranational authority implements additional spending for three quarters. As in Bartocci et al. (2020), taxes used to finance debt issued by the supranational fiscal authority are not active in the first three quarters when resources are distributed to member states. In both scenarios, we assume that additional union wide spending is set exogenously by the supranational authority and amounts to five percent of euro area GDP.

In all the scenarios considered in this section, we take the Netherlands as the home country. We report the impulse responses of output and inflation in the Netherlands and the euro area in Figure 16. The top panels display three impulse responses corresponding to three scenarios: no support from the EU (blue lines), EU transfers to the non-tradable goods sector financed by EU lump-sum taxes (orange lines) and EU transfers to the non-tradable goods sector financed by EU VAT taxes (grey lines). The bottom panels report the same set of impulse responses but for EU transfers to finance national governments' outstanding debt. In the scenario of no EU support, no other fiscal backing is assumed. That is, fiscal transfers from national governments to households and firms are turned off. This isolates the effects of fiscal transfers from the EU by excluding additional effects stemming from national government support.

Let us first focus on EU lump-sum taxes. The impulse responses reveal that the Netherlands benefits only marginally from EU transfers towards the non-tradable goods sector. In fact, output contracts only slightly less. Turning to lump-sum transfers to finance national government debt (bottom panels), effects are nearly zero. Obviously, this is largely driven by the fact that both national governments and the supranational authority use lump-sum taxes to stabilize debt.

Let us now turn to the case where the supranational authority uses VAT taxes to finance its debt. In this case, both forms of fiscal support from the supranational authority are beneficial. Specifically, transfers to the non-tradable goods sector and transfers to finance national debt both reduce the contraction in NL output. This result is evidently driven by the fact that the supranational authority stabilizes its debt using a distortionary tax. The intuition is as follows. Households are aware that the supranational authority will not raise VAT taxes immediately, but only in the future. From the Euler equation, private consumption before the increase in EU VAT taxes will be higher. Households frontload the effects of higher future VAT and, as a result, decide to raise their consumption (or limit the decline in their consumption) before the rise in taxes is actually implemented. This puts upward pressure on prices in both regions. This channel is absent when the supranational authority stabilizes its debt via lump-sum taxes. Moreover, given that monetary policy is constrained at the ELB for the first three years, the real rate declines further mitigating the recession. Therefore, the key difference between lump-sum EU taxes and VAT EU taxes is that the latter lead to frontloading in private consumption and to lower real interest rates.

7 Conclusion

We investigate the role of international spillovers during the COVID-19 pandemic for small open economies that are members of the monetary union. We use a unified framework, based on versions of the Euro Area and Global Economy (EAGLE) model. Despite particular features of the country-specific versions, they share the same basic framework, ensuring a much higher degree of comparability than most cross-country studies. We find that the decline in 2020 economic activity in Ireland, Luxembourg, the Netherlands and Slovenia mostly resulted from foreign factors, either related to trade or to fiscal policies. This finding is not surprising for small open economies. However, the effective lower bound on interest rates, the specific design of fiscal measures, and the monetary union framework can significantly affect the results. We explain the transmission mechanisms behind these findings. In particular, the interaction of fiscal policy with the effective lower bound is important, both for the effects of national fiscal policies and for international spillovers.

We also find important fiscal spillovers from the rest of the monetary union. The unprecedented fiscal measures taken by euro area countries boosted aggregate demand in the whole union, which, according to our models, had non-trivial effects in the small economies studied here. In addition, we explore the macroeconomic effects of the recently approved Next Generation EU program.

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TABLE 1. Great ratios

	IE	LU	NL	SI
Share in percentage of GDP				
Private consumption	63.45	33.30	56.56	56.92
Private investment	14.14	20.40	20.56	15.06
Public expenditure	18.80	21.95	22.55	24.80
Public consumption	15.80	9.25		20.80
Public investment	3.00	4.45		4.00
Public employment		8.25		
Imports total	75.81	190.4	24.40	69.81
Imports consumption	28.81	17.65	14.40	22.03
Imports investment	9.64	18.60	10.00	12.97
Imports exports	37.35	152.1		31.81
Imports public expenditures				3
Share non-tradable sector	35.20	11.35	60.00	42.59
Tax rates				
VAT	18.3	16.00	16.80	15.35
Labour income tax rate	14.90	14.54	18.30	12.89
SSC by firms	9.90	11.93	13.00	13.88
Share of world GDP	0.026	0.0005	0.76	0.002

Table 2. Calibration

	IE	LU	NL	SI
Mark-up				
Wages – households		1.30	1.30	1.30
Prices – domestic tradable goods	1.20	1.30	1.20	1.30
Prices – exports	1.30	1.30	1.20	1.30
Prices – domestic non-tradable goods	1.50	1.50	1.50	1.50
Real rigidities				
Investment	6.00	5.00	5.00	3.00
Imports – consumption	2.00	2.00	2.00	1.00
Imports – investment	1.00	2.00	2.00	1.50
Nominal rigidities				
Households				
Wage stickiness	0.75	0.75	0.80	0.81
Wage indexation		0.75	0.75	0.75
Tradable goods sector				
Price stickiness (domestic goods)	0.75	0.90	0.90	0.90
Price indexation (domestic goods)	0.50	0.50	0.50	0.50
Price stickiness (exported goods)	0.75	0.75	0.90	0.75
Price indexation (exported goods)	0.50	0.50	0.50	0.50
Non-tradable goods sector				
Price stickiness (domestic goods)	0.75	0.75	0.90	0.93
Price indexation (domestic goods)	0.50	0.50	0.50	0.50

TABLE 3. Empirical targets I

	E.C 2020 Forecasts Autumn 2019	Spring 2020	Targets	Model simulations
Ireland				
GDP	3.5	-7.9	-11.4	-6.9
Consumption	2.5	-8.8	-11.3	-11.5
Investment	4.5	-41.6	-46.1	-29.6
Inflation	1.5	1.3	-0.2	-4.9
Luxembourg				
GDP	2.6	-5.4	-8.0	-7.6
Consumption	2.7	-4.1	-6.8	-7.3
Investment	2.9	-12.0	-14.9	-17.9
Inflation	1.9	0.4	-1.5	-1.4
Netherlands				
GDP	1.3	-6.8	-8.1	-6.2
Consumption	1.7	-9.5	-11.2	-3.6
Investment	1.8	-11.2	-13.0	-22.28
Inflation	1.5	1.1	-0.4	-0.45
Slovenia				
GDP	2.7	-7.0	-9.7	-5.6
Consumption	2.9	-6.1	-9.0	-18.0
Investment	6.0	-13.0	-19.0	-29.0
Inflation	2.4	2.1	-0.3	-0.5

Note: The Autumn 2019 and the Spring 2020 European Economic Forecasts by the European Commission provides the data for all European economies, the Euro Area, and the United States. The October 2019 and April 2020 World Economic Database by the International Monetary Fund provides the data for the Rest of the World. The Rest of the World refers to an average of China, Japan and the United Kingdom, where each country is weighted according to its 2018 Gross Domestic Product.

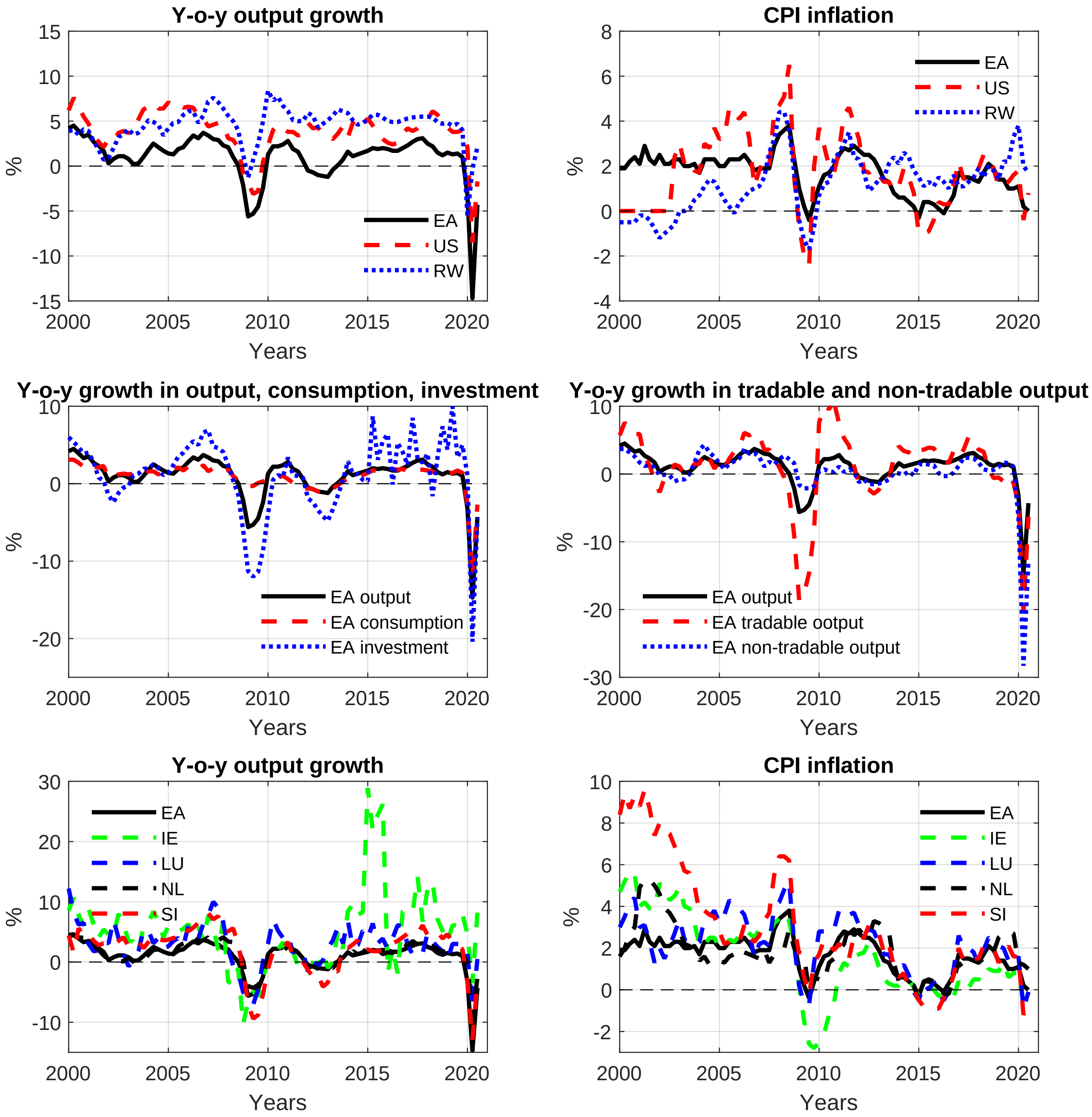
Table 4. Empirical targets II

	E.C 2020 Forecasts		Targets	Model simulations
	Autumn 2019	Spring 2020		
Euro area				
GDP	1.2	-7.7	-8.9	-7.3
Consumption	1.2	-9.0	-10.2	-10.7
Investment	2.0	-13.3	-15.3	-17.1
Inflation	1.5	1.3	-0.2	-1.7
United States				
GDP	1.8	-6.5	-8.3	-8.4
Consumption	2.2	-7.2	-9.4	-10.8
Investment	1.1	-12.2	-13.3	-11.5
Inflation	1.8	-0.6	-2.4	-2.2
Rest of the world				
GDP	4.3	-1.3	-5.6	-4.9

Table 5. Fiscal Measures

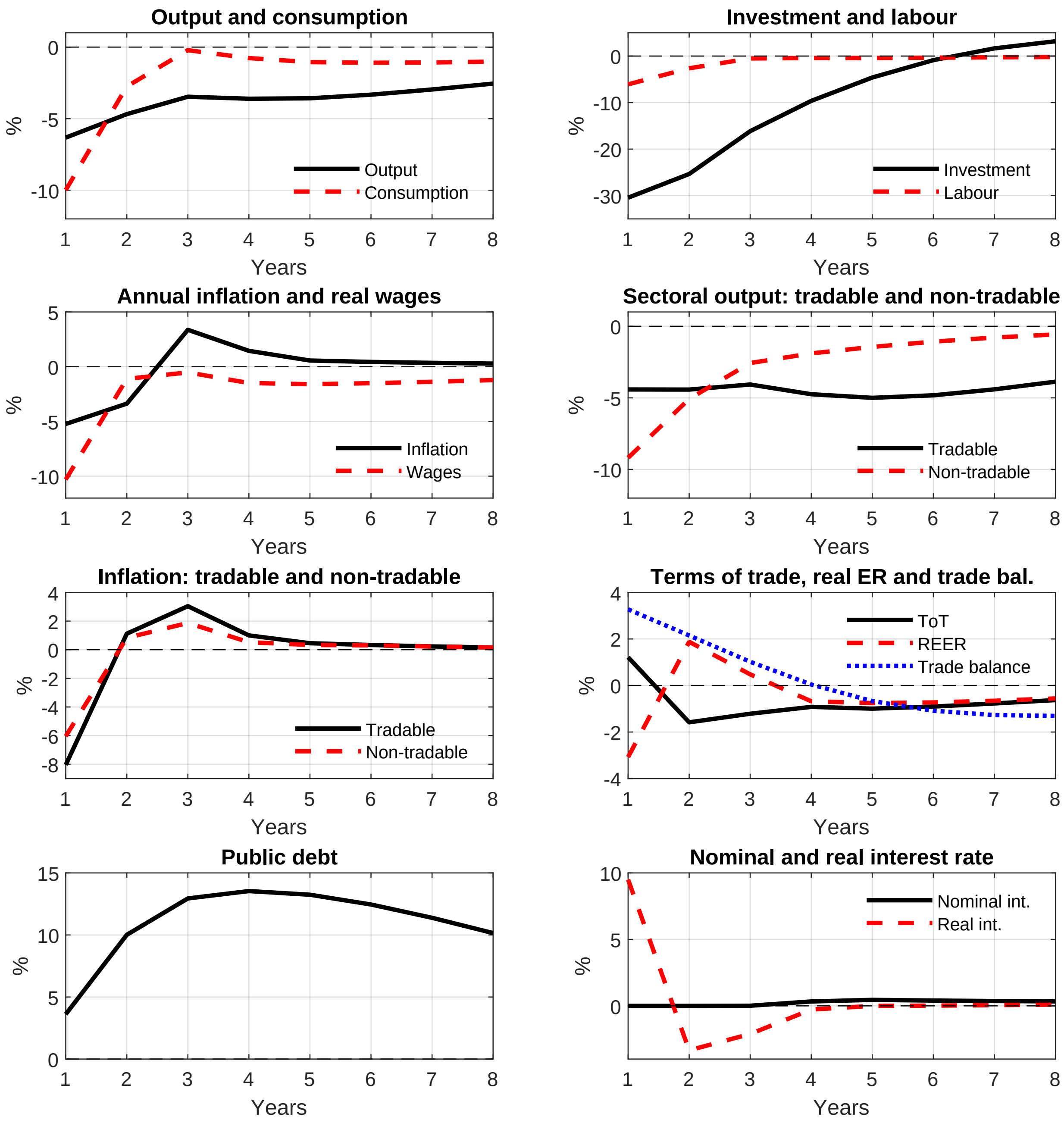
	Fiscal measure	% of ex-ante annual GDP
Euro Area		
	Government consumption	2.2
	Transfers to households	4.5
Ireland		
	Government consumption	1.0
	Transfers to households	2.0
Luxembourg		
	Transfers to households	3.0
	Transfers to firms	1.2
	Public investment	0.3
Netherlands		
	Government Consumption	0.77
	Transfers to households	1.0
	Transfers to firms	3.64
Slovenia		
	Transfers to households	1.4
	Transfers to firms	1.4
	Government consumption	0.6
	Social benefits	0.8

Figure 1. Stylised facts



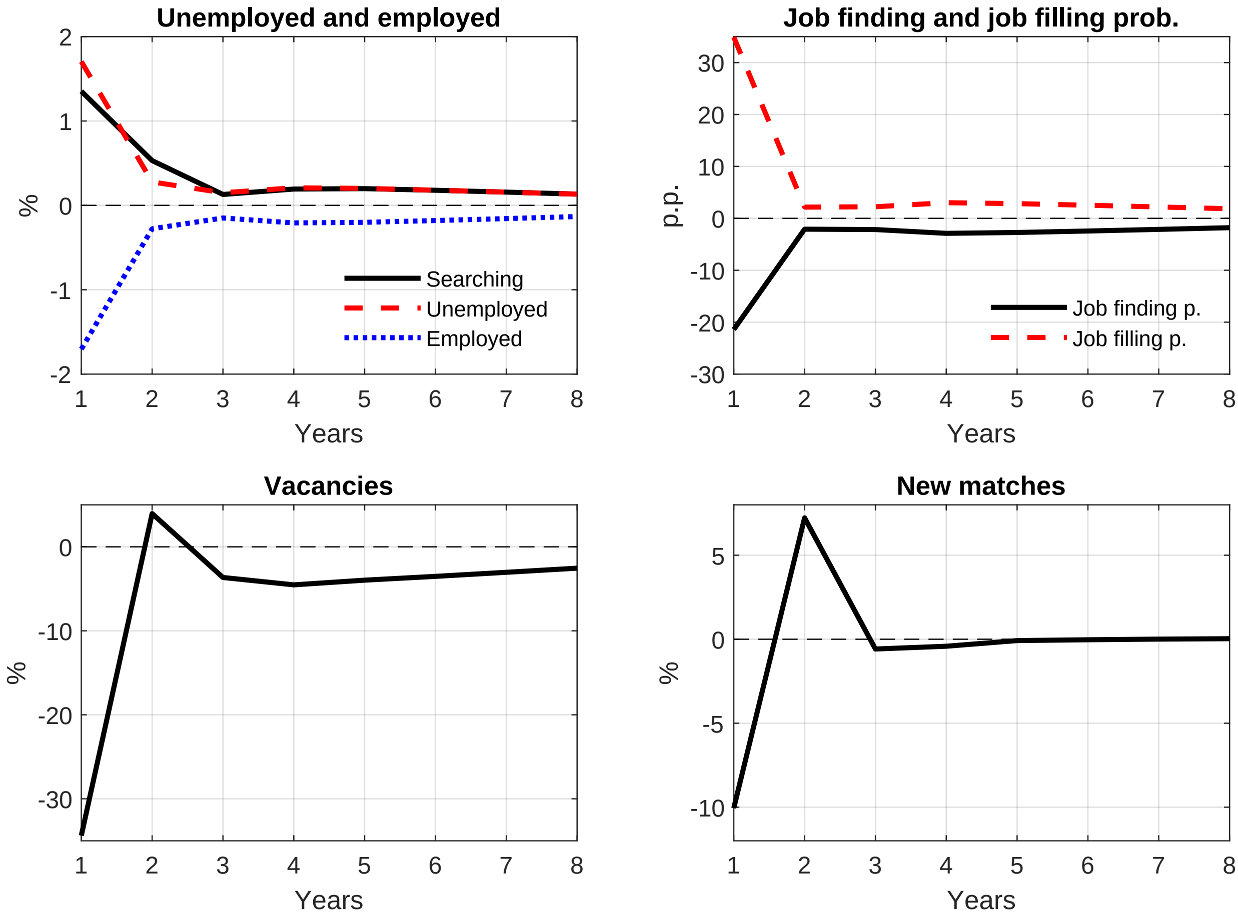
Source: Years. Eurostat, OECD, St. Louis FED (FRED).

Figure 2. Benchmark scenario in Ireland



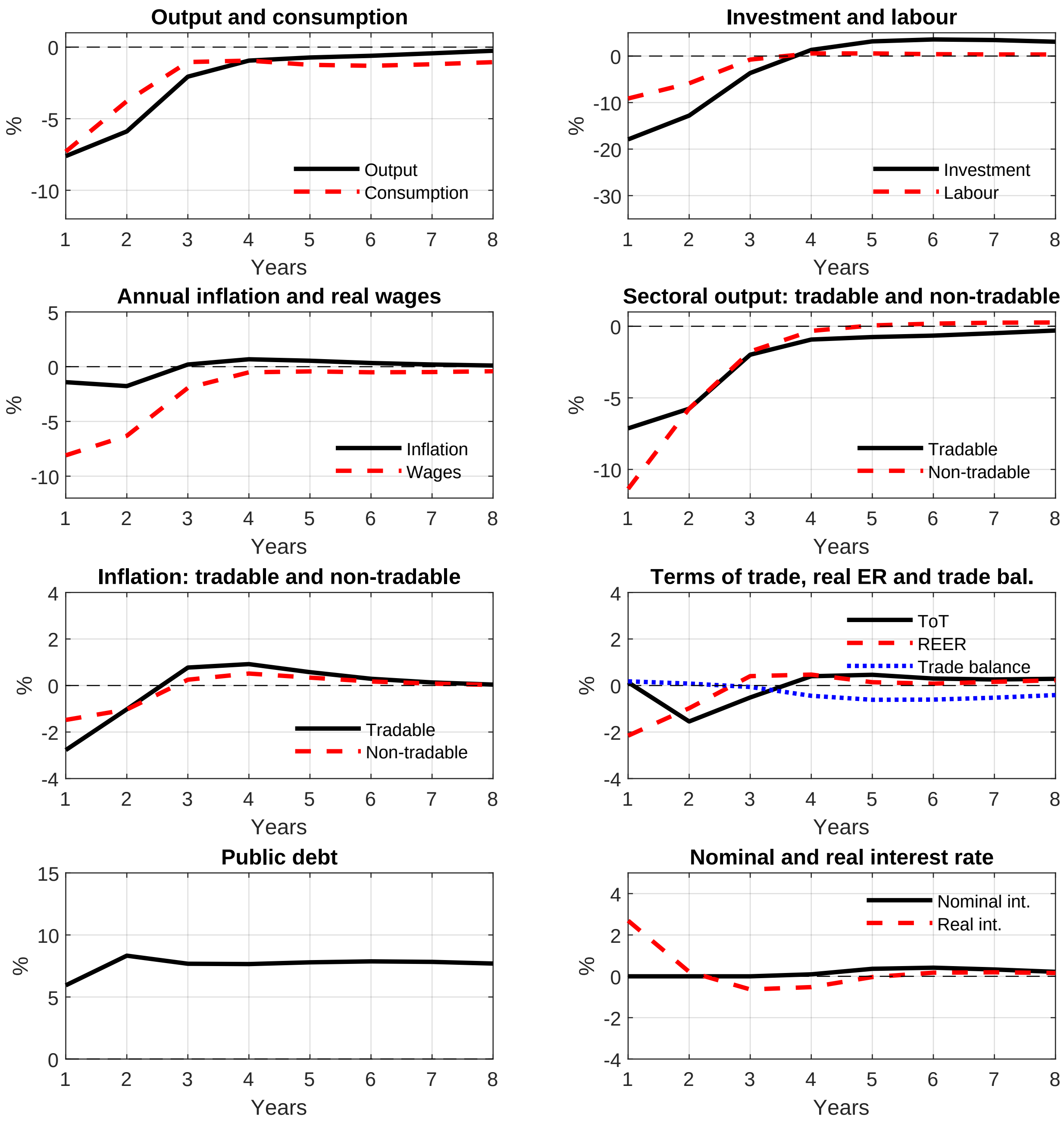
Horizontal axes: Years. Vertical axes: Percent deviations from the initial value, except for inflation and interest rates (annualised percentage point deviations) and the trade balance (trade-balance-to-GDP ratio, in p.p. deviations). GDP and its components are reported in real terms.

Figure 3. Benchmark scenario in Ireland, labour market



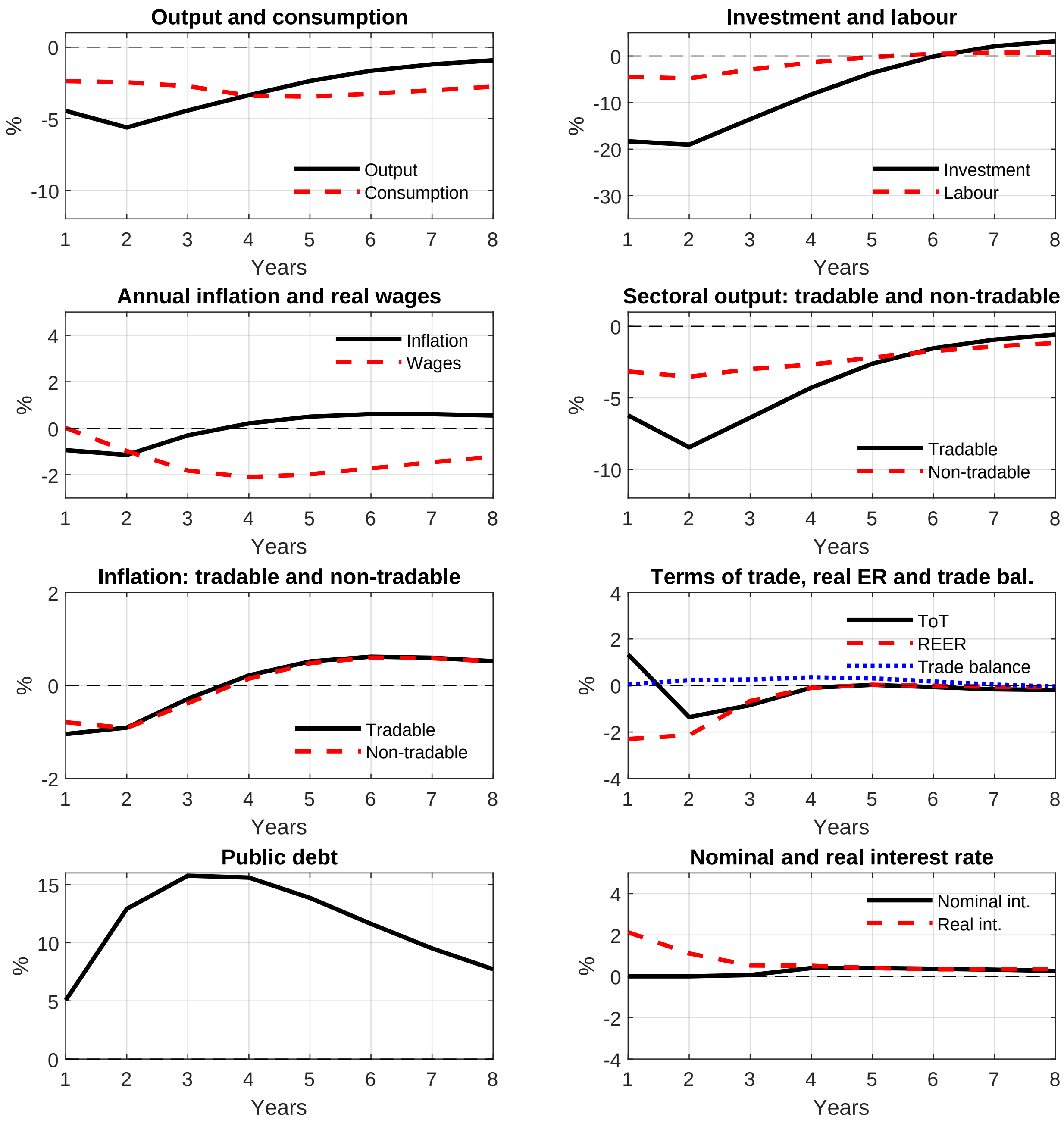
Horizontal axes: Years. Vertical axes: Percent deviations from the initial value, except for probabilities (percentage point deviations).

FIGURE 4. Benchmark scenario in Luxembourg



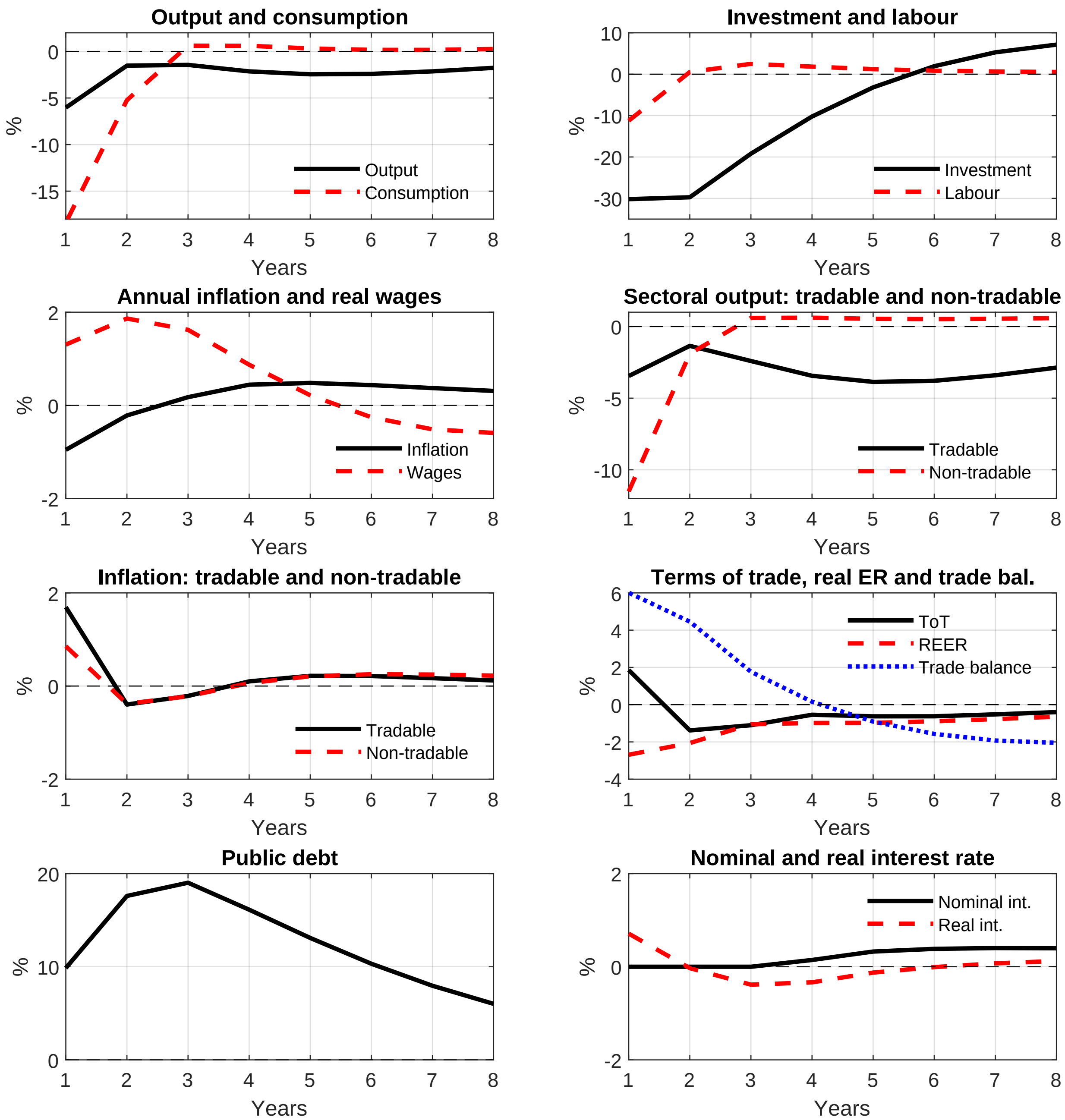
Horizontal axes: Years. Vertical axes: Percent deviations from the initial value, except for inflation and interest rates (annualised percentage point deviations) and the trade balance (trade-balance-to-GDP ratio, in p.p. deviations). GDP and its components are reported in real terms.

FIGURE 5. Benchmark scenario in The Netherlands



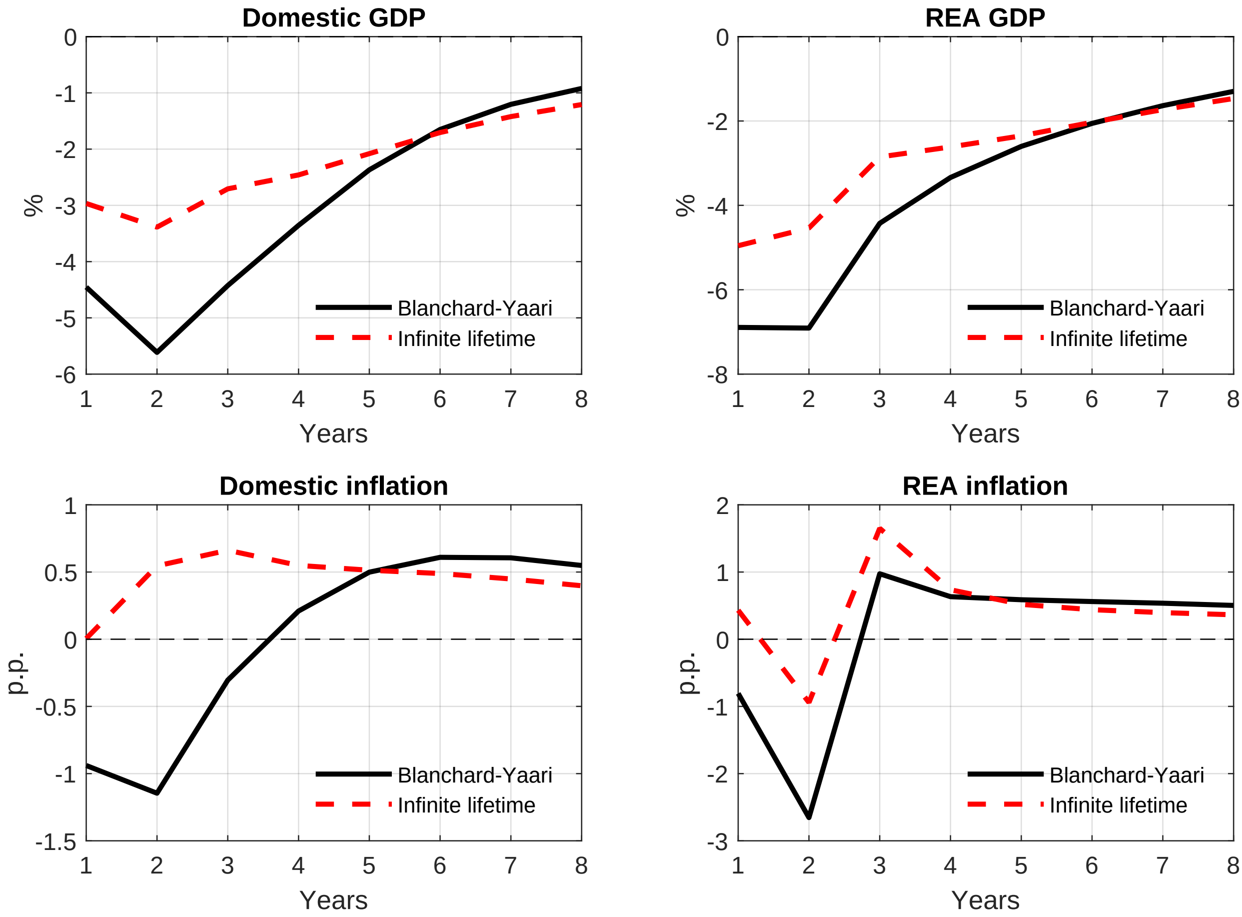
Horizontal axes: Years. Vertical axes: Percent deviations from the initial value, except for inflation and interest rates (annualised percentage point deviations) and the trade balance (trade-balance-to-GDP ratio, in p.p. deviations). GDP and its components are reported in real terms.

FIGURE 6. Benchmark scenario in Slovenia



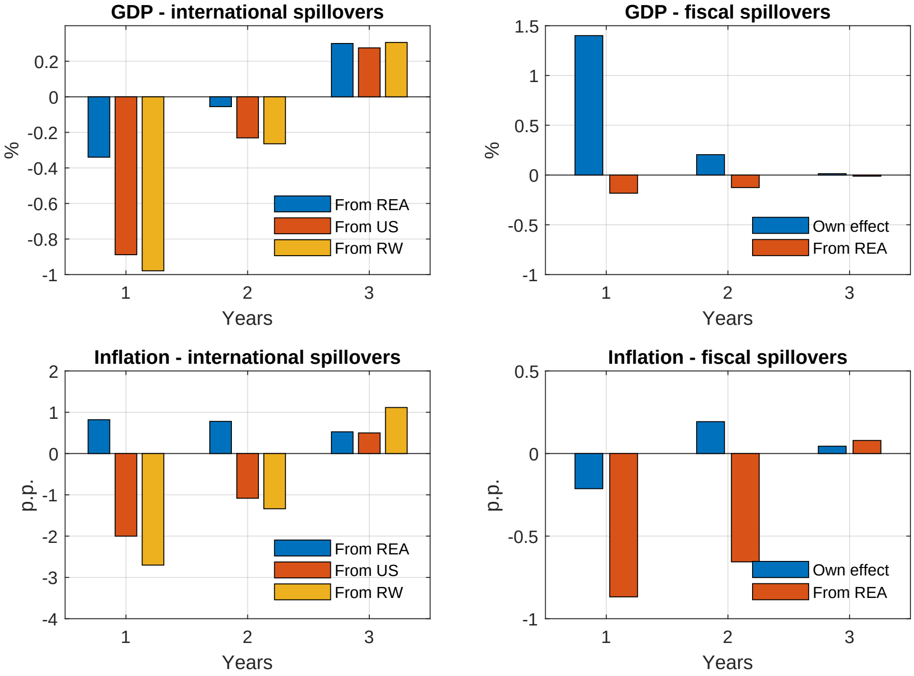
Horizontal axes: Years. Vertical axes: Percent deviations from the initial value, except for inflation and interest rates (annualised percentage point deviations) and the trade balance (trade-balance-to-GDP ratio, in p.p. deviations). GDP and its components are reported in real terms.

Figure 7. Blanchard-Yaari vs. infinite-lifetime utility (NL)



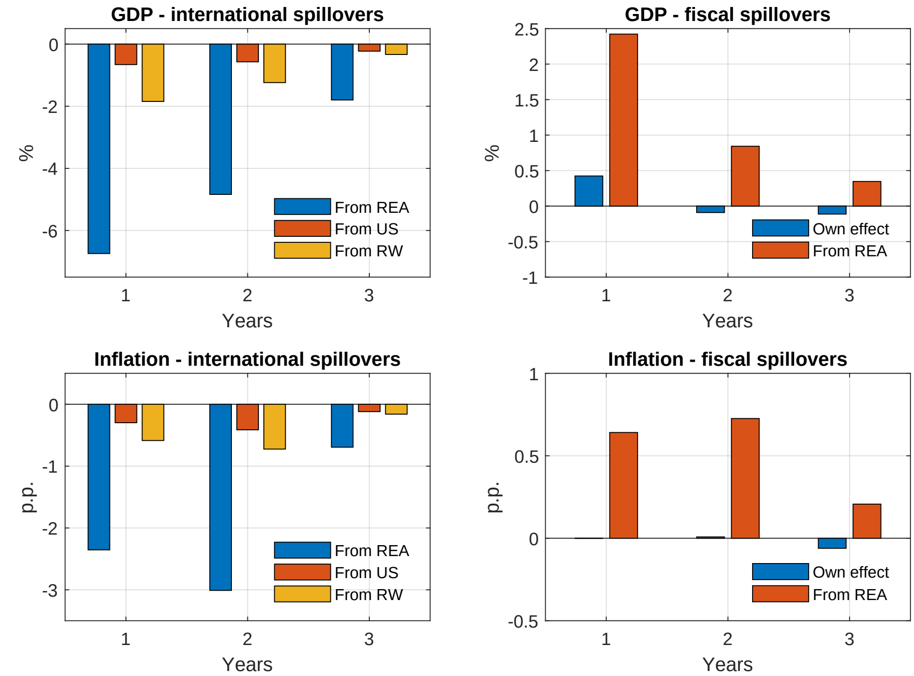
Horizontal axes: Years. Vertical axes: Percent deviations from the initial value, except for inflation (percentage point deviations).

FIGURE 8. Spillovers in Ireland



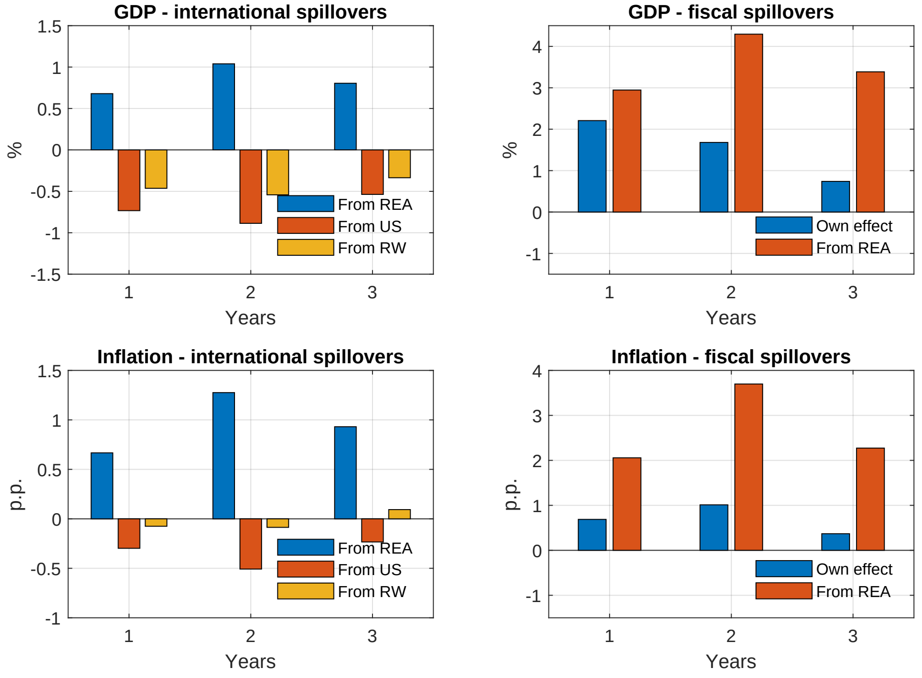
Horizontal axes: Years. Vertical axes: Percent deviations from the initial value, except for inflation (p. p. dev.).

FIGURE 9. Spillovers in Luxembourg



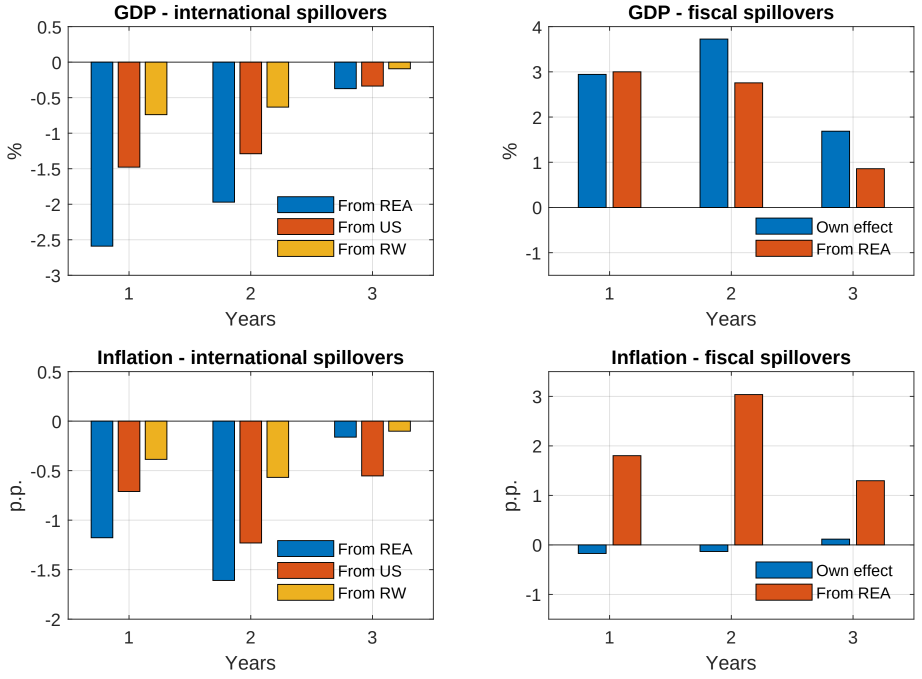
Horizontal axes: Years. Vertical axes: Percent deviations from the initial value, except for inflation (p. p. dev.).

FIGURE 10. Spillovers in The Netherlands



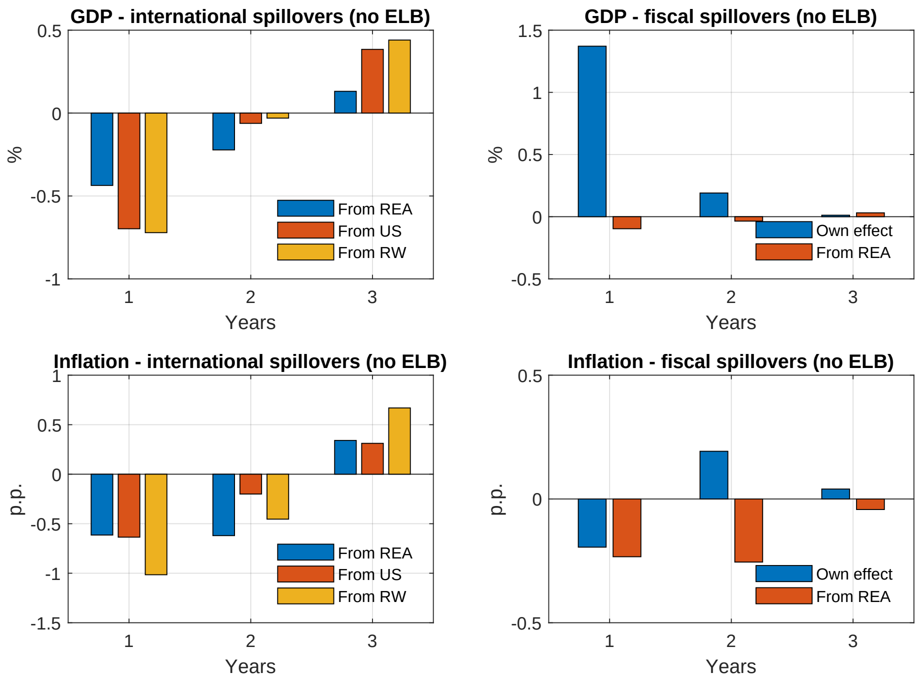
Horizontal axes: Years. Vertical axes: Percent deviations from the initial value, except for inflation (p. p. dev.).

FIGURE 11. Spillovers in Slovenia



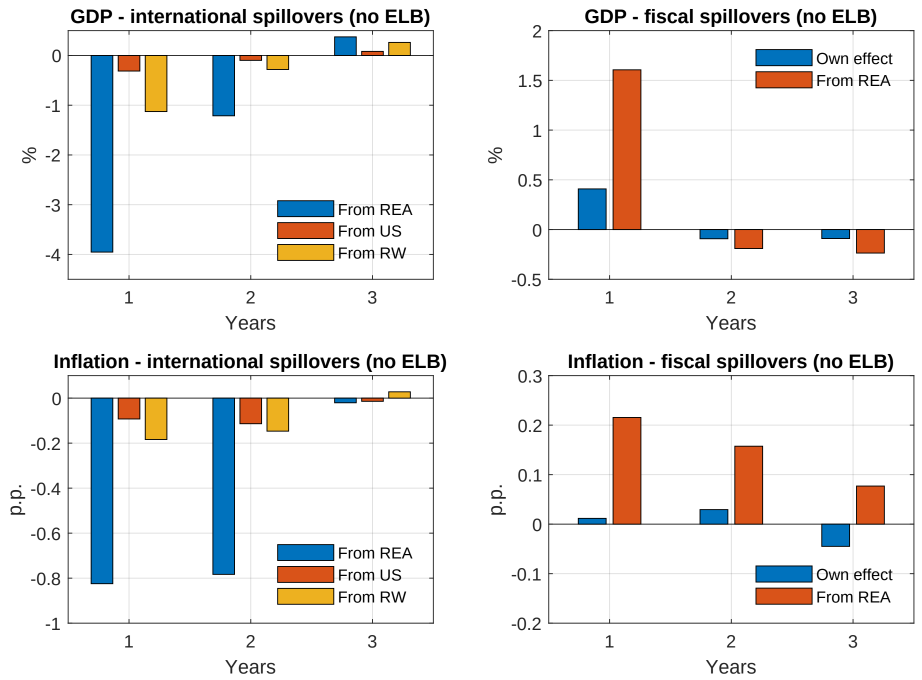
Horizontal axes: Years. Vertical axes: Percent deviations from the initial value, except for inflation (p. p. dev.).

FIGURE 12. No ELB - Spillovers in Ireland



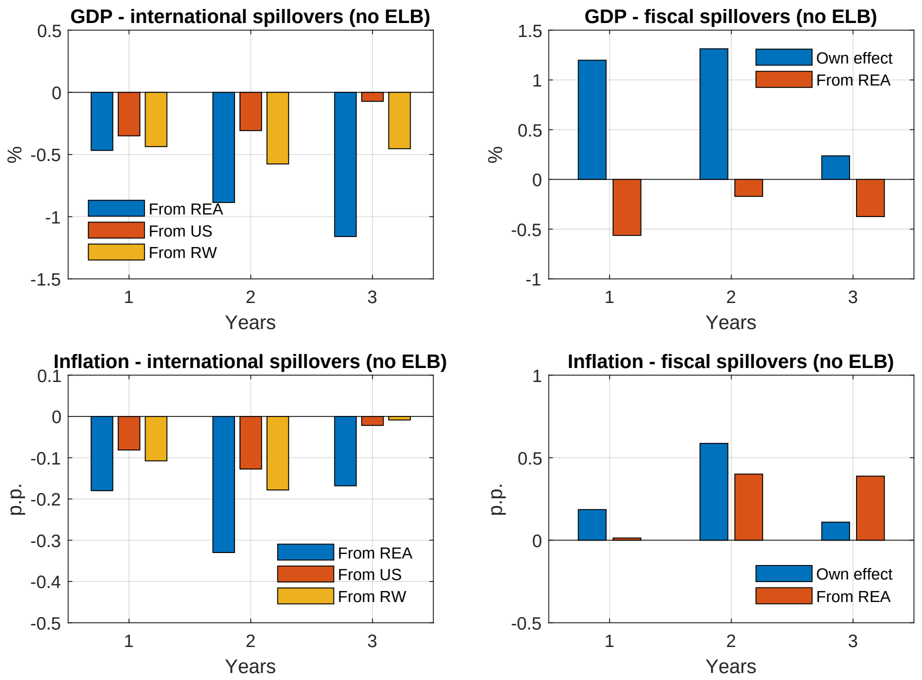
Horizontal axes: Years. Vertical axes: Percent deviations from the initial value, except for inflation (p. p. dev.).

FIGURE 13. No ELB - Spillovers in Luxembourg



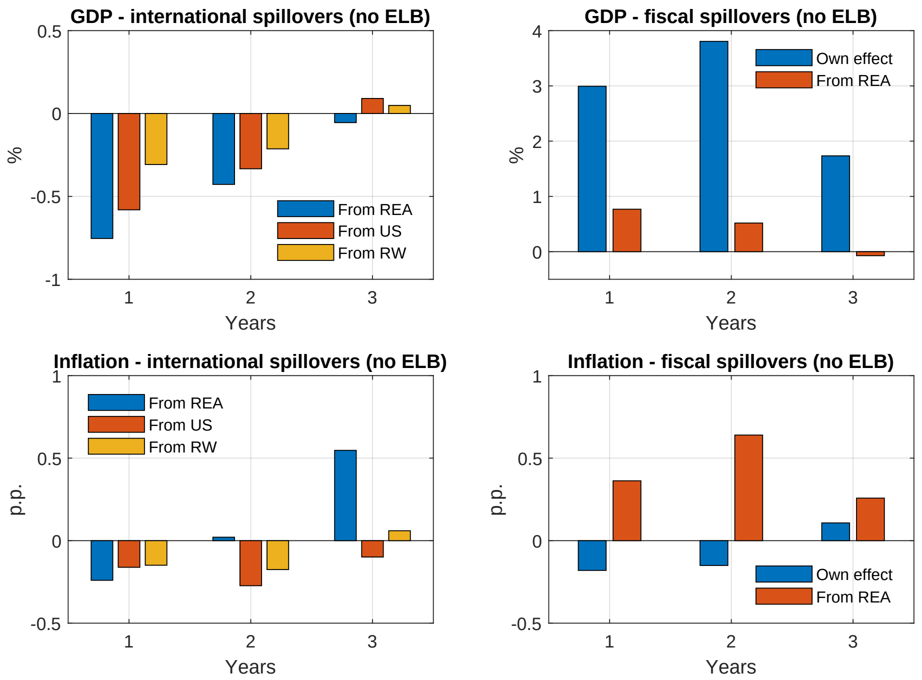
Horizontal axes: Years. Vertical axes: Percent deviations from the initial value, except for inflation (p. p. dev.).

FIGURE 14. No ELB - Spillovers in The Netherlands



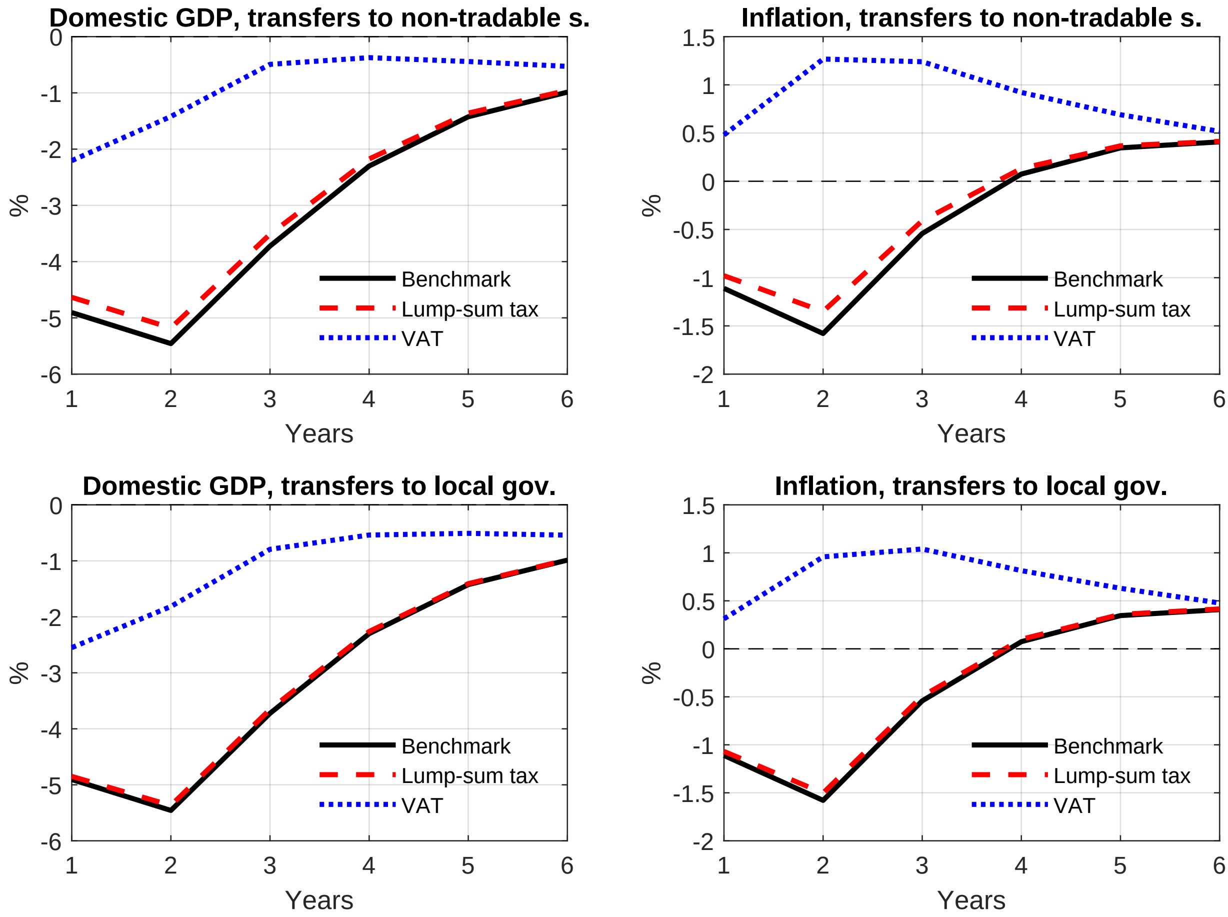
Horizontal axes: Years. Vertical axes: Percent deviations from the initial value, except for inflation (p. p. dev.).

FIGURE 15. No ELB - Spillovers in Slovenia



Horizontal axes: Years. Vertical axes: Percent deviations from the initial value, except for inflation (p. p. dev.).

FIGURE 16. EU transfers



Horizontal axes: Years. Vertical axes: Percent deviations from the initial value, except for inflation (percentage point deviations).

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At the start of the project, Matija Lozej has been at the Central Bank of Ireland, Irish Economic Analysis.

Pablo Garcia
Banque Centrale du Luxembourg, Luxembourg, Luxembourg; email: pablo.garciasanchez@bcl.lu

Pascal Jacquinot
European Central Bank, Frankfurt am Main, Germany; email: pascal.jacquinot@ecb.europa.eu

Crt Lenarcic
Bank of Slovenia, Ljubljana, Slovenia; email: crt.lenarcic@bsi.si

Matija Lozej
European Central Bank, Frankfurt am Main, Germany; email: matija.lozej@ecb.europa.eu

Kostas Mavromatis
De Nederlandsche Bank, Amsterdam, The Netherlands; email: k.mavromatis@dnb.nl

Postal address 60640 Frankfurt am Main, Germany
Telephone +49 69 1344 0
Website www.ecb.europa.eu

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