BANCA D'ITALIA
EUROSISTEMA

Temi di discussione

(Working Papers)

Macroeconomic effects of growth-enhancing measures in the euro area

by Alessandro Cantelmo, Alessandro Notarpietro and Massimiliano Pisani

October 2022

Number 1384

BANCA D'ITALIA
EUROSISTEMA

Temi di discussione

(Working Papers)

Macroeconomic effects of growth-enhancing measures in the euro area

by Alessandro Cantelmo, Alessandro Notarpietro and Massimiliano Pisani

Number 1384 - October 2022

The papers published in the Temi di discussione *series describe preliminary results and are made available to the public to encourage discussion and elicit comments.*

The views expressed in the articles are those of the authors and do not involve the responsibility of the Bank.

Editorial Board: Antonio Di Cesare, Raffaela Giordano, Monica Andini, Marco Bottone, Lorenzo Braccini, Luca Citino, Valerio Della Corte, Lucia Esposito, Danilo Liberati, Salvatore Lo Bello, Alessandro Moro, Tommaso Orlando, Claudia Pacella, Fabio Piersanti, Dario Ruzzi, Marco Savegnago, Stefania Villa.
Editorial Assistants: Alessandra Giammarco, Roberto Marano.

ISSN 1594-7939 (print)
ISSN 2281-3950 (online)

Printed by the Printing and Publishing Division of the Bank of Italy

MACROECONOMIC EFFECTS OF GROWTH-ENHANCING MEASURES IN THE EURO AREA

by Alessandro Cantelmo*, Alessandro Notarpietro* and Massimiliano Pisani*

Abstract

We evaluate the short- and long-term effects of different growth-enhancing policy measures implemented in the euro area by simulating a calibrated New Keynesian model featuring endogenous growth via the private sector's R&D accumulation. We find that higher public investment in infrastructures, pro-competition reforms in the product market, and subsidies to R&D have a positive effect on long-term growth and raise the natural rate of interest. In the short term, these measures can have mildly negative effects on inflation through their positive effect on aggregate supply.

JEL Classification: E30, E52, O30, O42.
Keywords: endogenous growth, R&D spending, new Keynesian model, monetary policy, euro area.
DOI: 10.32057/0.TD.2022.1384

Contents

* Bank of Italy, Directorate General for Economics, Statistics and Research.

1 Introduction[1]

Labor productivity growth has significantly slowed in the euro area (EA) since the global financial crisis. The slowdown is the continuation of a downward trend in productivity growth common to the main industrialized countries that has started in the mid-1990s.[2]

The long-term growth rate of the economy is relevant also for monetary policy, because it affects the natural rate of interest, i.e., the level of the real interest rate that is consistent with the economy growing at its potential rate, and inflation being at the central bank's target. A higher long-run growth rate of the EA economy would contribute to increasing the natural rate, currently estimated to be at historically low levels, and expand the room for monetary policy to stabilize the short-run macroeconomic conditions.[3]

One possible way to enhance productivity growth is the adoption of measures that, directly or indirectly, stimulate investment in research and development (R&D).[4] This is true in particular for the EA, because European R&D expenditure has been persistently lower than in other main advanced economies such as the United States (US) and Japan.[5] Moreover, a long-run productivity slowdown cannot be excluded, if the Covid-19 pandemic shock has long-lasting consequences on economic activity through scarring and hysteresis effects.

In this paper, we evaluate the short- and long-run macroeconomic effects of EA-wide higher public investment in infrastructures, pro-competition

[1]The views expressed in this paper are those of the authors alone and should not be attributed to the Bank of Italy or the Eurosystem. We thank two anonymous referees, Michele Caivano, Paolo Del Giovane, Stefano Neri, and Luigi Federico Signorini for useful comments. All remaining errors are ours.

[2]See European Central Bank (2017).

[3]See Neri and Gerali (2017) on natural rate estimates for the EA.

[4]IMF (2021), using citations of some 38 million US and European patents to scientific articles, estimates that the effect of a 10% permanent increase in the stock of a country's own basic research is to increase productivity by 0.30%. According to estimates by IMF (2018), R&D was the main source of labor productivity growth among advanced economies over the 2004-14 period. Hall et al. (2013) use data on a large panel data sample of Italian manufacturing firms and find that R&D is strongly associated with innovation and productivity.

[5]European Commission (2020) stresses that research and innovation expenditure should have a key role in supporting Europe's recovery from the pandemic crisis. Within the European Next Generation EU, EUR 93.72 billion will fund investment in research and innovation (see European Commission, 2021). Policies aimed at boosting R&D investment are therefore key for enhancing long-term growth prospects in the EA.

structural reforms, and fiscal incentives for private sector's investment in R&D, by simulating a medium-scale New Keynesian model.[6] Different from the canonical New Keynesian model, we endogenize the long-run determinants of growth by allowing for R&D accumulation in the private sector and cross-firms knowledge spillovers, and assess the implications of changes in R&D spending associated with the considered policy measures.[7]

We simulate a permanent increase in public investment spending in infrastructures, a permanent reduction in firms' markup (associated with pro-competition reforms in the product market), and a permanent increase in subsidies to R&D investment.

Our results are as follows. Higher public investment, pro-competition reforms in the product market, and subsidies to R&D have a positive effect on long-run growth and raise the natural rate of interest (defined, consistent with the literature, as the real interest rate in the version of the model without nominal rigidities).[8] In the short run, these measures can have mildly negative effects on inflation through their positive effect on aggregate supply. Our results are robust to changes in the parameters regulating the sensitivity of R&D accumulation to public investment and degree of market competition, and to alternative assumptions on the timing of the policy measures.

Our paper contributes to the literature on the macroeconomic effects of R&D spending. Our R&D setup builds on Bianchi et al. (2019), which construct and estimate with US data an endogenous growth model with debt and equity financing frictions, to study the relation between business cycle fluctuations and long-term growth. The presence of spillover effects from R&D implies an endogenous relation between productivity growth and the state of the economy. Different from them, we calibrate our model to the EA economy. Schmoller and Spitzer (2020) analyze the endogeneity of EA total factor productivity (TFP) and its role in business cycle amplification by estimating with EA data a medium-scale dynamic stochastic general equi-

[6]We do not consider the case of public investment in R&D.

[7]The model is well-suited for the analysis of fiscal policy and other growth-friendly measures such as those contained in the European Next Generation EU, which, however, we do not explicitly consider here.

[8]Thus, the considered measure add space for monetary policy, which in the neighborhood of the new steady state can respond to possible disinflationary shocks by reducing the policy rate without hitting the effective lower bound (or hitting it with a lower probability). We do not run this type of analysis.

librium model where TFP evolves endogenously as a consequence of costly investment in R&D and adoption of new technologies. They find that the endogeneity of TFP induces a high degree of persistence in EA business cycle via a feedback mechanism between overall economic conditions and investment in productivity-enhancing technologies. Different from both Bianchi et al. (2019) and Schmoller and Spitzer (2020), we focus on the short- and long-run macroeconomic impact of specific policy measures. Jorda et al. (2020) using data for a wide panel of countries provide empirical evidence of persistent effects of monetary policy on the productive capacity of the economy, and show that a small open economy New Keynesian model with endogenous TFP growth (due to hysteresis effects) can reconcile such empirical findings. Different from them, we endogenize TFP growth via R&D accumulation and calibrate a closed-economy model to the EA. Canova and Pappa (2021) estimate that an increase in the European Regional Development Fund equal to 1% of regional gross value added makes the latter jump, on average and cumulatively over three years, by 1%, while a similar increase in the European Social Fund leads to a 5% cumulative increase in gross value added.[9] They interpret such results using a New Keynesian model with endogenous growth via R&D accumulation and human capital. We consider different fiscal measures, including subsidies to R&D, and focus on R&D accumulation as a source of growth in our model. Cova et al. (2021) evaluate the global macroeconomic effects of fiscal and monetary policy measures aimed at counterbalancing secular stagnation, by simulating a five-region New Keynesian model of the world economy. Their model includes investment in R&D as a factor that affects global growth. They find that a cross-country simultaneous increase in public investment and an accommodative monetary policy enhance global growth. Different from them, we focus on the alternative measures implemented in the EA economy.

The paper is organized as follows. The next section describes the model setup and calibration. Section 3 reports the results. Section 4 concludes.

[9]The European Regional Development Fund aim is to foster innovation and research, to favor the digital agenda, and to support small and medium-sized enterprises. The European Social Fund aim is to support investments in education and health and to fight poverty.

2 Model

We develop a medium-scale New Keynesian model featuring endogenous growth and calibrate it to the EA. Different from the standard New-Keynesian setup, we allow for R&D accumulation, which permanently affects labor productivity and, thus, long-run economic growth.

In this section, we first provide an overview of the model setup, then report the key equations, i.e., those related to investment in R&D and to central bank and fiscal authority decisions. Finally, we illustrate the calibration of the model.

2.1 Overview

The economy is populated by households, firms producing final and intermediate goods, a central bank, and a fiscal authority.

Households consume final goods and supply labor under monopolistic competition to firms. Each household is a nominal wage setter, as she sets the nominal wage taking into account labor demand by firms and subject to quadratic nominal wage adjustment costs.[10] Households invest in physical capital, bonds, and – crucially – R&D. They rent, under perfect competition, physical capital and R&D to firms in the intermediate sector.

On the production side, there is a continuum of firms that under perfect competition produce final goods used for private consumption, government consumption, private investment in physical capital, public investment in infrastructures, and private investment in R&D. Moreover, there is a continuum of firms producing intermediate goods – which enter the final goods bundle – under monopolistic competition using labor, private physical capital, and public capital stocks as inputs. The labor input is affected by a technological trend, which positively depends on the accumulated stock of R&D. Each firm is a price-setter, as it sets the price of its intermediate good taking into account demand conditions and subject to quadratic price adjustment costs.[11] Firms' profits from monopolistic competition are rebated

[10] See Rotemberg (1982). Wages are also indexed to the previous-period consumer price inflation rate and to the inflation target of the central bank, with corresponding weights summing to one.

[11] See Rotemberg (1982). The same indexation scheme assumed for wages applies to prices.

in a lump-sum way to households.

The central bank sets the monetary policy rate according to a Taylor rule, where the interest rate reacts to its previous value (to capture inertia in the monetary policy conduct), current inflation rate, and quarterly output growth.

The fiscal authority issues bonds and levies lump-sum taxes on households to finance public consumption, public investment in infrastructures, and subsidies to R&D accumulation.

2.2 Production function

Each firm j in the intermediate goods sector produces in period t output $Y_{j,t}$ according to the following production function

$$Y_{j,t} = (Z_{j,t} L_{j,t})^{1-\alpha-\gamma} K_{j,t-1}^{\alpha} K_{G,t-1}^{\gamma}, \tag{1}$$

where $Z_{j,t}$ represents labor-augmenting technology, $L_{j,t}$ is the labor input (hours worked), $K_{j,t-1}$ is the beginning-of-period-t private physical capital stock, α $(0 < \alpha < 1)$ is the output elasticity with respect to private capital, $K_{G,t-1}$ is beginning-of-period-t public capital stock in infrastructures, γ is the output elasticity with respect to public capital $(0 < \gamma < 1,\ \alpha + \gamma < 1)$. The public capital stock is taken as given by firms. Its accumulation is exogenously chosen by the government and financed via taxes and/or public debt.

2.3 R&D accumulation, long-run growth rate, and steady-state natural rate of interest

The labor-augmenting technology $Z_{j,t}$ depends on the stock of R&D demanded by the individual firm j $(R\&D_{j,t})$ and the economy-wide overall stock $(R\&D_t)$:

$$Z_{j,t} = (R\&D_{j,t})^{\eta} (R\&D_t)^{1-\eta}, \tag{2}$$

where $(1-\eta)$, with $0 < \eta < 1$, measures cross-firm knowledge spillovers associated with R&D (the smaller the parameter η, the larger the spillovers). The stock of R&D is accumulated by households according to the following equation:

$$R\&D_{j,t} = (1-\delta_{R\&D})\, R\&D_{j,t-1} + \kappa_{R\&D}\left(1-\frac{\psi_{R\&D}}{2}\left(\frac{I_{R\&D,j,t}}{I_{R\&D,j,t-1}}-gr_t\right)^2\right)\kappa_{i_G}\left(\frac{i_{G,t}}{\bar{i}_G}\right)^{\alpha_{i_G}}\kappa_\theta\left(\frac{\theta_t}{\bar{\theta}}\right)^{\alpha_\theta} I_{R\&D,j,t}, \tag{3}$$

where the parameter $\delta_{R\&D}$ $(0 < \delta_{R\&D} < 1)$ measures the depreciation rate of the R&D stock, the parameter $\psi_{R\&D} > 0$ is the R&D investment adjustment cost, and $I_{R\&D,j,t}$ is investment in R&D.

The parameter $\kappa_{R\&D}$ measures the exogenous component of R&D investment efficiency. If it is lower than 1, only a fraction of the investment accumulates into the R&D stock.

We allow efficiency of R&D investment to also have two endogenous components, which aim at capturing the complementarity between R&D accumulation and public investment in infrastructures, on the one hand, and between R&D and market competition on the other hand.

The first term is $\kappa_{i_G}\left(\frac{i_{G,t}}{\bar{i}_G}\right)^{\alpha_{i_G}}$ $(\kappa_{i_G}, \alpha_{i_G} > 0$ are parameters), which captures the dependence of the return on R&D investment on deviations of the public investment-to-GDP ratio $(i_{G,t})$ from its initial steady-state level $\bar{i}_G$. As public investment increases above its initial steady-state level, the stock of public capital increases too, which implies positive spillovers on private sector R&D efficiency. Indirect evidence on this relation is reported by Aschauer (1989a), which shows that a "core" infrastructure of, among the others, streets, highways, and airports has a significant impact on productivity, and Aschauer (1989b), which documents a positive effect of public spending for infrastructures on labor productivity growth.

In a similar way, the term $\kappa_\theta\left(\frac{\theta_t}{\bar{\theta}}\right)^{\alpha_\theta}$ $(\kappa_\theta, \alpha_\theta > 0$ are parameters), captures the effect on the return on R&D investment of variations in the parameter θ_t relative to its initial steady-state level $\bar{\theta}$. Since θ_t denotes the degree of substitutability among different varieties of intermediate goods, an increase in its value reflects a more competitive goods market and a correspondingly lower markup. As a result of more competition in the goods market, R&D investment becomes more efficient. The latter effect can be rationalized based on the evidence of Aghion et al. (2005). When competition is relatively low, a large fraction of firms tends to engage in R&D

investment to escape competition of "neck-and-neck" incumbent firms that operate at similar technologies. This is likely to be the case in an environment in which competition is relatively low, or in which there is space for reforms aimed at reducing firms' market power, as in the case of the EA.[12] Relatedly, Bloom et al. (2013) using panel data for the US show that positive knowledge spillovers due to R&D quantitatively outweigh the negative effect of R&D on a firm's value due to product market rivalry. More generally, as noted by Bloom et al. (2019), while the net impact of competition on innovation remains an open empirical question, existing empirical evidence suggests that competition typically increases innovation, especially in markets that initially have low levels of competition.

In our simulations we will consider a symmetric equilibrium, i.e., an equilibrium featuring a representative household and a representative firm in each sector. The (gross) growth rate of the aggregate labor-augmenting technology Z_t is defined as:

$$gr_t = \frac{Z_t}{Z_{t-1}}, \tag{4}$$

where Z_t is aggregate labor-augmenting technology in a symmetric equilibrium, i.e., an equilibrium featuring a representative household and a representative firm for each sector.

Different from the standard New Keynesian model, the long-run steady-state value of gr_t permanently changes if the model is perturbed by a permanent shock. Thus, also the steady-state value of the policy rate permanently changes, because, according the household's Euler equation, the steady-state relation between the policy rate and the technology growth rate is

$$\overline{R}_t = \frac{\overline{gr}_t \overline{\pi}}{\beta}, \tag{5}$$

where $\overline{R}_t$ is the gross interest rate, $\overline{gr}_t$ the growth rate, $\overline{\pi}$ the central bank gross inflation rate target, and β $(0 < \beta < 1)$ a parameter measuring the household's deterministic discount rate. Throughout all simulated scenarios we assume that the central bank inflation target is kept constant. Note that in steady state the real interest rate corresponds to the natural rate of

[12] See also IMF (2019).

interest

$$\overline{R}_t^* = \frac{\overline{gr}_t}{\beta}, \tag{6}$$

because we consider steady-state equilibria with flexible nominal wages and prices.

2.4 Monetary policy

The central bank sets the policy rate R_t according to the monetary policy rule:

$$\frac{R_t}{\overline{R}_t} = \left(\frac{R_{t-1}}{\overline{R}_t}\right)^{\rho_r} \left(\frac{\pi_t}{\overline{\pi}}\right)^{(1-\rho_r)\rho_\pi} \left(\frac{y_t}{y_{t-1}}\right)^{(1-\rho_r)\rho_y}. \tag{7}$$

The parameters $0 \leq \rho_r \leq 1$, $\rho_\pi > 0$, ρ_y measure the sensitivity of the (gross) policy rate to its lagged value (in deviations from the steady-state interest rate), to the (quarterly) gross inflation rate (in deviation from the constant target $\overline{\pi}$), and to the quarterly gross growth rate of the cyclical (i.e., trend-less) component of output y_t, respectively.[13] Thus, in our simulations the monetary policy stance will be affected also by changes in the steady-state nominal interest rate $\overline{R}_t$ associated with changes in the economy growth rate gr_t (see Eq. 5). In some simulations, we allow for forward guidance (FG), i.e., we assume that the central bank adopts an accommodative stance by credibly announcing its commitment to keeping the policy rate at a low level for a specified number of periods and, thereafter, it resumes to follow the Taylor rule. FG is interesting as it shows how a change in the monetary policy stance affects aggregate demand in the short-term.[14]

2.5 Fiscal policy

The government budget constraint is

$$B_{G,t} - B_{G,t-1}R_{t-1} = I_{G,t} + G_t + (1 + \tau_{R\&D,t})R_t^{R\&D} R\&D_t - TAX_t - T_t, \tag{8}$$

where $B_{G,t}$ is a one-period nominal bond that pays the (gross) monetary policy interest rate R_t ($B_{G,t} > 0$ is public debt). The variable $I_{G,t}$ is public

[13]The lagged interest rate ensures that the policy rate is adjusted smoothly and captures the idea that the central bank prefers to avoid large changes in its policy instrument.

[14]We do not consider here the possible presence of an effective lower bound that limits the room for manoeuvre of the central bank, nor the use of unconventional measures other than FG.

investment in infrastructure, G_t represents government purchases of goods and services, $\tau_{R\&D,t} > 0$ is the subsidy rate to the return rate $R_t^{R\&D}$ on R&D stock, and $TAX_t > 0$ are lump-sum taxes paid by households. T_t are total government revenues from distortionary taxation:

$$T_t \equiv \tau_{w,t} W_t L_t + \tau_{k,t} R_t^k K_{t-1} + \tau_{c,t} P_t C_t, \tag{9}$$

where $\tau_{w,t}$, $\tau_{k,t}$, and $\tau_{c,t}$ are tax rates on labor income, capital income, and consumption, respectively ($0 \leq \tau_{w,t}, \tau_{k,t}, \tau_{c,t} \leq 1$). The accumulation law of public capital K_G is

$$K_{G,t} = (1 - \delta_{K_G}) K_{G,t-1} + I_{G,t}, \tag{10}$$

where $0 < \delta_{K_G} < 1$ is a parameter measuring the depreciation rate of public capital, while $I_{G,t}$ is exogenously set.

The fiscal authority follows a fiscal rule defined on lump-sum taxes as a percentage to output, tax, to bring the public debt as a percentage of domestic output, $b_G > 0$, in line with its long-run (steady-state) target $\bar{b}_G$. The rule is

$$\frac{tax_t}{tax_{t-1}} = \left(\frac{b_{G,t}}{\bar{b}_G}\right)^{\phi_1} \left(\frac{b_{G,t}}{\bar{b}_{G,t-1}}\right)^{\phi_2}, \tag{11}$$

where the parameters $\phi_1, \phi_2 > 0$ call for an increase (reduction) in lump-sum taxes whenever the current-period public debt (as a ratio to GDP) is above (below) the target and/or there is a positive (negative) change in the debt-to-GDP ratio. We choose lump-sum taxes to stabilize public finances as they are non-distortionary and, thus, allow for a clean evaluation of the transmission of the shocks. The public debt-to-output target does not change and, in particular, the public debt-to-output level is the same in the initial and final steady-state equilibria.

2.6 Calibration

The model is calibrated to the EA economy at quarterly frequency. Table 1 reports the matched great ratios (private consumption, public consumption, private investment in physical capital, public investment, private investment in R&D, public debt, all as a percentage of GDP) in the initial steady-state equilibrium (in the steady state, wages and prices are flexible and the adjustment costs on investment in physical capital and R&D are zero). Long-run inflation is set to the EA central bank target (2% in net annual terms). The steady-state growth rate is set to a relatively low value, 0.9%, in line with empirical evidence. The implied nominal policy rate is 2.9%.

Table 2 contains the calibration of the parameters, chosen in line with the literature and to match quantities reported in Table 1.

The discount factor is set to 0.99998, in order to obtain the desired level of the natural rate, given the inflation target and the long-run technology growth rate. The intertemporal elasticity of substitution is set to one (equivalent to log-utility), consistent with the requirements for a balanced growth path. Both the consumption habit persistence parameter and the Frisch elasticity of labor supply are set to 0.75.

The elasticities of output with respect to private and public physical capital in the Cobb-Douglas production function are set to 0.31 and 0.08, respectively, to match the private and public investment-to-GDP ratios. Specifically, the elasticity of output to public capital is in line with the literature (see Elekdag and Muir, 2014 and Vetlov et al., 2017) and with ample empirical evidence provided by Bom and Ligthart (2014).

The R&D spillover parameter, η, is set to 0.04, to match the R&D investment-to-GDP ratio.[15] The depreciation rates for private and public physical and for R&D are set to 0.025 and 0.003, respectively. Investment adjustment costs in physical capital are set to 2. Such value implies a response of investment to a standard monetary policy shock in line with evidence for the EA. The same value holds for the adjustment cost of R&D investment. Concerning parameters regulating the sensitivity of R&D investment to public investment in infrastructures and market power, under the chosen calibration, an increase in public investment or, alternatively, pro-competition reforms has a medium-term effect on the *level* of the main macroeconomic variables that is in line, for shocks of similar size, with those reported in existing studies that use a similar model without endogenous growth.[16] In Section 3.6.1 we run a sensitivity analysis by changing the

[15] Bianchi et al. (2019) report an estimate of around 0.28 for the same parameter, using data for the US. The R&D investment-to-GDP ratio is close to 3% in the US, as opposed to 2% in our calibration, based on euro-area data.

[16] We have benchmarked, in particular, Burlon et al. (2017) and Busetti et al. (2019) for the effects on the level of the main macroeconomic variables of an increase in public investment in Italy, and Ciapanna et al. (2020) for the corresponding effects of pro-competition

values of these parameters, which are characterized by some degree of uncertainty.

Nominal price and wage rigidities parameters are set to 300 and 400, respectively, whereas indexation to the previous-period consumer price inflation rate is set to 0.5 for both prices and wages. Such values correspond to a probability of not adjusting prices and wages of 0.88 and 0.85, respectively, in terms of Calvo (1983), in line with existing evidence for the EA (see e.g. Coenen et al., 2018).

In the monetary policy rule, the interest rate smoothing parameter is set to 0.87, the response to inflation to 1.9 and the response to output growth to 0.15. Similar values are reported in Coenen et al. (2018).

In the fiscal rule, the parameters measuring the sensitivity of lump-sum taxes to changes in public debt, ϕ_1 and ϕ_2, are set to 2.01 and 10.01, respectively. The subsidy rate to R&D is set to zero. Finally, the consumption, labor, and private physical capital tax rates are set to 0.2, 0.4 and 0.3, respectively.

Table 3 reports the gross markups in the goods and labor markets, and the corresponding elasticities of substitution among goods and labor services varieties. Such values characterize the initial steady state of the economy.

3 Results

We study the following scenarios. We initially simulate an increase in public investment spending equal to 1% of the EA (initial) steady-state GDP level. Thereafter, we consider a 1 percentage point (pp) exogenous permanent reduction in firms' markup, associated with pro-competition reforms in the goods' market. Then we study the effects of a permanent increase in subsidies to firms' R&D. Finally, we simulate a mix of these three policy measures. The analysis is conducted under alternative assumptions on the central bank's FG on the policy rate. In the cases of higher public investment, higher subsidies, and policy mix, it is assumed that the fiscal rule is not active in the first three years and it is subsequently activated. The fiscal rule is instead always active in the case of pro-competition reform. All scenarios are run under perfect foresight. Thus, once each policy measure

reforms implemented in the Italian economy over the last decade.

is announced in the first period of simulation, there is no uncertainty and agents fully anticipate the future evolution of all variables in the economy. At the end of the section, we report results of a sensitivity analysis. First, we change the value of the parameters that regulate the dependence of R&D accumulation on public investment and the degree of market competition, as captured by Eq. (3). Second, we investigate how the main results change when we assume that the policy measures are credibly announced, but implemented with delay.

3.1 Permanent increase in public investment

We simulate a permanent increase in public investment equal to 1% of (pre-shock) GDP. We consider three alternative scenarios: in the first one, public investment is immediately increased in the first period of simulation; in the second, the fiscal stimulus is gradually implemented over a one-year horizon; in the third, the gradual implementation of the fiscal stimulus is accompanied by an accommodative monetary policy stance, in the form of FG. As we show in the following, the speed of implementation of the fiscal measure is crucial for the determination of the response of the main macroeconomic variables, since it affects the anticipation effect that characterizes forward-looking households and firms. The case of FG is interesting as it shows how a change in the monetary policy stance affects aggregate demand in the short-term. Importantly, the long-run effects of the fiscal measure are the same in the three alternative scenarios.

Figure 1 reports the responses of the main variables. When the increase in public investment is immediately and fully implemented (red-dashed lines), it stimulates both aggregate demand and aggregate supply. The higher public capital stock makes labor, private physical capital, and the R&D stock more productive, inducing firms to increase their demand for the corresponding production factors in the medium term, in order to expand production and meet the increase in demand. The consumption growth rate gradually increases to its new long-run level, given the assumption of consumption habit. The growth rate of private investment in physical capital is initially negative, because households finance the increase in public investment and smooth consumption. The investment growth rate shows positive values in the medium term. Investment in R&D initially mildly falls, and starts showing positive values in the medium term, when its return has sufficiently increased. Inflation only mildly increases, as the higher aggregate demand is matched by the expansion in aggregate supply. The policy rate increases, consistent with the slightly higher inflation rate, and gradually converges towards its new level.

When the increase in public investment is gradually implemented over a one-year horizon (black solid lines), the overall effects on economic activity are recessionary in the short term. As the increase in the public capital stock is gradual, the corresponding positive spillover effects of public capital accumulation on private capital, R&D, and labor productivity only materialize in the medium-to-long term. Thus, investments in physical capital and in R&D initially fall, because firms anticipate that the returns will be higher in the future, once the public capital stock has increased. Consumption also initially falls. As a result of a more muted and slower expansion in aggregate demand, inflation falls. The monetary policy rate correspondingly increases more slowly than in the case of a sudden increase in public investment.

Finally, in order to highlight the role of the monetary policy stance, we consider the case of a gradual increase in public investment accompanied by a three-quarter FG, in which the central bank credibly announces that it will keep the policy rate fixed at its initial steady-state level in the first three quarters (blue lines with circle).[17] Thereafter, the profile of the policy rate is dictated by the Taylor rule (Eq. 7).

Relative to the case of a gradual increase in public investment accompanied with standard monetary policy, the more accommodative monetary policy stance limits the initial drop in consumption, investment in private physical capital and, thus, output. R&D investment widely decreases initially, by virtually the same amount as under standard monetary policy. The short-run output stabilization comes at the cost of a relative increase in consumer price inflation. Once the Taylor rule starts operating, in the fourth quarter, the evolution of macroeconomic variables tends to overlap with the one observed without FG, and the two perfectly overlap in the long run.[18]

[17]We keep the duration of FG deliberately short, in order to avoid the so-called "FG puzzle".

[18]A sudden increase in public investment coupled with a three-quarter FG (not reported) favors an immediate expansion in aggregate demand and inflation, larger than in the case of standard monetary policy.

Table 4 reports the long-run results. Conditionally to the increase in public investment, the new growth rate of the economy is equal to 1.2% in annual terms (0.9% in the initial steady state). The policy rate consistent with the new higher long-run growth rate of the economy is equal to 3.2%, 0.3 percentage points higher than in the initial steady state. The (real) natural rate, which is equal to the nominal interest rate net of the inflation rate, correspondingly increases to 1.2%.[19]

3.2 Permanent firms' markup decrease

We assess the macroeconomic effects of a pro-competition reform that permanently reduces firms' markup in the intermediate goods sector by 1 percentage point, from 1.20 to 1.19, over a one-year period. As in the case of an increase in public investment, comparing a one-year implementation to a reform suddenly implemented helps clarify the role of the speed of implementation of the considered measure in determining the short-term response of the main macroeconomic variables. The shock is implemented by increasing the parameter measuring the elasticity of substitution among brands, θ, from 6 (corresponding to a net mark-up of 20% in the initial steady-state, see Table 3) to 6.264 (corresponding to a net mark-up of 19% in the final steady-state).

Figure 2 reports the responses of the main macroeconomic variables (black-solid lines).[20] The markup reduction has, *ceteris paribus*, a negative effect on prices and, thus, inflation. The latter decreases in a hump-shaped way, because of partial indexation of prices to previous inflation. After the initial decrease, inflation gradually returns to its long-run level (which coincides with the central bank target, assumed to be constant at 2% in annualized terms).

The lower price level makes goods cheaper and increases real wages and the return on physical capital. Thus, households increase consumption and investment in physical capital favoring higher production and economic

[19]Reported results rest on the assumption that the public investment programme is implemented efficiently. A similar assumption holds for subsidies to R&D investment (see below). We leave the analysis of the consequences of possible delays and inefficiencies in the implementation of such measures for future research.

[20]The short-run markup, which is affected by nominal rigidities, decreases in a more or less gradual way, depending on the scenario, towards its new steady-state level. We do not report its response to save on space.

growth. The growth rate of R&D investment initially decreases because firms substitute labor and physical capital for the R&D stock in the production process, since output has a larger elasticity with respect to the former two inputs. After one year, the R&D investment growth shows values above its initial steady state.

The monetary policy rate stays roughly constant at its initial level in the short run, as dictated by the Taylor rule (Eq. 7), as a result of two opposite forces, i.e., the lower inflation and the new higher steady-state level of the nominal rate, $\bar{R}_t$.

To highlight the role of the timing of the reform, Figure 2 also shows the case of the reform being suddenly and entirely implemented in the first quarter of simulation (red-dashed lines). Compared to the case of gradual implementation, there is a larger initial increase in growth rates, which substantially overshoot their new long-run values. The impact response of R&D investment growth becomes positive and favors the immediate increase in the technology growth rate. The fall in inflation is smaller and its return to the target quicker, because of the larger improvement in aggregate demand. Consistently, the monetary policy rate increases at a faster pace.

Different from the case of an increase in public investment, in both the gradual and the sudden implementation of the reform, the interest rate does not immediately increase in response to higher inflation, but rather remains constant in the first year. In order to emphasize the importance of the monetary policy stance to counteract disinflationary pressures in the short run, Figure 2 also reports the case in which, in the face of a 1-year implementation, the central bank stabilizes the inflation rate at the target by announcing in period 1 a reduction in the monetary policy rate by 15 annualized basis points (bp) that will last three quarters (blue-dotted lines).[21] The expansionary stance further stimulates aggregate demand by reducing the real interest rate in the short run. As a result, the short-term growth rates of output, consumption and investment are larger than in the case of standard monetary policy.

In the long run, all real variables converge to a new balanced growth path characterized by a higher technology growth rate, equal to 1.1% on

[21] The reduction of the policy rate is implemented through (monetary policy) shocks to the Taylor rule in the first three quarters. The quarter-2 and quarter-3 shocks are anticipated by households in the initial quarter, while quarter-1 shock is a surprise.

an annual basis (it is equal to 0.9% in the initial steady state, see Table 4). While the higher level of the cyclical component of all variables directly reflects the reduction in the steady-state markup, the permanently higher growth rate is due to the increase in R&D expenditure, driven by the higher return. The policy rate increases from 2.9% in the initial steady state to 3.1% in the new steady state, consistent with the higher long-run growth rate of the economy, as illustrated by Eq. (5). The natural rate correspondingly increases from 0.9% to 1.1%.[22]

3.3 Permanent increase in subsidies to R&D

Figure 3 reports the responses to an increase in public subsidies to R&D. The size of the fiscal shock is calibrated to generate an increase in the ratio of R&D investment to the initial GDP level of 0.5 percentage points in the medium-to-long term, from 2% in the initial steady state to 2.5% in the final steady state.

The corresponding increase in public subsidy spending, as a ratio of the initial steady-state level of GDP, amounts to 0.6%. The subsidy rate $\tau_{R\&D,t}$ increases from 0% to 28%.

In the case of a sudden increase, immediately and fully implemented (red-dashed lines), firms expand their investment in R&D, whose relative return is directly and positively affected by the subsidy, and substitute it for investment in physical capital and labor, which decrease in the short run and subsequently rise above their corresponding steady-state values in the medium run, once the technology improvement induced by larger R&D spending has displayed its effect on labor productivity. Consumption growth gradually increases to its new long-run value, reflecting the increase in households' permanent income.

Firms face an increase in labor productivity and, thus, a reduction in their production costs, which is passed-through to lower prices and lower inflation. The supply-side expansion is not matched by an equal increase

[22]Markup shocks are usually not included in the computation of the natural rate in standard New Keynesian models, as they are inefficient. However, in our setup, a markup shock such as the one related to pro-competition reforms affects R&D accumulation and technology via Eq. (3) and therefore implies a change in the long-run growth rate of the economy that can be considered as "efficient". For this reason, we include the markup shock among the determinants of the natural rate.

in aggregate demand. Thus, inflation slightly decreases in the short run to restore the equilibrium in the goods market. In fact, the increase in R&D incentives works very similarly to a technology shock. As a result, while the increase in public spending (subsidies to R&D investment) sustains aggregate demand, it also favours a sufficiently large, permanent expansion in aggregate supply, which offsets the former effect and drives the short-term fall in inflation.

Inflation decreases also because of the central bank's response to the shock. The central bank very gradually raises the policy rate to the new, higher long-run value.

In the case of a 1-year implementation (black solid lines), the dynamics are virtually identical to those observed in the case of a sudden implementation. The reason is that R&D accumulation (see Eq. (3)) reflects the expected sum of current and discounted future returns, which does not greatly change among the two considered cases.[23]

Finally, Figure 3 also reports the case of 1-year implementation assuming that the central bank stabilizes the inflation rate at the target by announcing in period 1 a reduction in the monetary policy rate by about 10 annualized bp that will last three quarters (blue-dotted lines). The expansionary stance counteracts deflationary pressures and further stimulates aggregate demand by reducing the real interest rate.

In the long run, the growth rates of GDP and its components stabilize at the common permanently higher value of 1.5%, 0.6 percentage points higher than the pre-shock value (see Table 4). The policy rate new, higher long-run value is equal to 3.5% (+0.6 percentage points compared to the initial steady state). The natural rate of the economy increases to 1.5%, consistent with the increase in the economy's growth rate.

3.4 The policy mix

We now evaluate the macroeconomic effects of the simultaneous implementation of the three previously considered measures. Specifically, public investment permanently increases by 1 percentage point as a ratio to the initial

[23] Differences would arise if we compared a sudden implementation with an implementation over a three-year (or longer) horizon. Results are not reported to save on space, they are available upon request.

GDP level, the markup in the goods' market permanently declines by 1 percentage point (from 1.20% to 1.19%), and subsidies to R&D investment are increased by the same amount previously considered (i.e., such that, when the subsidy increase is implemented in isolation, R&D investment increases by 0.5 percentage points in the long run as a ratio of the initial GDP level). It is assumed, for simplicity, that the measures are immediately implemented. Figure 4 reports the results. We initially consider the cases of a standard monetary policy (black solid lines) and a 2-quarter FG (red-dashed lines).[24]

The mix has expansionary effects on economic activity in the short run. Moreover, inflation decreases less than in the case of pro-competition reforms and subsidies to R&D implemented individually, because public investment stimulates aggregate demand and, thus, partially offsets the short-run disinflationary forces associated with higher competition and subsidies to R&D. Inflation is stabilized around its target if the central banks initially keeps the policy rate constant at its baseline level instead of raising it (2-quarter FG). The lower current and future real interest rates favor private demand for consumption and investment. The additional rise in aggregate demand offsets to a larger extent the current and expected increase in aggregate supply.

Finally, in order to highlight the role of the increase in public investment in sustaining aggregate demand and inflation in the short term, we also report the case in which the policy mix only consists of the decline in the markup in the goods' market and the increase in subsidies to R&D, but public investment does not vary, i.e., it is kept constant at its baseline level (blue-dotted lines). The fall in inflation is larger compared to the benchmark scenario. The response of consumption is more muted, while private investment falls by less, as households do not have to finance the increase in public investment. Importantly, under this composition of the policy mix, a 2-quarter FG is no longer sufficient to stabilize inflation (green line with crosses). Hence, the support provided by public investment provides a favorable interaction with monetary policy.

As reported in Table 4, the long-run macroeconomic effects are expansionary, since all the measures individually considered favor an increase in

[24]We consider 2 quarters of FG, instead of 3, in order to be conservative and avoid possible overreactions related to the FG puzzle, given the larger size of the shock compared to the previous single-measure scenarios.

long-run growth rate of the economy. The long-term increase in the technology growth rate is equal to 1 percentage point, slightly larger than the sum of the individual effects of each reform, as a reflection of the endogenous growth mechanism activated by higher R&D investment. Both the nominal interest rate and the natural rate correspondingly increase by 1 percentage point in the new steady state.

Overall, the ingredients of a growth-enhancing policy mix are crucial for its short-term expansionary impact on economic activity and, importantly, on inflation. A mix that sufficiently stimulates aggregate demand can limit the negative effects on inflation. In this respect, also the monetary policy stance can play a key role.

3.5 Natural rate of interest, output gap, and monetary policy stance

Figure 5 reports, for each of the four scenarios, the corresponding responses of three variables that are crucial from a monetary policy perspective: the ex-ante real interest rate, i.e., the difference between the nominal interest rate and the expected next-period inflation rate, which is the key determinant of consumption and savings decisions; the natural rate of interest, defined as the interest rate that would prevail in an economy without nominal price and wage rigidities; the output gap, defined as the difference between the level of output in presence of sticky nominal price and wage rigidities and the level of output in the absence of nominal rigidities (both types of output are computed as % deviations from the common initial steady-state level).[25]

The real interest rate increases above its initial steady-state level in all scenarios, unless the central bank provides monetary accommodation by either implementing FG on the policy rate, or stabilizing the inflation rate (blue lines with circles). The accommodative stance is captured by the fall in the real interest rate.

The natural rate of interest always increases in the long-run, reflecting the expansionary nature of all measures, which permanently increase out-

[25] See, among the others, Del Negro et al. (2017), Barsky et al. (2014), and Justiniano et al. (2011) for a discussion of the definitions of the natural rate of interest rate in standard New Keynesian models (which do not feature endogenous growth).

put growth. Its short-term dynamics depend on the specific assumptions underlying each scenario.

The output gap is generally positive in the short run, because higher aggregate demand stimulates economic activity under nominal rigidities. It becomes negative in the medium run when supply-side effects dominate and affect mainly the flexible-price (and wage) version of the economy.[26]

In the case of a sudden permanent increase in public investment (red-dashed line), the natural rate overshoots its new long-run level. The output gap increases, which reflects the initial expansion in aggregate demand.

In the case of a 1-year implementation of the public investment permanent increase (black solid line), the natural rate initially decreases below both its initial and final level. As aggregate demand initially falls (see Figure 2), the output gap is negative. The output gap is positive in the case of 3-quarter FG, which stimulates aggregate demand and, thus, economic activity in the nominal rigidities economy.[27]

In the case of a permanent decrease in firms' markup, the natural rate of interest increases in the long run.[28]

The short-term response reflects the speed of implementation of the reform and the corresponding response of the output gap. When the reform is suddenly implemented, both aggregate supply and aggregate demand increase. The natural rate falls, because savings are higher than investment and the equilibrium has to be restored. In the case of a 1-year implementation, the expansion in aggregate supply does not fully materialize in the initial periods. Nonetheless, aggregate demand immediately reacts because of households and firms anticipating the new future permanent higher income. Thus, there is excess investment relative to saving and, in equilibrium, the natural rate has to increase to partly counteract the increase in aggregate demand.[29]

[26]In both the initial and final steady states the output gap is closed, i.e., it is equal to zero.

[27]There is no distinction between the response of the natural rate in the benchmark case (black solid line) and in the case of 3-quarter FG, since the latter has no effect in the economy without nominal rigidities.

[28]IMF (2019) reports that, across the 2000s, market power has risen in advanced economies, thus reducing the natural (real) rate of interest because of a lack of investment, and thereby making the effective lower bound on policy interest rates more binding. Our results are in line with such evidence, because the natural rate increases in correspondence of a lower market power.

[29]If we followed the standard definitions of natural rate and output gap in the New

With a permanent increase in subsidies to R&D investment, the natural rate gradually increases towards its new long-term level. The output gap is negative (except in the initial periods, in the case of monetary policy accommodation).

Finally, in the policy mix scenario, the natural rate increases. When the permanent increase in public investment is included (black solid lines), the mix stimulates aggregate demand (as illustrated above), which expands more than aggregate supply. The output gap raises in the short run and the natural rate overshoots its new long-run level. If the policy mix does not include a permanent increase in public investment, the sustain to aggregate demand is largely reduced and the natural rate increases to a smaller extent. The output gap raises in the short run.

Overall, the considered policy measures raise the natural rate of interest. Thus, compared to the initial steady state, in the new steady state the central bank has more space to reduce the policy rate to stabilize the economy in the aftermath of possible disinflationary shocks.

3.6 Sensitivity analysis

3.6.1 The role of R&D accumulation and the related parameters

In the following we reduce the values of the parameters that regulate the dependence of R&D accumulation on public investment and the degree of market competition, i.e. α_{iG} and α_θ in Eq. (3), by one order of magnitude with respect to the benchmark calibration, setting $\alpha_{iG} = 0.2$ (from $\alpha_{iG} = 2$) and $\alpha_\theta = 0.04$ (from $\alpha_\theta = 0.4$), respectively.

Figures 6 and 7 report the results for the policy mix scenario, i.e. the simultaneous implementation of higher public investment, firms' markup decrease, and increased subsidies to R&D.

A lower value of α_{iG} implies, *ceteris paribus*, a smaller effect of higher public investment on R&D accumulation. In fact, the red-dashed lines in Figure 6 closely resemble the blue and green lines in Figure 4, which correspond to the case of a policy mix without an increase in public investment.

Keynesian literature, which do not consider markup shocks because they are inefficient, the responses of the natural rate and flexible-price output would be equal to zero and, thus, the response of the output gap would coincide with the response of output in presence of nominal rigidities (see Figure 2).

As variations in the public investment-to-GDP ratio now only mildly influence R&D accumulation, the overall macroeconomic effects of the policy mix are smaller compared to the benchmark case (black solid line in Figure 6).

Turning to the effect of increasing competition on R&D accumulation, the blue-dotted lines in Fig. 6 report the case of $\alpha_\theta = 0.04$. Results are qualitatively similar, but quantitatively more muted, compared to the benchmark case.

Figure 7 reports the (ex-ante) real interest rate, the natural rate of interest, and the output gap. As the overall macroeconomic effects are more muted, both the real and the natural rate of interest increase by a smaller amount compared to the benchmark case. The output gap initially increases by less, reflecting the more muted response of aggregate demand in the short term, and subsequently falls by a smaller amount in the medium-to-long term, because of the smaller effects on long-term economic growth.

Table 5 reports the long-run results. A lower α_{iG} implies that the increase in long-run growth, policy rate and natural rate of interest amounts to 0.9pp, as opposed to 1.2pp under the benchmark calibration.

Under the assumption of lower α_θ the corresponding long-run increase is 1.

Finally, when we reduce both α_{iG} and α_θ, the overall effect of the policy mix on growth amounts to 0.7pp, about half a percentage point less than in the benchmark case. Still, as under the benchmark calibration, the growth rate in the new steady state is close to 1.0pp higher than in the initial one.

Overall, the macroeconomic effects of the policy mix are robust to changes in the parameters regulating the effects of public investment and market power on R&D accumulation.

3.6.2 The timing of implementation

In the benchmark simulations (and in the ones illustrated above), it is assumed that all policy measures are credibly announced in the first period of simulation, and subsequently implemented, either suddenly, or gradually within one year. In the following we assume instead that, while in the first period the policymaker announces the size and composition of the policy package, it is also announced that all measures will start to be implemented with some delay. The latter assumption captures, in a stylized way, the possible presence of regulatory or red-tape restrictions that avoid a swift implementation of the announced policy measures.[30]

Figures 8 and 9 report the results for the policy mix scenario.

While the long-run effects on technology and output growth and interest rates are unchanged, the short-run responses are affected by the postponed implementation. Compared to the benchmark case of sudden implementation (black solid line in Figure 8), when the announcement also includes a 2-quarter (red-dashed line) or 3-quarter (blue-dotted line) delay, the very short-term dynamics is affected. As agents foresee a larger productivity of R&D investment in the future, when public investment will be higher, market competition will increase, and subsidies to R&D will be higher too, they postpone R&D investment and consumption, and increase savings. A weaker aggregate demand drives inflation further down, which triggers a reduction in the monetary policy rate. The latter is slightly more pronounced with a more delayed implementation of the policy mix. Output growth, output gap and the natural rate of interest increase with a corresponding delay. After about three years, the dynamics of all macroeconomic variables is very close to the one observed in the benchmark case.

4 Conclusions

We have evaluated the macroeconomic impact of different growth-enhancing policy measures in the EA, through their effects on investment in R&D.

All considered measures – higher public investment in infrastructures, pro-competition reform, and subsidies to R&D – have a positive effect on growth. The permanently higher growth raises the natural rate. In the short run, these measures can have a mildly negative effect on inflation, because they favor an expansion in aggregate supply.

Our work can be extended along several dimensions. First, we could consider a multi-country setup of the EA and evaluate the domestic and cross-country macroeconomic effects of measures implemented at country

[30] Importantly, the delay between announcement and beginning of implementation is perfectly anticipated by all agents in the economy. We leave the analysis of possible uncertainty about the timing (and composition) of the policy measures for future research.

level or coordinated across countries. Second, the setup could be enriched to assess the macroeconomic and environmental impacts of an increase in R&D spending in environmentally-friendly technologies, possibly financed by a carbon tax. Third, we could introduce in the model also human capital and assess the macroeconomic effects of policy measures that, directly or indirectly, favor its accumulation. Fourth, we could allow for changes in distortionary taxation, instead of changes in lump-sum taxes, to finance higher public investment in infrastructures and subsidies to R&D and, thus, introduce some trade-offs, which could be optimally solved by a welfare-maximizing social planner. Finally, our framework is well-suited for the analysis of fiscal policy and other growth-friendly measures such as those contained in the European Next Generation EU. In this respect, it is important to take into account lags and inefficiencies in the decision and implementation phases that can reduce, in the short run at least, the effectiveness of R&D subsidies and public investment spending.[31] We leave these issues for future research.

[31] See Busetti et al. (2019) for the case of public investment effectiveness in Italy.

References

Aghion, Philippe, Nick Bloom, Richard Blundell, Rachel Griffith, and Peter Howitt, "Competition and Innovation: an Inverted-U Relationship," *The Quarterly Journal of Economics*, 2005, *120* (2), 701–728.

Aschauer, David Alan, "Is public expenditure productive?," *Journal of Monetary Economics*, March 1989, *23* (2), 177–200.

_ , "Public investment and productivity growth in the Group of Seven," *Economic Perspectives*, 1989, *13* (Sep), 17–25.

Barsky, Robert, Alejandro Justiniano, and Leonardo Melosi, "The Natural Rate of Interest and Its Usefulness for Monetary Policy," *American Economic Review*, May 2014, *104* (5), 37–43.

Bianchi, Francesco, Howard Kung, and Gonzalo Morales, "Growth, slowdowns, and recoveries," *Journal of Monetary Economics*, 2019, *101* (C), 47–63.

Bloom, Nicholas, John Van Reenen, and Heidi Williams, "A Toolkit of Policies to Promote Innovation," *Journal of Economic Perspectives*, Summer 2019, *33* (3), 163–184.

_ **, Mark Schankerman, and John Van Reenen**, "Identifying Technology Spillovers and Product Market Rivalry," *Econometrica*, July 2013, *81* (4), 1347–1393.

Bom, Pedro R.D. and Jenny E. Ligthart, "What Have We Learned From Three Decades Of Research On The Productivity Of Public Capital?," *Journal of Economic Surveys*, December 2014, *28* (5), 889–916.

Burlon, Lorenzo, Alberto Locarno, Alessandro Notarpietro, and Massimiliano Pisani, "Public investment and monetary policy stance in the euro area," Temi di discussione (Economic working papers) 1150, Bank of Italy, Economic Research and International Relations Area December 2017.

Busetti, Fabio, Cristina Giorgiantonio, Giorgio Ivaldi, Sauro Mocetti, Alessandro Notarpietro, and Pietro Tommasino, "Capital and public investment in Italy: macroeconomic effects, measurement and regulatory weaknesses," Questioni di Economia e Finanza (Occasional Papers) 520, Bank of Italy, Economic Research and International Relations Area October 2019.

Calvo, Guillermo A., "Staggered prices in a utility-maximizing framework," *Journal of Monetary Economics*, September 1983, *12* (3), 383–398.

Canova, Fabio and Evi Pappa, "What are the likely macroeconomic effects of the EU Recovery Plan?," mimeo 2021.

Ciapanna, Emanuela, Sauro Mocetti, and Alessandro Notarpietro, "The effects of structural reforms: Evidence from Italy," Temi di discussione (Economic working papers) 1303, Bank of Italy, Economic Research and International Relations Area November 2020.

Coenen, Gunter, Peter Karadi, Sebastian Schmidt, and Anders Warne, "The New Area-Wide Model II: an extended version of the ECB's micro-founded model for forecasting and policy analysis with a financial sector," Working Paper Series 2200, European Central Bank November 2018.

Cova, Pietro, Alessandro Notarpietro, Patrizio Pagano, and Massimiliano Pisani, "Secular Stagnation, R&D, Public Investment, And Monetary Policy: A Global-Model Perspective," *Macroeconomic Dynamics*, July 2021, *25* (5), 1267–1287.

Del Negro, Marco, Domenico Giannone, Marc Giannoni, and Andrea Tambalotti, "Safety, Liquidity, and the Natural Rate of Interest," *Brookings Papers on Economic Activity*, 2017, *48* (1 (Spring), 235–316.

Elekdag, Selim and Dirk V. Muir, "Das Public Kapital; How Much Would Higher German Public Investment Help Germany and the Euro Area?," IMF Working Papers 14/227, International Monetary Fund December 2014.

European Central Bank, "Economic Bulletin Issue 3–Article The slowdown in euro area productivity in a global context," Technical Report, European Central Bank 2017.

European Commission, "The role of research and innovation in support of Europe's Recovery from the COVID-19 crisis," R&I paper series policy brief, European Commission 2020.

_ , "The EU's 2021-2027 long-term Budget and NextGenerationEU – Facts and Figures," Technical Report, European Commission 2021.

Hall, Bronwyn H., Francesca Lotti, and Jacques Mairesse, "Evidence on the impact of R&D and ICT investments on innovation and productivity in Italian firms," *Economics of Innovation and New Technology*, April 2013, *22* (3), 300–328.

IMF, "Is productivity growth shared in a globalized economy?," World Economic Outlook Chapter 4, International Monetary Fund 2018.

_ , "The Rise of Corporate Market Power and its Macroeconomic Effects," World Economic Outlook Chapter 2, International Monetary Fund 2019.

_ , "Research and innovation: fighting the pandemic and boosting long-term growth," World Economic Outlook Chapter 3, International Monetary Fund 2021.

Jorda, Oscar, Sanjay R. Singh, and Alan M. Taylor, "The Long-Run Effects of Monetary Policy," NBER Working Papers 26666, National Bureau of Economic Research, Inc January 2020.

Justiniano, Alejandro, Giorgio Primiceri, and Andrea Tambalotti, "Investment Shocks and the Relative Price of Investment," *Review of Economic Dynamics*, January 2011, *14* (1), 101–121.

Neri, Stefano and Andrea Gerali, "Natural rates across the Atlantic," Temi di discussione (Economic working papers) 1140, Bank of Italy, Economic Research and International Relations Area September 2017.

Rotemberg, Julio J., "Monopolistic Price Adjustment and Aggregate Output," *Review of Economic Studies*, October 1982, *49* (4), 517–31.

Schmoller, Michaela and Martin Spitzer, "Endogenous TFP, business cycle persistence and the productivity slowdown in the euro area," Working Paper Series 2401, European Central Bank May 2020.

Vetlov, Igor, Marien Ferdinandusse, Jasper de Jong, and Josip Funda, "The effect of public investment in Europe: a model-based assessment," Working Paper Series 2021, European Central Bank February 2017.

Table 1: Initial steady-state equilibrium

Variable	Value
Inflation rate (400*($\overline{\pi}$-1))	2.0
Technology growth rate (400*($\overline{gr} - 1$)	0.9
Nominal interest rate (400*($\overline{R}$-1))	2.9
Real interest rate	0.9
Private consumption	57.0
Public consumption	20.0
Private investment in physical capital	18.0
Public investment in physical capital	3.0
R&D investment	2.0
Public debt	96.0

Note: inflation, growth, and interest rates are reported as net annualized percentage point values. Private consumption, public consumption, private and public investment, R&D investment as % of GDP. Public debt as % of annualized GDP.

Table 2: Calibration

Parameter	Symbol	Value
Preferences		
Discount factor	β	0.99998
Intertemporal elasticity of substitution	σ	1.0
Habit in consumption	h	0.75
Frisch labor elasticity	τ	0.75
Technology		
Output elasticity wrt private capital	α	0.31
Output elasticity wrt public capital	γ	0.08
Private capital depreciation rate	δ_K	0.025
Private capital investment adjustment cost		2.0
Public capital depreciation rate	δ_{K_G}	0.025
R&D spillover on trend productivity	η	0.04
R&D depreciation rate	$\delta_{R\&D}$	0.003
R&D investment adjustment cost scaling parameter	$\kappa_{R\&D}$	1.0
Sensitivity of R&D to public investment: scaling parameter	κ_{i_G}	0.2
Sensitivity of R&D to public investment: exponent	α_{i_G}	0.4
Sensitivity of R&D to goods market competition: scaling parameter	κ_θ	1.0
Sensitivity of R&D to goods market competition: exponent	α_θ	2.0
Nominal rigidities		
Price stickiness (Rotemberg)	k_p	300
Wage stickiness (Rotemberg)	k_w	400
Inflation indexation to previous inflation	ι	0.50
Wage indexation to previous inflation	ι_w	0.50
Monetary policy		
Interest rate smoothing	ρ_r	0.87
Response to inflation	ρ_π	1.90
Response to output growth	ρ_y	0.15
Fiscal policy		
Response to changes in the level of the debt-to-GDP ratio	ϕ_1	2.01
Response to changes in the growth rate of the debt-to-GDP ratio	ϕ_2	10.01
Consumption tax rate	τ_c	0.2
Labor tax rate	τ_w	0.4
Physical capital tax rate	τ_{rk}	0.3
R&D subsidy	$\tau_{R\&D}$	0.0

Table 3: Gross markups (initial steady-state equilibrium)

	Markup (elasticity of substitution)
Intermediate goods	1.20 ($\theta = 6.0$)
Labor varieties	1.33 ($\theta_w = 4.3$)

Table 4: Growth-enhancing measures: long-run effects

	gr	R	R^*
(1): Initial steady state	0.9	2.9	0.9
(2): Increase in public investment	1.2	3.2	1.2
difference (2)-(1)	*0.3*	*0.3*	*0.3*
(3): Pro-competition reform	1.1	3.1	1.1
difference (3)-(1)	*0.2*	*0.2*	*0.2*
(4): Incentive to R&D investment	1.5	3.5	1.5
difference (4)-(1)	*0.6*	*0.6*	*0.6*
(5): Policy mix	2.1	4.2	2.1
difference (5)-(1)	*1.2*	*1.2*	*1.2*

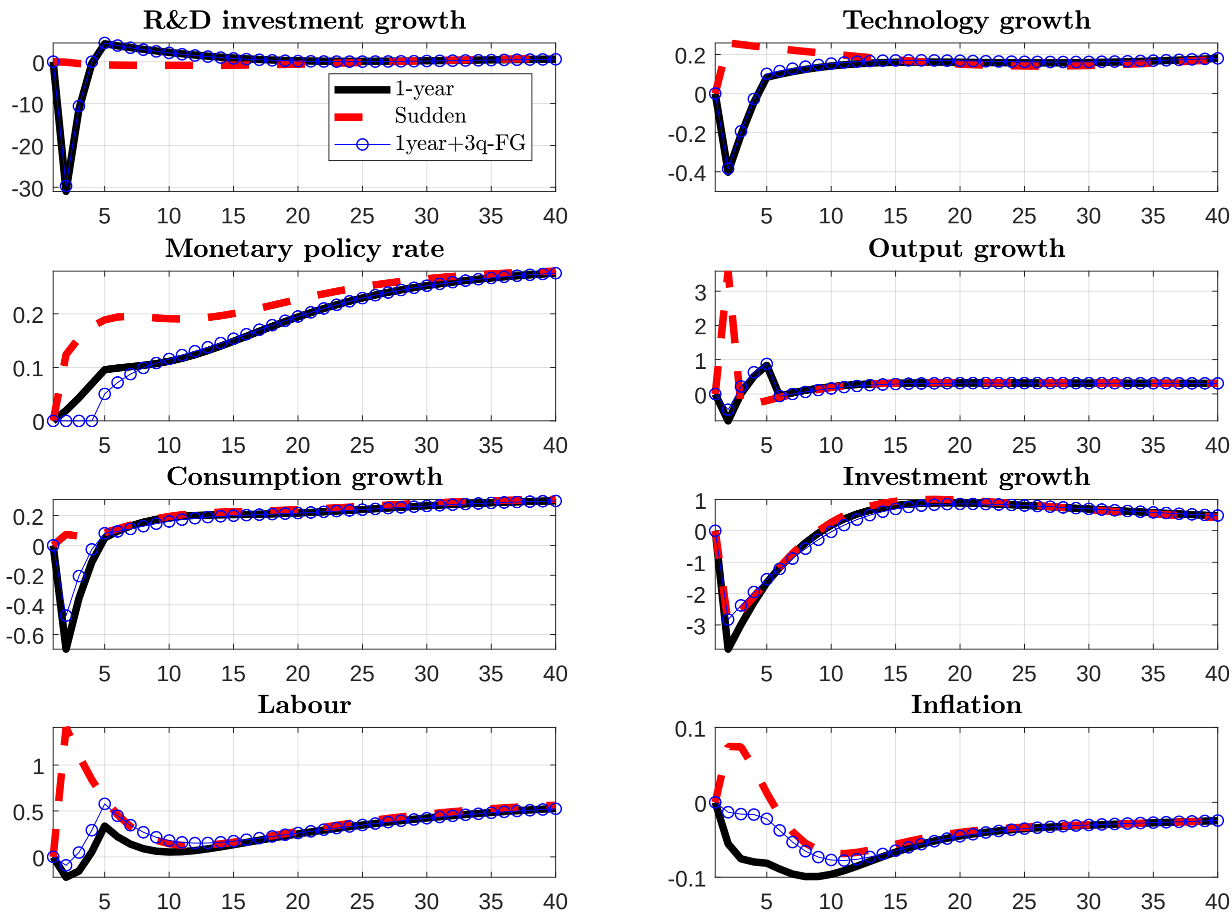
Note: gr is the long-run growth rate; R is the nominal interest rate in levels, R^* is the natural (real) rate of interest in levels. All are in annualized percentage points.

Table 5: Sensitivity. The policy mix: long-run effects

	gr	R	R^*
(1): Benchmark			
difference w.r.t. initial steady state	*1.2*	*1.2*	*1.2*
(3): Lower sensitivity of R&D to public investment: $\alpha_{i_G} = 0.04$			
difference (3)-(1)	*-0.3*	*-0.3*	*-0.3*
(2): Lower sensitivity of R&D to goods market competition: $\alpha_\theta = 0.2$			
difference (2)-(1)	*-0.2*	*-0.2*	*-0.2*
(4): Lower sensitivity of R&D to both: $\alpha_\theta = 0.2$ and $\alpha_{i_G} = 0.04$			
difference (4)-(1)	*-0.5*	*-0.5*	*-0.5*

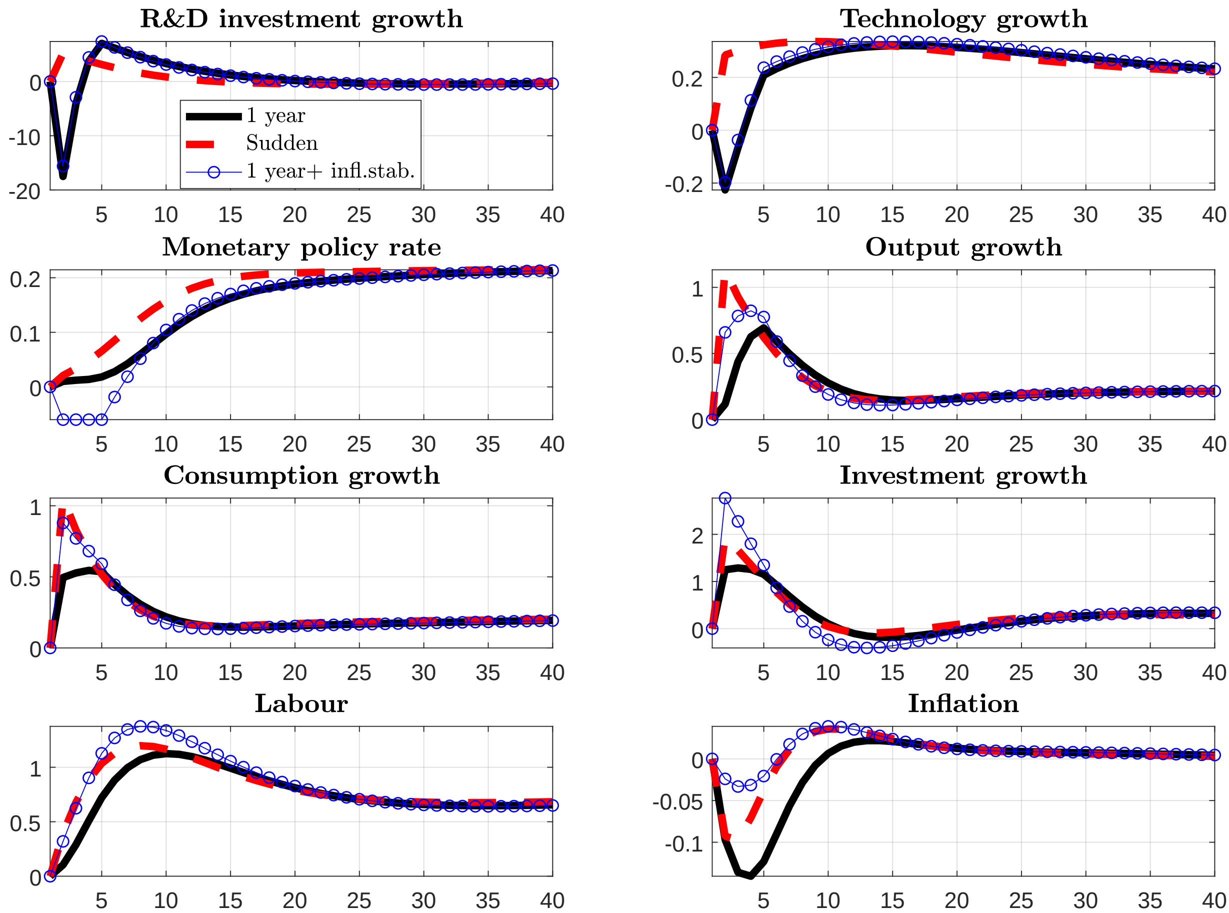
Note: gr is the long-run growth rate; R is the nominal interest rate in levels, R^* is the natural (real) rate of interest in levels. Differences are in annualized percentage points.

Figure 1: Permanent increase in public investment



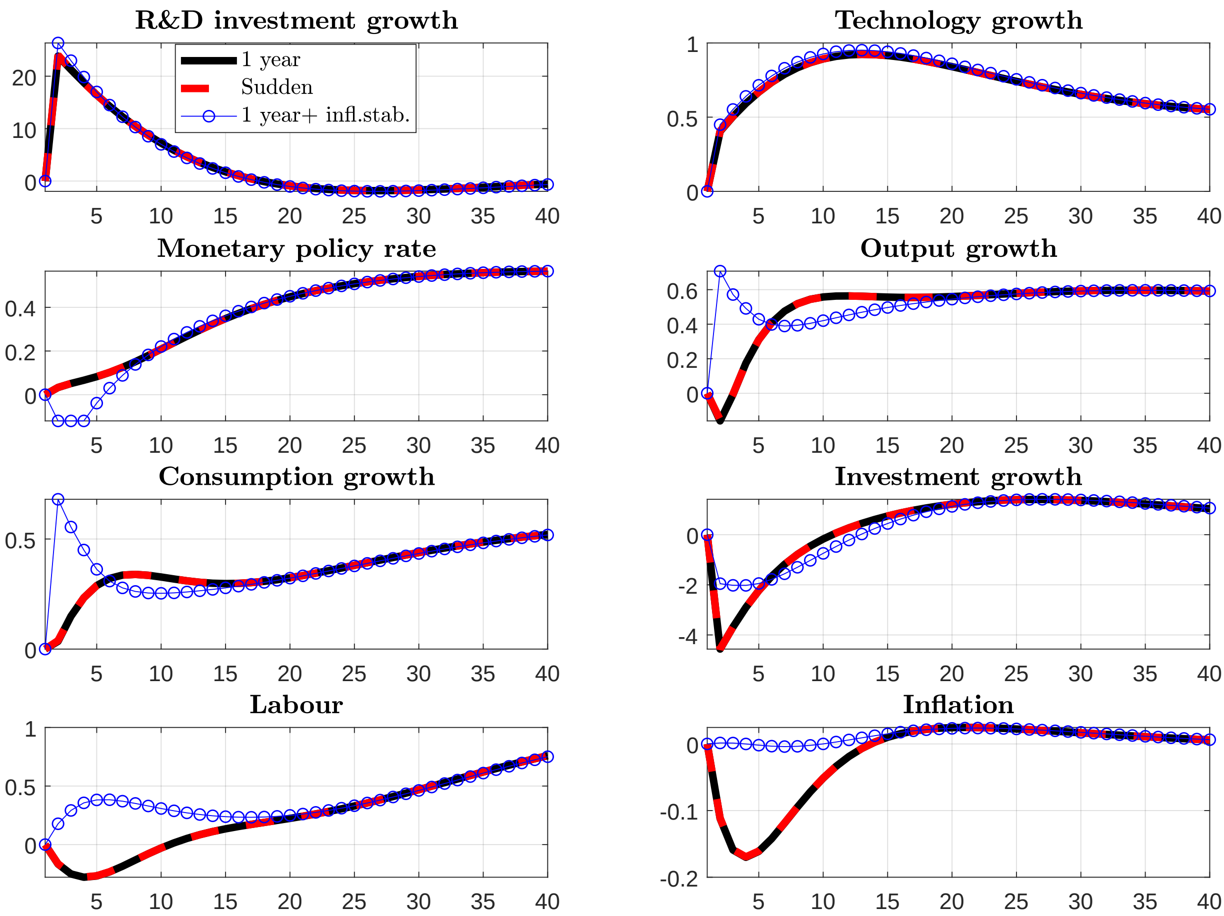
Note. Horizontal axis: quarters; vertical axis: labor-augmenting technology, real GDP, and its components are reported in growth rates, annualized percentage point deviations from the initial steady state; monetary policy rate and inflation: annualized percentage point deviations from initial steady state; labor: hours worked, % deviation from the initial steady state.

Figure 2: Permanent firms' markup decrease



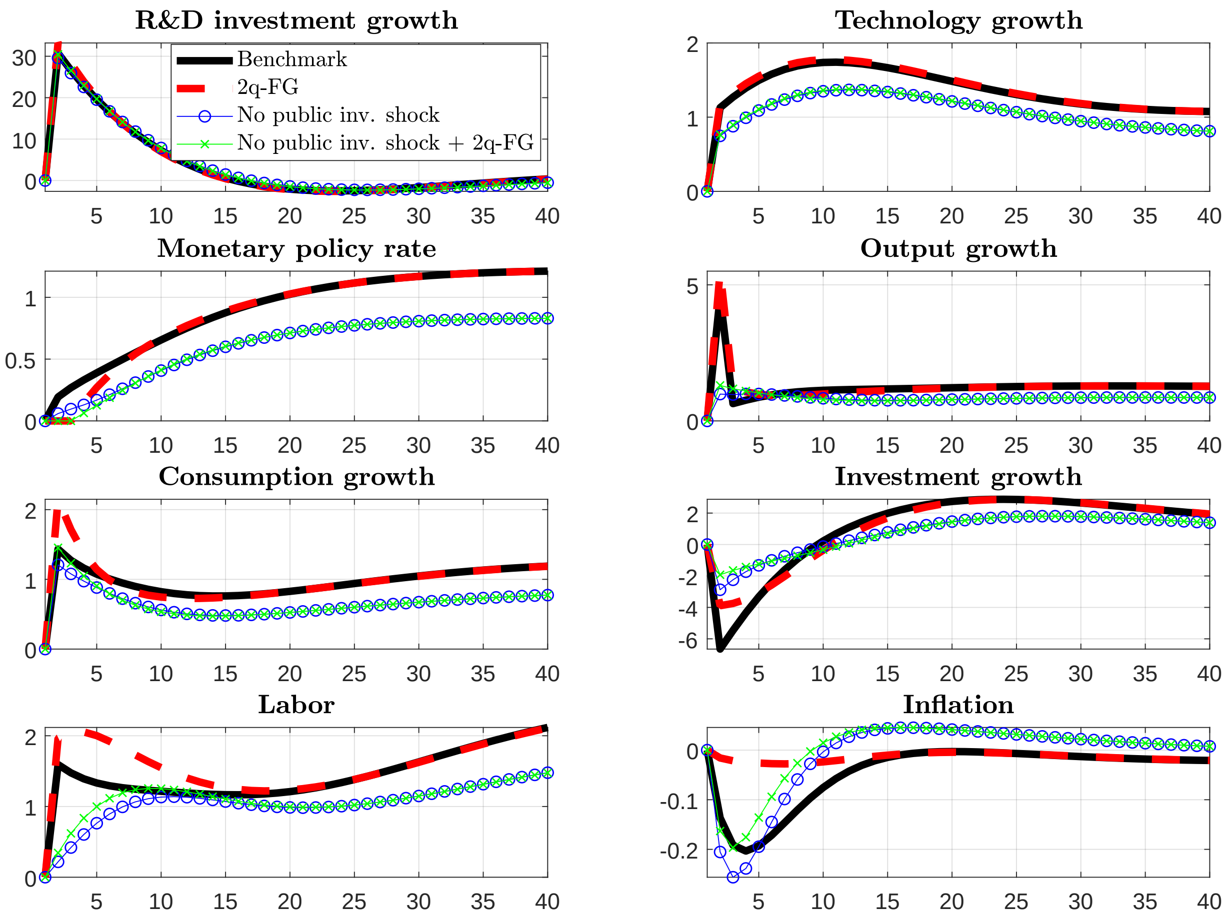
Note. Horizontal axis: quarters; vertical axis: labor-augmenting technology, real GDP, and its components are reported in growth rates, annualized percentage point deviations from the initial steady state; monetary policy rate and inflation: annualized percentage point deviations from initial steady state; labor: hours worked, % deviation from the initial steady state.

Figure 3: Permanent increase in subsidies to R&D



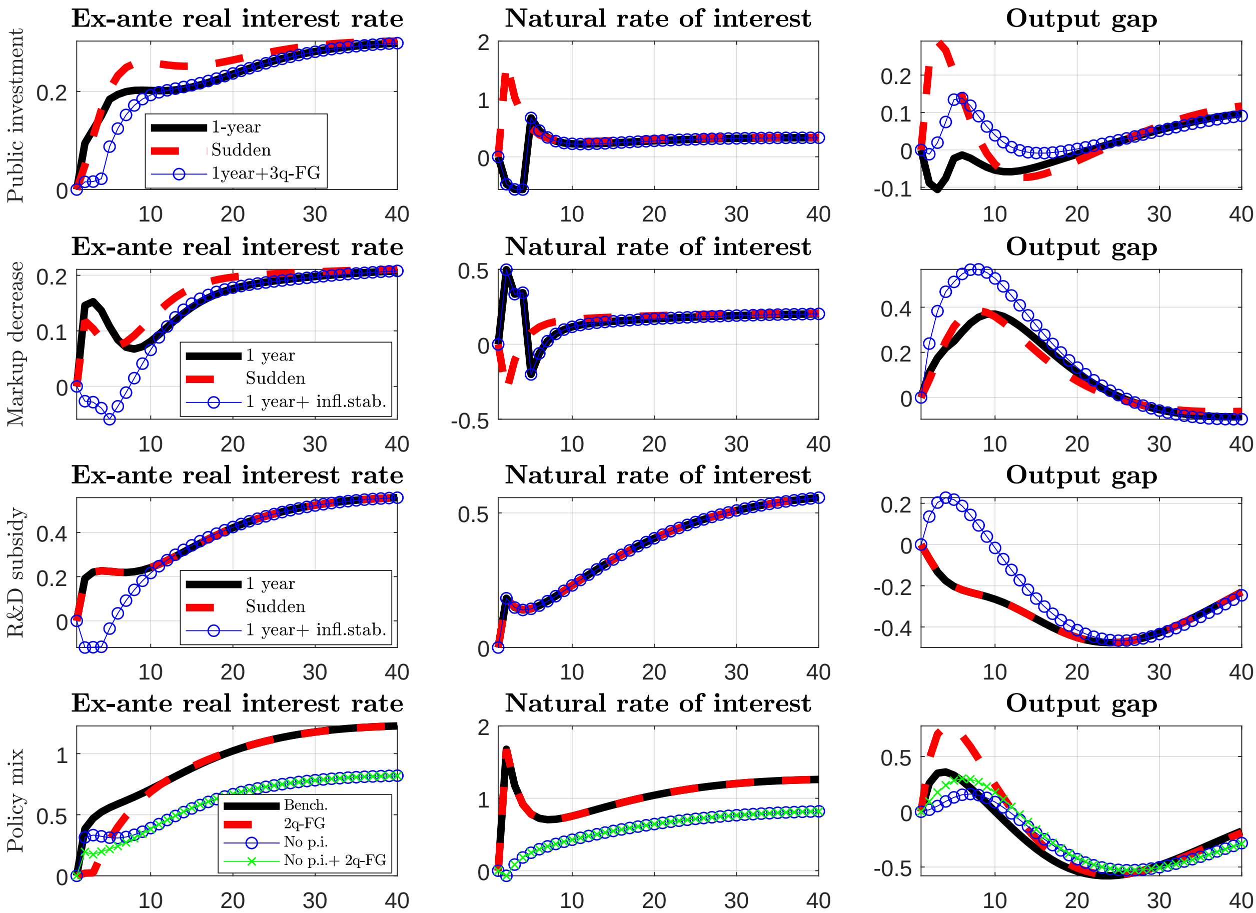
Horizontal axis: quarters; vertical axis: labor-augmenting technology, real GDP, and its components are reported in growth rates, annualized percentage point deviations from the initial steady state; monetary policy rate and inflation: annualized percentage point deviations from initial steady state; labor: hours worked, % deviation from the initial steady state.

Figure 4: The policy mix



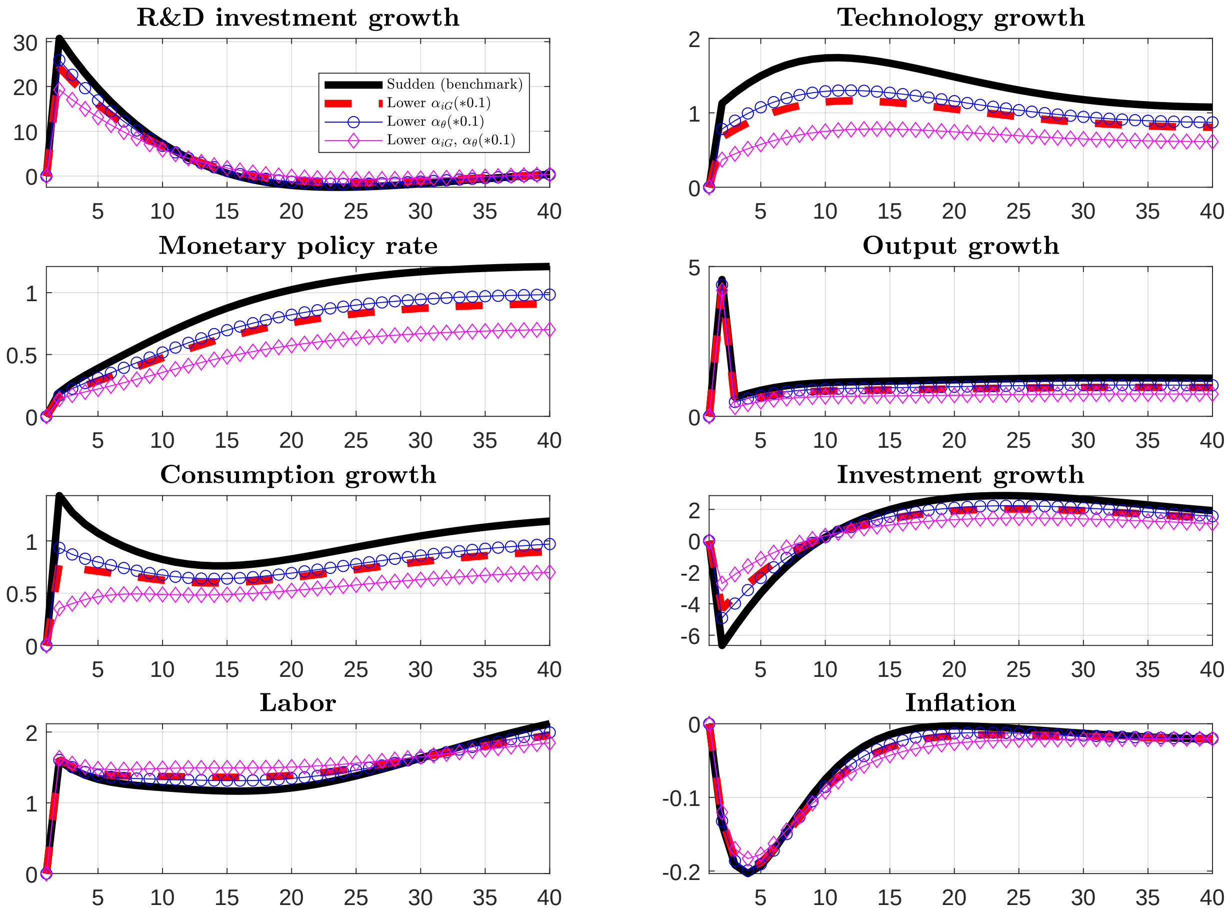
Horizontal axis: quarters; vertical axis: labor-augmenting technology, real GDP, and its components are reported in growth rates, annualized percentage point deviations from the initial steady state; monetary policy rate and inflation: annualized percentage point deviations from initial steady state; labor: hours worked, % deviation from the initial steady state.

Figure 5: Ex-ante real interest rate, natural rate of interest, and output gap



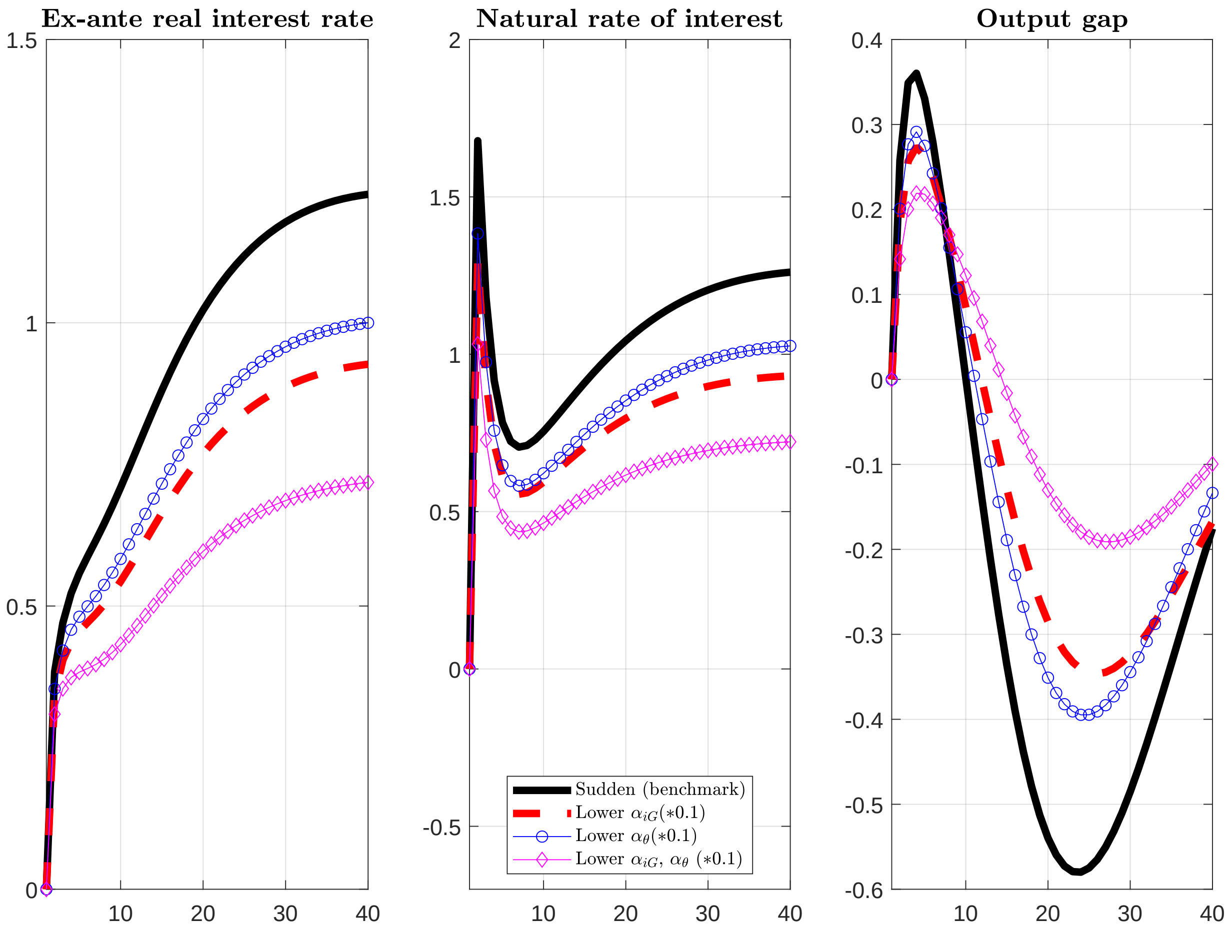
Note. Horizontal axis: quarters; vertical axis: interest rates: annualized percentage point deviations from initial steady state; output gap: difference between output in the model with nominal rigidities and the output in the model without nominal rigidities, both as % deviations from the initial steady-state level; p.i.=public investment.

Figure 6: Sensitivity. The policy mix: the role of R&D accumulation.



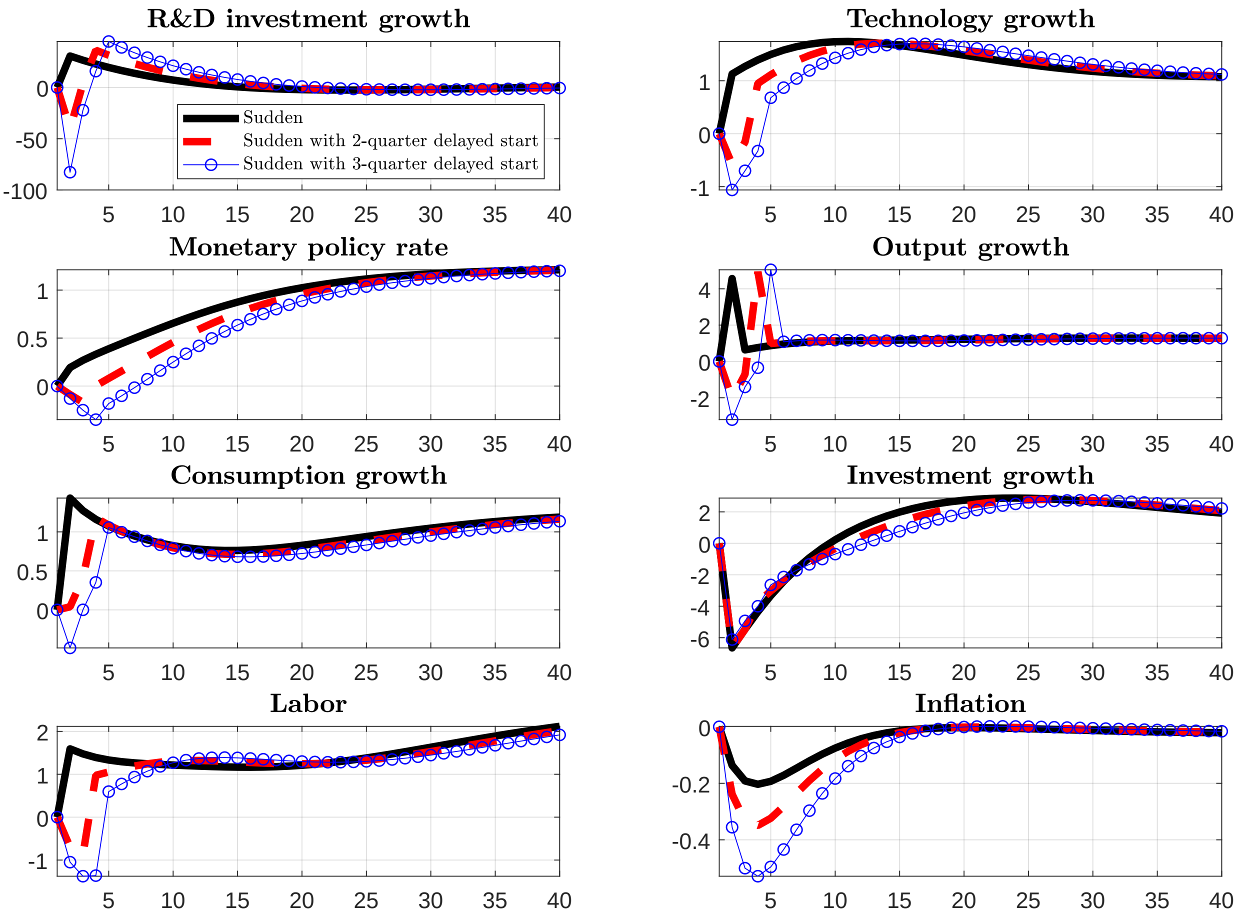
Horizontal axis: quarters; vertical axis: labor-augmenting technology, real GDP, and its components are reported in growth rates, annualized percentage point deviations from the initial steady state; monetary policy rate and inflation: annualized percentage point deviations from initial steady state; labor: hours worked, % deviation from the initial steady state.

Figure 7: Ex-ante real interest rate, natural rate, and output gap. Sensitivity: the role of R&D accumulation.



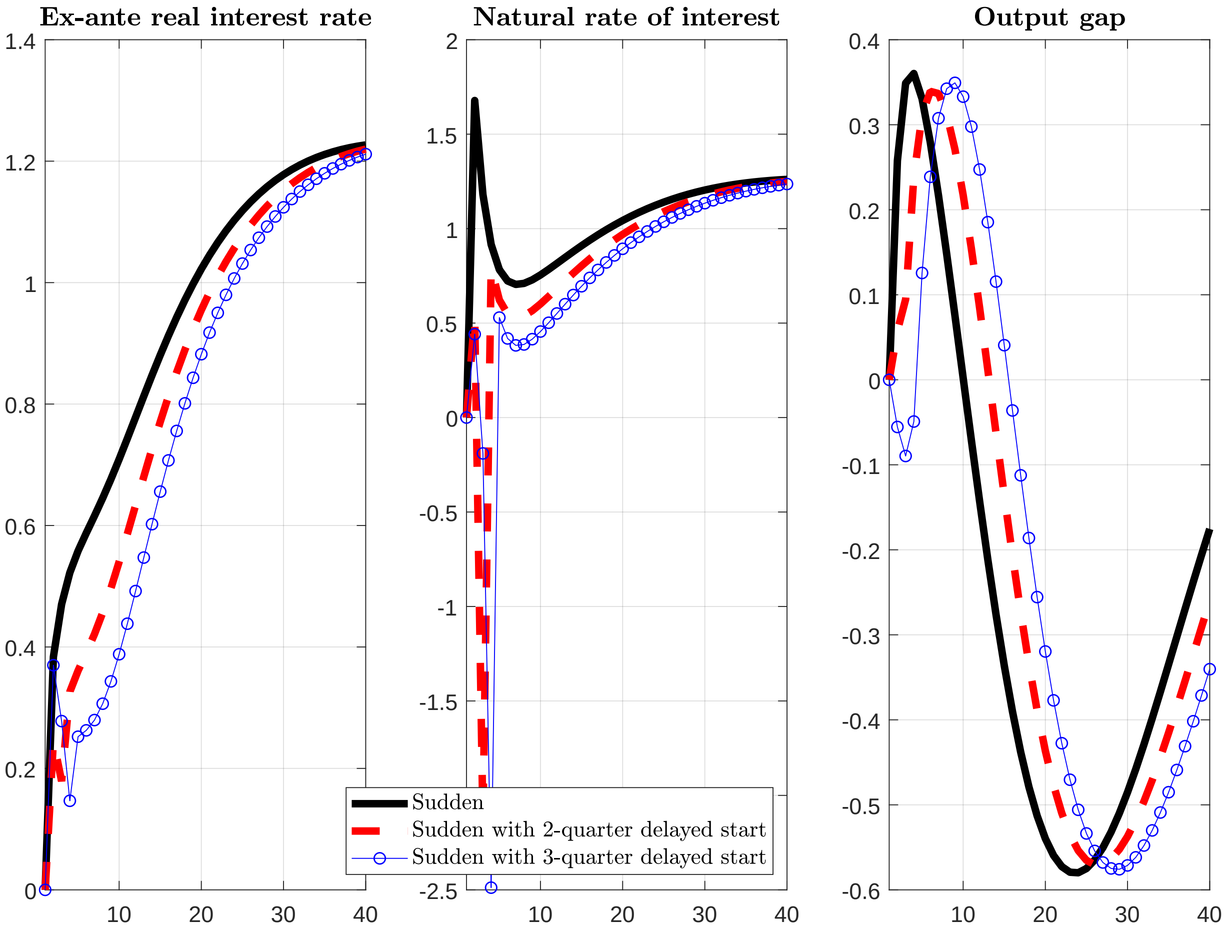
Note. Horizontal axis: quarters; vertical axis: interest rates: annualized percentage point deviations from initial steady state; output gap: difference between output in the model with nominal rigidities and the output in the model without nominal rigidities, both as % deviations from the initial steady-state level.

Figure 8: The policy mix. Sensitivity: the timing of implementation.



Horizontal axis: quarters; vertical axis: labor-augmenting technology, real GDP, and its components are reported in growth rates, annualized percentage point deviations from the initial steady state; monetary policy rate and inflation: annualized percentage point deviations from initial steady state; labor: hours worked, % deviation from the initial steady state.

Figure 9: Ex-ante real interest rate, natural rate, and output gap. Sensitivity: the timing of implementation.



Note. Horizontal axis: quarters; vertical axis: interest rates: annualized percentage point deviations from initial steady state; output gap: difference between output in the model with nominal rigidities and the output in the model without nominal rigidities, both as % deviations from the initial steady-state level.

RECENTLY PUBLISHED "TEMI" (*)

N. 1361 – *How do firms adjust to a negative labor supply shock? Evidence form migration outflows*, by Emanuele Dicarlo (February 2022).

N. 1362 – *Nowcasting the state of the Italian economy: the role of financial markets*, by Donato Ceci and Andrea Silvestrini (February 2022).

N. 1363 – *Insurers' investments before and after the Covid-19 outbreak*, by Federico Apicella, Raffaele Gallo and Giovanni Guazzarotti (February 2022).

N. 1364 – *Making subsidies work: rules vs. discretion*, by Federico Cingano, Paolo Pinotti, Filippo Palomba and Enrico Rettore (March 2022).

N. 1365 – *Foreign monetary policy and domestic inflation in emerging markets*, by Marco Flaccadoro and Valerio Nispi Landi (April 2022).

N. 1366 – *Monetary policy in the open economy with digital currencies*, by Pietro Cova, Alessandro Notarpietro, Patrizio Pagano and Massimiliano Pisani (April 2022).

N. 1367 – *The role of non-bank financial institutions in the intermediation of capital flows to emerging markets*, by Alessandro Moro and Alessandro Schiavone (April 2022).

N. 1368 – *Exchange rate pass-through in small, open, commodity-exporting economies: lessons from Canada* , by Marco Flaccadoro (April 2022).

N. 1369 – *Public guarantees and credit additionality during the Covid-19 pandemic*, by Giuseppe Cascarino, Raffaele Gallo, Francesco Palazzo and Enrico Sette (April 2022).

N. 1370 – *The effects of local demand and supply restrictions on markup*, by Antonio Acconcia and Elisa Scarinzi (June 2022).

N. 1371 – *Mutual fund trading and ESG stock resilience during the Covid-19 stock market crash*, by Rui Albuquerque, Yrjö Koskinen and Raffaele Santioni (June 2022).

N. 1372 – *Higher capital requirements and credit supply: evidence from Italy*, by Maddalena Galardo and Valerio Vacca (June 2022).

N. 1373 – *Voluntary support and ring-fencing in cross-border banks*, by Gyoengyi Loranth, Anatoli Segura and Jing Zeng (June 2022).

N. 1374 – *PIt ain't where you're from it's where you're at: firm effects, state dependence, and the gender wage gap*, by Sabrina Di Addario, Patrick Kline, Raffaele Saggio and Mikkel Søelvsten (June 2022).

N. 1375 – *New facts on consumer price rigidity in the Euro Area*, by Erwan Gautier, Cristina Conflitti, Riemer P. Faber, Brian Fabo, Ludmila Fadejeva, Valentin Jouvanceau, Jan-Oliver Menz, Teresa Messner, Pavlos Petroulas, Pau Roldan-Blanco, Fabio Rumler, Sergio Santork, Elisabeth Wieland and Hélène Zimmer (July 2022).

N. 1376 – *Connecting to power: political connections, innovation, and firm dynamics*, by Ufuk Akcigit, Salomé Baslandze and Francesca Lotti (July 2022).

N. 1377 – *"Green" fiscal policy measures and non-standard monetary policy in the Euro Area*, by Anna Bartocci, Alessandro Notarpietro and Massimiliano Pisani (July 2022).

N. 1378 – *Firm liquidity and the transmission of monetary policy*, by Margherita Bottero and Stefano Schiaffi (July 2022).

N. 1379 – *The impact of Covid-19 on the european short-term rental market*, by Elisa Guglielminetti, Michele Loberto and Alessandro Mistretta (July 2022).

N. 1380 – *An analysis of objective inflation expectations and inflation risk premia*, by Sara Cecchetti, Adriana Grasso and Marcello Pericoli (July 2022).

(*) Requests for copies should be sent to:
Banca d'Italia – Servizio Studi di struttura economica e finanziaria – Divisione Biblioteca e Archivio storico – Via Nazionale, 91 – 00184 Rome – (fax 0039 06 47922059). They are available on the Internet www.bancaditalia.it.

2020

ALESSANDRI P. and M. BOTTERO, *Bank lending in uncertain times,* R European Economic Review, V. 128, **WP 1109 (April 2017).**

ANTUNES A. and V. ERCOLANI, *Public debt expansions and the dynamics of the household borrowing constraint,* Review of Economic Dynamics, v. 37, pp. 1-32, **WP 1268 (March 2020).**

ARDUINI T., E. PATACCHINI and E. RAINONE, *Treatment effects with heterogeneous externalities,* Journal of Business & Economic Statistics, , v. 38, 4, pp. 826-838, **WP 974 (October 2014).**

BALTRUNAITE A., C. GIORGIANTONIO, S. MOCETTI and T. ORLANDO, Discretion and supplier selection in public procurement, Journal of Law, Economics, and Organization, v. 37, 1, pp. 134-166, **WP 1178 (June 2018)**

BOLOGNA P., A. MIGLIETTA and A. SEGURA, *Contagion in the CoCos market? A case study of two stress events,* International Journal of Central Banking, v. 16, 6, pp. 137-184, **WP 1201 (November 2018).**

BOTTERO M., F. MEZZANOTTI and S. LENZU, *Sovereign debt exposure and the Bank Lending Channel: impact on credit supply and the real economy,* Journal of International Economics, v. 126, article 103328, **WP 1032 (October 2015).**

BRIPI F., D. LOSCHIAVO and D. REVELLI, *Services trade and credit frictions: evidence with matched bank – firm data,* The World Economy, v. 43, 5, pp. 1216-1252, **WP 1110 (April 2017).**

BRONZINI R., G. CARAMELLINO and S. MAGRI, *Venture capitalists at work: a Diff-in-Diff approach at late-stages of the screening process,* Journal of Business Venturing, v. 35, 3, **WP 1131 (September 2017).**

BRONZINI R., S. MOCETTI and M. MONGARDINI, *The economic effects of big events: evidence from the Great Jubilee 2000 in Rome,* Journal of Regional Science, v. 60, 4, pp. 801-822, **WP 1208 (February 2019).**

COIBION O., Y. GORODNICHENKO and T. ROPELE, *Inflation expectations and firms' decisions: new causal evidence,* Quarterly Journal of Economics, v. 135, 1, pp. 165-219, **WP 1219 (April 2019).**

CORSELLO F. and V. NISPI LANDI, *Labor market and financial shocks: a time-varying analysis,* Journal of Money, Credit and Banking, v. 52, 4, pp. 777-801, **WP 1179 (June 2018).**

COVA P. and F. NATOLI, *The risk-taking channel of international financial flows,* Journal of International Money and Finance, v. 102, **WP 1152 (December 2017).**

D'ALESSIO G., *Measurement errors in survey data and the estimation of poverty and inequality indices,* Statistica Applicata - Italian Journal of Applied Statistics, v. 32, 3, **WP 1116 (June 2017).**

DE BLASIO G., I. DE ANGELIS and L. RIZZICA, *Lost in corruption. Evidence from EU funding to Southern Italy,* Italian Economic Journal / Rivista italiana degli economisti, v. 6, 3, pp. 355–377, **WP 1180 (December 2016).**

DEL PRETE S. and S. FEDERICO, *Do links between banks matter for bilateral trade? Evidence from financial crises,* Review of World Economic, v. 156, 4, pp. 859 - 885, **WP 1217 (April 2019).**

D'IGNAZIO A. and C. MENON, *The causal effect of credit Guarantees for SMEs: evidence from Italy,* The Scandinavian Journal of Economics, v. 122, 1, pp. 191-218, **WP 900 (February 2013).**

ERCOLANI V. and F. NATOLI, *Forecasting US recessions: the role of economic uncertainty,* Economics Letters, v. 193, **WP 1299 (October 2020).**

MAKINEN T., L. SARNO and G. ZINNA, *Risky bank guarantees,* Journal of Financial Economics, v. 136, 2, pp. 490-522, **WP 1232 (July 2019).**

MODENA F., E. RETTORE and G. M. TANZI, *The effect of grants on university dropout rates: evidence from the Italian case,* Journal of Human Capital, v. 14, 3, pp. 343-370, **WP 1193 (September 2018).**

NISPI LANDI V., *Capital controls spillovers,* Journal of International Money and Finance, v. 109, **WP 1184 (July 2018).**

PERICOLI M., *On risk factors of the stock–bond correlation,* International Finance, v. 23, 3, pp. 392-416, **WP 1198 (November 2018).**

PIETRUNTI M. and F. M. SIGNORETTI, *Unconventional monetary policy and household debt: the role of cash-flow effects,* Journal of Macroeconomics, v. 64, Article 103201, **WP 1142 (October 2017).**

RAINONE E., *The network nature of OTC interest rates,* Journal of Financial Markets, v.47, article 100525, **WP 1022 (July 2015).**

RAINONE E. and F. VACIRCA, *Estimating the money market microstructure with negative and zero interest rates,* Quantitative Finance, v. 20, 2, pp. 207-234, **WP 1059 (March 2016).**

RIZZICA L., *Raising aspirations and higher education. Evidence from the UK's widening participation policy,* Journal of Labor Economics, v. 38, 1, pp. 183-214, **WP 1188 (September 2018).**

RIZZICA L. and M. TONELLO, *Persuadable perceptions: the effect of media content on beliefs about* *corruption,* Economic Policy, v. 35, 104, pp. 679–737, **WP 1043 (November 2016).**

SANTIONI, R., F. SCHIANTARELLI and P. STRAHAN, *Internal capital markets in times of crisis: the benefit of group affiliation*, Review of Finance, v. 24, 4, pp. 773-811, **WP 1146 (October 2017).**

SCHIANTARELLI F., M. STACCHINI and P. STRAHAN, *Bank Quality, judicial efficiency and loan repayment delays in Italy,* Journal of Finance, v. 75, 4, pp. 2139-2178, **WP 1072 (July 2016).**

2021

ACCETTURO A., A. LAMORGESE, S. MOCETTI and D. PELLEGRINO, *Housing Price elasticity and growth: evidence from Italian cities,* Journal of Economic Geography, v. 21, 3, pp. 367-396, **WP 1267 (March 2020).**

AFFINITO M. and M. PIAZZA, *Always look on the bright side? Central counterparties and interbank markets during the financial crisis*, International Journal of Central Banking, v. 17, 1, pp. 231-283, **WP 1181 (July 2018).**

ALBANESE G., E. CIANI and G. DE BLASIO, *Anything new in town? The local effects of urban regeneration policies in Italy,* Regional Science and Urban Economics, v. 86, **WP 1214 (April 2019).**

ALBANESE G., G. DE BLASIO and A. LOCATELLI, *Does EU regional policy promote local TFP growth? Evidence from the Italian Mezzogiorno,* Papers in Regional Science, v. 100, 2, pp. 327-348, **WP 1253 (December 2019).**

ALBERTAZZI A., A. NOBILI and F. M. SIGNORETTI, *The bank lending channel of conventional and unconventional monetary policy,* Journal of Money, Credit and Banking, v. 53, 2-3, pp. 261-299, **WP 1094 (Jan 2017).**

ANZUINI A. and L. ROSSI, *Fiscal policy in the US: a new measure of uncertainty and its effects on the American economy*, Empirical Economics, v. 61, 6, pp. 2613-2634, **WP 1197 (November 2018).**

APRIGLIANO V. and D. LIBERATI, *Using credit variables to date business cycle and to estimate the probabilities of recession in real time*, The Manchester School, v. 89, 51, pp. 76-96, **WP 1229 (July 2019).**

AUER S., M. BERNARDINI and M. CECIONI, *Corporate leverage and monetary policy effectiveness in the euro area,* European Economic Review, v. 140, Article 103943, **WP 1258 (December 2019).**

BANERJEE R, L. GAMBACORTA and E. SETTE, *The real effects of relationship lending,* Journal of Financial Intermediation, v. 48, Article 100923, **WP 1133 (September 2017).**

BARONE G., F. DAVID, G. DE BLASIO and S. MOCETTI, *How do house prices respond to mortgage supply?,* Journal of Economic Geography, v. 21, 1, pp.127-140, **WP 1282 (June 2020).**

BARONE G. and S. MOCETTI, *Intergenerational mobility in the very long run: Florence 1427-2011,* Review of Economic Studies, v. 88, 4, pp. 1863–1891, **WP 1060 (April 2016).**BARTOCCI A., L. BURLON, A. NOTARPIETRO and M. PISANI, *Macroeconomic effects of non-standard monetary policy measures in the Euro Area: the role of corporate bond purchases,* The Manchester School, v. 89, S1, pp. 97-130, **WP 1241 (Oct 2019).**

BATINI N., A. CANTELMO, G. MELINA and S. VILLA, *How loose, how tight? A measure of monetary and fiscal stance for the euro area,* Oxford Economic Papers, v. 73, 4, pp. 1536-1556, **WP 1295 (September 2020).**

BENETTON M. and D. FANTINO, *Targeted monetary policy and bank lending behavior,* Journal of Financial Economics, v. 142, 1, pp. 404-429, **WP 1187 (September 2018).**

BUSETTI F., M. CAIVANO and D. DELLE MONACHE, *Domestic and global determinants of inflation: evidence from expectile regression,* Oxford Bulletin of Economics and Statistics, v. 83, 4, pp. 982-1001, **WP 1225 (June 2019).**

BUSETTI F., M. CAIVANO, D. DELLE MONACHE and C. PACELLA, *The time-varying risk of Italian GDP,* Economic Modelling, v. 101, Article 105522, **WP 1288 (July 2020).**

BUSETTI F., S. NERI, A. NOTARPIETRO and M. PISANI, *Monetary Policy strategies in the new normal: a model-based analysis for the Euro Area,* Journal of Macroeconomics, v. 70, Article 103366, **WP 1308 (December 2020).**

CAPOLONGO A. and C. PACELLA, *Forecasting inflation in the Euro Area: countries matter*, Empirical Economics, v. 61, 4, pp. 2477-2499, **WP 1224 (June 2019).**

CARMIGNANI A., G. DE BLASIO, C. DEMMA and A. D'IGNAZIO, *Urbanization and firm access to credit,* Journal of Regional Science, v. 61, 3, pp. 597-622, **WP 1222 (June 2019).**

CORNELI F., *Financial integration without financial development,* Atlantic Economic Journal, v. 49, 2, pp. 201-220, **WP 1120 (June 2017).**

COVA P., P. PAGANO, A. NOTARPIETRO and M. PISANI, *Secular stagnation, R&D, public investment and monetary policy: a global-model perspective,* Macroeconomic Dynamics, v. 25, 5, pp. 1267-1287, **WP 1156 (December 2017).**

DE PHILIPPIS M., *Multitask agents and incentives: the case of teaching and research for university professors,* Economic Journal, v. 131, 636, pp. 1643-1681, **WP 1042 (December 2015).**

DEL PRETE S. and M. L. STEFANI, *Women as "Gold Dust": gender diversity in top boards and the performance of Italian banks,* Economic Notes, Monte dei Paschi di Siena, v. 50, 2, e12183, **WP 1014 (June 2015).**

FERRERO G., M. LOBERTO and M. MICCOLI, *The assets' pledgeability channel of unconventional monetary policy,* Economic Inquiry, v. 59, 4, pp. 1547-1568, **WP 1119 (June 2017).**

FIDORA M., C. GIORDANO and M. SCHMITZ, *Real exchange rate misalignments in the Euro Area,* Open Economies Review, v. 32, 1, pp. 71-107, **WP 1162 (January 2018).**

GAMBACORTA L., G. RICOTTI, S. SUNDARESAN and Z. WANG, *Tax effects on bank liability structure,* European Economic Review, v. 138, Article 103820, **WP 1101 (February 2017).**

HERTWECK M., V. LEWIS and S. VILLA, *Going the extra mile: effort by workers and job-seekers,* Journal of Money, Credit and Banking, v. 54, 8, pp. 2099-2127, **WP 1277 (June 2020).**

LI F., A. MERCATANTI, T. MAKINEN and A. SILVESTRINI, *A regression discontinuity design for ordinal running variables: evaluating central bank purchases of corporate bonds,* The Annals of Applied Statistics, v. 15, 1, pp. 304-322, **WP 1213 (March 2019).**

LOSCHIAVO D., *Big-city life (dis)satisfaction? The effect of urban living on subjective well-being,* Journal of Economic Behavior & Organization, vol. 192, pp. 740-764, **WP 1221 (June 2019).**

LOSCHIAVO D., *Household debt and income inequality: evidence from Italian survey data,* Review of Income and Wealth. v. 67, 1, pp. 61-103, **WP 1095 (January 2017).**

METELLI L. and F. NATOLI, *The international transmission of US tax shocks: a proxy-SVAR approach,* IMF Economic Review, v. 69, 2, pp. 325-356, **WP 1223 (June 2019).**

NISPI LANDI V. and A. SCHIAVONE, *The effectiveness of capital controls,* Open Economies Review, v. 32, 1, pp. 183-211, **WP 1200 (November 2018).**

PAPETTI A., *Demographics and the natural real interest rate: historical and projected paths for the Euro Area,* Journal of Economic Dynamics and Control, v. 132, Article 04209, **WP 1306 (November 2020).**

PEREDA FERNANDEZ S., *Copula-based random effects models for clustered data,* Journal of Business & Economic Statistics, v. 39, 2, pp. 575-588, **WP 1092 (January 2017).**

2022

ANDINI M., M. BOLDRINI, E. CIANI, G. DE BLASIO, A. D'IGNAZIO and A. PALADINI, *Machine learning in the service of policy targeting: the case of public credit guarantees,* Journal of Economic Behavior & Organization, v. 198, pp. 434-475, **WP 1206 (February 2019).**

ANGELICO C., J. MARCUCCI, M. MICCOLI and F. QUARTA, *Can we measure inflation expectations using twitter?,* Journal of Econometrics, v. 228, 2, pp. 259-277, **WP 1318 (February 2021).**

BOTTERO M., C. MINOIU, J. PEYDRÒ, A. POLO, A. PRESBITERO and E. SETTE, *Expansionary yet different: credit supply and real effects of negative interest rate policy,* Journal of Financial Economics, v. 146, 2, pp. 754-778, **WP 1269 (March 2020).**

CANTELMO A., *Rare disasters, the natural interest rate and monetary policy,* Oxford Bulletin of Economics and Statistics, v. 84, 3, pp. 473-496, **WP 1309 (December 2020).**

CARRIERO A., F. CORSELLO and M. MARCELLINO, *The global component of inflation volatility,* Journal of Applied Econometrics, v. 37, 4, pp. 700-721, **WP 1170 (May 2018).**

CIAPANNA E. and G. ROVIGATTI, *The grocery trolley race in times of Covid-19. Evidence from Italy,* Italian Economic Journal / Rivista italiana degli economisti, v. 8, 2, pp. 471-498, **WP 1341 (June 2021).**

FAIELLA I. and A. MISTRETTA, *The net zero challenge for firms' competitiveness,* Environmental & Resource Economics, v. 83, pp. 85-113, **WP 1259 (February 2020).**

GUISO L., A. POZZI, A. TSOY, L. GAMBACORTA and P. E. MISTRULLI, *The cost of steering in financial markets: evidence from the mortgage market,* Journal of Financial Economics, v.143, 3, pp. 1209-1226, **WP 1252 (December 2019).**

LAMORGESE A. and D. PELLEGRINO, *Loss aversion in housing appraisal: evidence from Italian homeowners,* Journal of Housing Economics, v. 56, Article 101826, **WP 1248 (November 2019).**

LI F., T. MÄKINEN, A. MERCATANTI and A. SILVESTRINI, *Causal analysis of central bank holdings of corporate bonds under interference,* Economic Modelling, v.113, Article 105873, **WP 1300 (November 2020).**

MIRENDA L., M. SAURO and L. RIZZICA, *The economic effects of mafia: firm level evidence,* American Economic Review, vol. 112, 8, pp. 2748-2773, **WP 1235 (October 2019).**

MOCETTI S., G. ROMA and E. RUBOLINO, *Knocking on parents' doors: regulation and intergenerational mobility,* Journal of Human Resources, v. 57, 2, pp. 525-554, **WP 1182 (July 2018).**

ROSSI P. and D. SCALISE, *Financial development and growth in European regions,* Journal of Regional Science, v. 62, 2, pp. 389-411, **WP 1246 (November 2019).**

SCHIVARDI F., E. SETTE and G. TABELLINI, *Credit misallocation during the European financial crisis,* Economic Journal, v. 132, 641, pp. 391-423, **WP 1139 (September 2017).**

TABOGA M., *Cross-country differences in the size of venture capital financing rounds: a machine learning approach,* Empirical Economics, v. 62, 3, pp. 991-1012, **WP 1243 (November 2019).**

FORTHCOMING

APRIGLIANO V., S. EMILIOZZI, G. GUAITOLI, A. LUCIANI, J. MARCUCCI and L. MONTEFORTE, *The power of text-based indicators in forecasting Italian economic activity,* International Journal of Forecasting, **WP 1321 (March 2021).**

BRONZINI R., A. D'IGNAZIO and D. REVELLI, *Financial structure and bank relationships of Italian multinational firms,* Journal of Multinational Financial Management, **WP 1326 (March 2021).**

FERRARI A. and V. NISPI LANDI, *Toward a green economy: the role of central bank's asset purchases,* International Journal of Central Banking, **WP 1358 (February 2022).**

LILLA F., *Volatility bursts: a discrete-time option model with multiple volatility components,* Journal of Financial Econometrics, **WP 1336 (June 2021).**

LOBERTO M, *Foreclosures and house prices,* Italian Economic Journal / Rivista italiana degli economisti, **WP 1325 (March 2021).**

LOBERTO M, A. LUCIANI and M. PANGALLO, *What do online listings tell us about the housing market?,* International Journal of Central Banking, **WP 1171 (April 2018).**

PERICOLI M. and M. TABOGA, *Nearly exact Bayesian estimation of non-linear no-arbitrage term-structure models,* Journal of Financial Econometrics, **WP 1189 (September 2018).**

RIZZICA L., G. ROMA and G. ROVIGATTI, *The effects of shop opening hours deregulation: evidence from Italy,* The Journal of Law and Economics, **WP 1281 (June 2020).**

TANZI G. M., *Scars of youth non-employment and labour market conditions,* Italian Economic Journal / Rivista italiana degli economisti, **WP 1312 (December 2020).**