Directed innovation policies and the supermultiplier: 

An empirical assessment of mission-oriented policies in the US economy

Matteo Deleidi and Mariana Mazzucato

Matteo Deleidi
Research Fellow
Institute for Innovation and Public Purpose (IIPP), University College London, 11 Montague Street, London, WC1B 5BP, UK
Parthenope University of Naples, Department of Business and Economics, Palazzo Pacanowski, Via Generale Parisi 13, 80132, Naples, Italy
Roma Tre University, Department of Economics, Via Silvio D’Amico 77, 00148, Rome, Italy
E-mail: m.deleidi@ucl.ac.uk

Mariana Mazzucato
Professor in the Economics of Innovation and Public Value
Director of the Institute for Innovation and Public Purpose (IIPP), University College London, 11 Montague Street, London, WC1B 5BP, UK
E-mail: m.mazzucato@ucl.ac.uk

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Abstract

This paper investigates the determinants of economic growth from both a theoretical and an empirical perspective. The paper combines the supermultiplier model of growth with the Neo-Schumpeterian framework that emphasises the entrepreneurial role of the state. We aim to detect the macroeconomic effect generated by alternative fiscal policies: generic ones and more directed ‘mission-oriented’ ones. Using an SVAR model for the US economy for the 1947–2018 period, we show that mission-oriented policies produce a larger positive effect on GDP (fiscal multiplier) and on private investment in R&D (crowd-in effect) than the one generated by more generic public expenditures.

Keywords: Directed technical change, mission-oriented innovation policies, Sraffian supermultiplier, fiscal multiplier, crowding-in effect

JEL codes: C32, E22, E62, O25, O30
1. Introduction

After the 2007 financial crisis, several advanced countries implemented austerity policies which were accompanied by labour market reforms aimed at increasing competitiveness through a reduction in labour costs. Austerity, defined as a retrenchment of government expenditure to boost private consumption and investment through a reduction in interest rates, finds its theoretical justification in the theory of ‘expansionary austerity’ (Alesina et al., 2018). According to this perspective, fiscal consolidation is supposed to foster economic growth, because the fiscal multiplier is assumed to be zero or even negative. While the assumption was that growth and competitiveness would return through the effect of fiscal consolidation policies on the alleviation of financial market speculation and the reduction of sovereign debt bond spreads, the reality soon became clear: growth did not return. Instead labour market reforms fuelled inequality without resulting in higher investment and lower unemployment, and financial markets remained vulnerable.

Over the last few years, the effectiveness of fiscal consolidation policies in fostering economic growth has been questioned by a growing literature (e.g. De Leidi et al., 2020a, 2020b; Fatás and Summers, 2018). Even the International Monetary Fund (IMF), which has been one of the key proponents of fiscal consolidation policies, affirmed that austerity has led to weak growth and increased inequality (Ostry et al., 2016). Olivier Blanchard, former chief economist of the IMF, stated that austerity failed because the fiscal multiplier was higher than those assumed by economists. Indeed, Blanchard and Leigh (2013) argue that the fiscal multiplier assumes a positive value close to 1.5, suggesting that a fiscal consolidation generates a standard Keynesian effect, namely causing an economic recession rather than an alleged expansion. Similarly, Fatás and Summers (2018) show that fiscal consolidation policies generate permanent and long-term negative effects on potential output, through a mechanism termed ‘hysteresis’ (Ball, 2014; Yellen, 2016). Finally, the IMF’s World
Economic Outlook of October 2014 claimed that economic growth depended on governments creating a global infrastructure push, rather than cutting spending.

In this paper we build on these premises of the benefits of public investment, but go further. We argue that, rather than simply arguing for generic public investment in areas like infrastructure (and other ‘shovel-ready projects’), it is essential to assess different types of fiscal policies. These can be broken down into generic government spending aimed at fixing market failures of different types versus directed government investment aimed at promoting structural change and transformation. This work builds on the work on directed innovation (Acemoglu, 2002; Acemoglu et al., 2012), but goes further. To study directed innovation we look at mission-oriented innovation policies that have been historically directed at solving key problems and creating markets, not (just) fixing them (Nelson, 2009; Mazzucato, 2016, 2018a). The hypothesis is that such investments have a greater multiplier effect as they involve many different sectors in the economy. For example, the types of investments needed to go to the moon required investments in aeronautics, materials, textiles, electronics, robotics and what eventually became software. The spillovers that result from such investments are by definition higher due to their inter-sectoral character. And there is still little to no research that looks at the degree to which their macroeconomic impacts are stronger or not.

To look at the macroeconomic effects of different types of investments the paper brings together the innovation literature with the macroeconomic literature. Specifically, we: (i) combine the Sraffian supermultiplier model of growth (e.g., Serrano, 1995; Cesaratto et al., 2003; Freitas and Serrano, 2015; Deleidi and Mazzucato, 2019) with the Neo-Schumpeterian framework that underlines the entrepreneurial role of the state (Mowery, 2010; Mazzucato, 2013); (ii) consider the macroeconomic effect of mission-oriented innovation policies; and (iii) estimate the effect of mission-oriented innovation policies and generic government
spending on GDP (i.e. fiscal multiplier) and on private R&D investment (i.e. crowding-in versus crowding-out mechanism). Our theoretical and empirical findings show that mission-oriented policies generate a larger effect on GDP and on private investment in R&D than generic public expenditures.

The paper is organised as follows. In Section 2, the Sraffian supermultiplier model of growth, which includes mission-oriented policies, is presented. After the presentation of data and methods in Section 3, Section 4 provides the empirical findings estimated using Structural Vector Autoregression (SVAR) models applied to US quarterly data for the 1947–2018 period. Section 5 concludes with a discussion of the policy implications of our results.

2. The Sraffian supermultiplier

The Sraffian supermultiplier model (henceforth, SSM) of growth relates the determination of economic output with effective demand. This model extends the so-called ‘Keynesian hypothesis’ to the long run, namely the idea of savings as determined by investment decisions in both the short and long run (Garegnani, 1992). In the SSM, output growth is driven by the growth rate of the autonomous components of aggregate demand and the traditional Keynesian multiplier effect (Keynes, 1936) is combined with an investment function grounded on the flexible accelerator principle. Following Deleidi and Mazzucato (2019), this paper introduces the notion of mission-oriented innovation policies within the SSM model by considering the Neo-Schumpeterian framework, which emphasises the relevant role played by targeted R&D public policies in affecting the direction and diffusion of innovation processes (e.g. Corredoira et al., 2018; Edquist and Zabala-Iturriagagoitia, 2012; Foray et al., 2012; Mazzucato, 2016, 2018a).

To start, we need to classify the components of aggregate demand, distinguishing between (i) autonomous and induced, and (ii) capacity- or non-capacity-creating. Table 1
shows this classification, where business expenditures, government spending and total consumption are non-capacity-creating, and only gross investment is able to create productive capacity. Public expenditure, autonomous consumption and autonomous business expenditures are independent of current level of income.

[INSERT HERE TABLE 1]

For the sake of simplicity, we consider a closed economy. The current level of output ($Y$) is equal to aggregate demand, which is composed by: total consumption ($C$), business expenditure ($BE$), gross investment ($I_t$) and public expenditure ($G$). This is shown in equation (1):

$$Y = C + BE + I_t + G$$  \hspace{1cm} (1)

where all variables are considered in real terms. Equation (2) represents the consumption function, which includes an autonomous and an induced component:

$$C = C_a + c \cdot Y_D$$  \hspace{1cm} (2)

$C_a$ represents autonomous consumption that could be financed in the credit market via an endogenous money creation process (Pariboni, 2016). In equation (2), the induced component depends on the disposable income $Y_D$, where $c$ is the marginal propensity to consume, assumed to be lower than one. When the disposable income ($Y_D \equiv Y - T$) and total taxes ($T \equiv T_a + t \cdot Y$) are substituted in equation 2, the consumption function can be written as follows in equation (3):

$$C = C_a - c \cdot T_a + c \cdot (1 - t) \cdot Y$$  \hspace{1cm} (3)
The gross investment function is shown in equation (4). In the SSM, investment \( I_i \) is fully induced, and is positively affected by the replacement coefficient \( (d) \) and by the normal capital-output ratio \( (v) \) representing the technical conditions of production.\(^{iii}\) Moreover, the actual level of effective demand and its expected growth \( (g_e) \) exert a positive effect on investment \( (I_i) \): firms increase investment in order to satisfy a greater expected demand:\(^{iv}\)

\[
I_i = v \times (d + g_e) \times Y
\]  
(4)

The investment function in equation 4 does not imply that the actual degree of capacity utilisation \( (u) \) is equal to the normal one \( (u_n) \), though a continuous process of adjustment of the former towards the latter is operational.\(^{v}\) In the long run, a slow and gradual adjustment of the capital stock is driven by changes in long-term expectations \( (g_e) \) and by a flexible accelerator mechanism. Firms adjust their capital stock by increasing (when \( g_y > g_e \)) and decreasing (when \( g_y < g_e \)) investment gradually over time rather than in one single period:\(^{vi}\)

\[
G = G_1 + G_2
\]  
(5)

Equation (5) represents government spending, which consists of two components. While the former is a more generic spending based on the purchase of goods and services \( (G_1) \), the latter aims at promoting structural change, namely stimulating technical progress by means of industrial policies \( (G_2) \). For instance, mission-oriented innovation expenditures can be included in \( G_2 \). These have led to major technological advances, such as the ARPA-E (Department of Energy) investments in renewable energy; the DARPA (Department of Defense) investment in ARPANET, which became the modern-day internet; or the National Institutes of Health investments in the biotechnology sector (Block and Keller, 2009, 2011; Mowery et al., 2010; Anadón, 2012; Sampat, 2012; Mazzucato, 2018a, 2018b).\(^{vii}\) By
addressing grand societal challenges (Mazzucato, 2018a, 2018b), these types of public expenditure *de facto* operate as an industrial policy (Moretti et al., 2019), and represent a crucial channel through which governments foster and shape innovation processes by actively creating new markets through mission-oriented objectives (Edquist and Zabala-Iturriagagoitia, 2012; Mazzucato, 2016; Mowery, 2012). Such policies are the most important forward-looking industrial policies oriented to finding solutions for technical problems, speeding up innovation and stimulating productivity growth (Tavani and Zamparelli, 2018), because they lead to new technological opportunities and directions for technical change (Corredoira et al., 2018):

\[ BE = BE_a + \gamma \ast G_2 \]  

(6)

Equation (6) shows the business expenditure (*BE*). In *BE*, we can include managerial expenses, for example, unproductive consumption and R&D private expenditures. We include in the autonomous *BE_a* the unproductive consumption (e.g. the purchase of a company car, executive jet and marketing expenditure) and a share of R&D due to an intrinsic capitalist competition. Firms’ R&D is also endogenously affected by targeted public expenditures oriented to promote innovation (Mazzucato, 2013; Mazzucato and Semieniuk 2017). These policies are able to induce and positively affect private firms’ R&D (Mazzucato, 2016, 2018a; Moretti et al., 2019; Deleidi et al., 2020) by also generating spin-offs, through which research and innovation are developed and diffused to other sectors (Crespi and Guarascio, 2019; Mowery, 2010, 2012). In these cases, state intervention creates new landscapes, rather than simply fixing market failures (Mazzucato, 2016), which results in an increase in private expenditure through a crowding-in effect. That may occur for the following reasons. First, targeted government expenditures aimed at promoting innovation and creating new markets can stimulate the expectations of business (Mazzucato, 2013,
Second, government R&D investment generates technological spillovers that create advantages for other private firms (David et al., 2000; Moretti and Wilson, 2014; Moretti et al., 2019). Third, R&D activities are typically based on large fixed costs (for instance, labs, high-skilled labour and research activities) that can be used for multiple projects. If government finances part of these costs, some of the private R&D investment projects become profitable for private firms (Moretti et al., 2019). Fourth, defence R&D investment affects private R&D by generating spinoffs in both civilian and defence-related industries (Pivetti, 1992; Mowery, 2010). Fifth, public-funded R&D activities could relax financial and credit constraints by lowering the firms’ riskiness associated with such activities (Moretti et al., 2019). Sixth, mission-oriented R&D investment is based on contracts, partnerships and cooperative agreements between public-private organisations, which have historically required the commitment and the co-investment of both public and private actors (Mowery, 2010, 2012; Mazzucato and Semieniuk 2018; Robinson and Mazzucato, 2019). For the abovementioned arguments, we introduce in equation (6) \( \gamma \), which is a coefficient assuming positive values (\( \gamma > 0 \)) that shows how an increase of \( G_2 \) leads to an endogenous rise in firms’ BE. In particular, the size of \( \gamma \) depends on the capacity of industrial policy to capture and involve more sectors in the economy. For instance, an industrial policy focused on one specific sector will show a lower \( \gamma \) compared to a policy that involves several sectors across the economy, as in the case of mission-oriented policies (Mazzucato, 2018a).

Equation (1) and equations (3) to (6) allow the output supermultiplier to be obtained. The level of output in equation (7) is determined by autonomous components of demand (numerator of equation (7)) and by the supermultiplier (denominator of equation (7)). As shown in equation (7), government spending targeted toward strategic sectors (\( G_2 \)) – as in the case of mission-oriented policies – generates the largest effect on output level, while changes in taxes (\( T_a \)) produce the lowest effect on GDP, as \( c \) is lower than one:
\[ Y = \frac{c_a - c \cdot T_a + BE_a + G_1 + (1 + \gamma) \cdot G_2}{1 - c \cdot (1 - \tau) - \nu \cdot (d + g_e)} \]  

(7)

The numerator of equation (7) can be termed as \( Z \) (where \( Z = c_a - c \cdot T_a + BE_a + G_1 + (1 + \gamma) \cdot G_2 \)) and the marginal propensity to save as \( s \) (where \( s = 1 - c \cdot (1 - \tau) \)). The output supermultiplier can be also represented by equation (8):

\[ Y = \frac{Z}{s - \nu \cdot (d + g_e)} \]  

(8)

As shown in equation (8), a rise in the autonomous components of aggregate demand, as well as a reduction in the marginal propensity to save, leads to an increase in total output.\(^{ix}\) The output level in equation (8) is not necessarily combined with a normal degree of the capacity utilisation \( (u_n) \). However, \( u_n \) must be considered as a centre of gravitation towards which the actual degree of capacity utilisation \( (u) \) is attracted. This attraction occurs through a continuous tendency of productive capacity to adjust to the trend of effective demand through gradual changes in investment behaviour. Such changes occur by means of reconsiderations by entrepreneurs about the expected rate of growth of the effective demand \( (\hat{g}_e) \), based on the current growth rate \( (g_y) \). The behaviour through time of long-term expectations about the growth of effective demand can be represented by equation (9):

\[ \hat{g}_e = \chi \cdot (g_y - g_e) \]  

(9)

where \( \chi \) assumes positive values less than 1 \( (0 < \chi < 1) \), and a gradual process of the revision of the expectations (equation 9) allows a tendency to the alignment of the actual output growth rate \( (g_y) \) and the expected growth rate \( (g_e) \). The larger is the effect on output
(\(g_y\)), for instance driven by an increase in government spending, the greater will be the effect on the variation of expectation of growth (\(\hat{g}_e\)).\(^x\)

Analysing dynamically equation (8), we can represent the rate of growth of output in equation (10):

\[
g_y = g_x + \frac{\nu^*(\hat{g}_e)}{s - \nu^*(d + g_e)}
\]  

(10)

where \(g_x\) is the rate of growth of the autonomous components of aggregate demand, and \(\hat{g}_e\) represents the change over time of the expected growth rate of demand. Similarly, when the investment function (4) is analysed dynamically, the rate of growth of investment (\(g_I\)) can be summarised by equation (11):

\[
g_I = g_y + \frac{\hat{g}_e}{d + g_e}
\]  

(11)

meaning that the rate of growth of investment depends on the growth rate of output and the evolution of expected demand.

In light of this model, we can understand that the rate of output growth and investment is strictly related to the rate of growth of autonomous components of demand passing through a multiplier and an accelerator effect. When analysing the effect of different types of fiscal policy, mission-oriented policy has the potential to generate the largest effect on output through a positive impact on private investment in R&D (Deleidi and Mazzucato, 2019), which in turn produces the largest effect on expectations of growth (equation 9) and on investment (equation 11).

3. Methodology
To assess the relationships predicted by the macroeconomic model developed in Section 2, we will estimate the effect of mission-oriented innovation policies on selected macroeconomic variables, namely on the level of GDP and on private investment in R&D. The impact of fiscal policies on GDP and on its component is usually measured through the estimations of the so-called fiscal multipliers, namely the output response to an exogenous fiscal policy shock. In recent years, the debate around the magnitude of fiscal multipliers has assumed particular relevance, especially after the US financial crisis. However, little to no literature exists on the macroeconomic effects of mission-oriented innovation policies, especially in comparison with classes of public expenditure not targeted at promoting radical structural transformation in the economy.

The macroeconomic literature on fiscal policies is based on three main methods for estimating fiscal multipliers: (i) simulations built within dynamic stochastic general equilibrium (DSGE) models (see, among others, Leeper et al., 2017); (ii) the narrative approach, which consists in building dummy variables corresponding to exogenous historical episodes of changes in fiscal policy stances, typically used in VAR models (see, among others, Ramey and Shapiro; 1998; Romer and Romer, 2010; Ramey, 2011, 2016); and (iii) SVAR models, which allow us to isolate exogenous components of the fiscal variables by imposing an identification strategy (e.g. Auerbach and Gorodnichenko, 2012; Blanchard and Perotti, 2002; Caldara and Kamps, 2008; Perotti, 2004, 2014). The SVAR method enables us to consider the effects of a broader set of fiscal interventions and to provide an objective quantitative estimate of the effects of an average increase in different classes of government expenditures. This approach can be regarded as the most general approach, as results are not affected by: (i) the choice of parameters and the calibration of models or (ii) the selection of the relevant dummies, which relies on a more qualitative and subjective assessment of the nature of the fiscal episodes. Generally, the empirical literature estimates the fiscal multiplier
associated with government expenditure as showing that GDP increases in response to a
government spending shock (see, among others, Auerbach and Gorodnichenko, 2012;
Blanchard and Perotti, 2002; Caldara and Kamps, 2008). However, the magnitude assumed
by fiscal multipliers varies among different studies (Gechert, 2015) and is dependent on
several countries’ peculiarities, for example the accumulated public debt, the exchange rate
regime, the degree of development and the openness to trade (Ilzetzki et al., 2013). While the
main existing literature focuses on assessing the effect of total government expenditure on
GDP, few works focus on selected classes of public expenditures, namely public
consumption versus government investment (Boehm, 2019; Ilzetzki et al., 2013; Pappa, 2009;
Perotti, 2004) and military versus non-military expenditure (Auerbach and Gorodnichenko,
2012; Burriel et al., 2010). When government expenditure is broken down, Boehm (2019),
Ilzetzki et al (2013), Pappa (2009) and Perotti (2004) show that public investment is no more
effective than government consumption in boosting GDP growth. Contrarily, Auerbach and
Gorodnichenko (2012) and Burriel et al. (2010) show that the fiscal multiplier associated
with government investment is larger than the one estimated for government consumption.
Additionally, when Auerbach and Gorodnichenko (2012) distinguish between defence and
non-defence expenditure, they claim that the former generates the largest effect on the GDP
level.\textsuperscript{xii}

In parallel to the fiscal multiplier literature, a widespread – though mixed – empirical
literature has estimated the effect of alternative types of fiscal policies on the level of private
investment in R&D. Specifically, Aschhoff and Sofka (2009), Draca (2013), and Guellec and
Van Pottelsberghe De La Potterie (2003) show that direct public R&D investment generates a
positive effect on private R&D investment. Moretti et al. (2019) find strong evidence of a
crowd-in effect produced by defence expenditures in 27 OECD countries. Similarly,
Slavtchev and Wiederhold (2016) find that a $1.00 increase in high-tech procurement raises
private R&D of $0.21. In contrast, other studies have supported the idea that government R&D expenditures crowd out private R&D investment (see, among others, Bronzini and Iachini, 2014; Goolsbee, 1998; Wallsten, 2000). According to supporters of the crowding-out thesis, demand shocks are supposed to: (i) displace scientific and engineering manpower because of an inelastic short-run labour supply (Goolsbee, 1998; Lichtenberg, 1989, 1995); and (ii) increase the level of prices rather than real private R&D investment (Cowan and Foray, 1995; Walker, 1993).

In the present paper we make use of the SVAR modelling to estimate the macroeconomic effect of alternative classes of fiscal policy for the US economy, considering the period 1947Q1–2018Q3. The estimated SVAR will enable us to simultaneously assess:

1. the magnitude of the fiscal multipliers associated with alternative types of fiscal policies, namely mission-oriented innovation and generic policies; and
2. the effect on private R&D expenditures (crowding-in versus crowding-out effect) generated by the two considered fiscal policies.

Compared to existing literature, this is the first paper to: (i) estimate the fiscal multiplier associated with mission-oriented innovation policies; and (ii) analyse the effect generated by different classes of government spending on private investment in R&D.

3.1. Data

To estimate the effect of different classes of public expenditures, we make use of quarterly data for the US economy provided by the Bureau of Economic Analysis (BEA) for the 1947–2018 period. Specifically, the gross domestic product ($Y$), government consumption and investment expenditures ($G$), and private research and development expenditure ($R&D$) are the variables included in the dataset. To account for the effects of different classes of spending, we break down $G$ as follows: (i) $G_{MO}$, which is the federal national defence
government gross investment in research and development; and (ii) $G_R$, which is the residual of total government expenditure $G$, when $G_{MO}$ is subtracted. Following Mowery (2010, 2012), Mowery et al. (2010), and Robinson and Mazzucato (2019), $G_{MO}$ – which is defence-related R&D funded by public agencies – can be regarded as an example of mission-oriented R&D, where the defence component represents the most important part. Thus, the public defence R&D investment is our proxy for capturing the effect on GDP and on private R&D of mission-oriented innovation policies.xii

All variables are expressed in real terms as they are divided by the implicit price deflator (2012 base year). As variables are considered in logarithm form and thus findings are expressed in elasticities, it is necessary to multiply each coefficient by the corresponding ex-post conversion factor to obtain the partial derivatives. Only after this transformation do coefficients express dollar-change in $Y$ and in $R&D$, in response to a one-dollar increase in the selected government expenditure.xiii All modelled variables are plotted in Figure 1, and summarised in Table 2 and in Appendix A.1., Table A.1.

[INSERT HERE FIGURE 1]

[INSERT HERE TABLE 2]

3.2. Methods
In this paper the SVAR methodology is used to detect the effect of $G_{MO}$ and $G_R$ on $R&D$ and $Y$. The estimated model includes four variables: $G_{MO}$, $G_R$, $R&D$, and $Y$.

As a first step, a standard unit root test is conducted to understand the order of integration of the variables. For this purpose, the Phillips-Perron Test is performed (Phillips and Perron, 1988). As shown in Appendix A.2. (Table A.2), all considered variables are I(1) at level and become I(0) when the first difference is considered. In our model, we make use
of variables at the first difference. Secondly, we conduct the optimal lag length of the VAR by minimising the Akaike Information Criterion (AIC), which suggests five quarters as the optimal lag (Appendix A.3., Table A.3).

To estimate a SVAR model, we start by estimating a reduced-form VAR(p) as shown in equation (12):

\[ y_t = c + \sum_{t=1}^{p} A_t y_{t-p} + u_t \]  \hspace{1cm} (12)

where \( y_t \) is the \( k \times 1 \) vector of considered variables, \( c \) is the constant term, \( A_t \) is the \( k \times k \) matrix of reduced-form coefficients, and \( u_t \) is a \( k \times 1 \) vector composed by the error terms.

To study the effect of changes in different classes of government spending on GDP and private R&D, we need to isolate the exogenous changes in the fiscal policy stances. To do this an identification strategy is imposed on the reduced-form VAR(p), which in turn makes it possible to obtain a SVAR(p). More formally, a SVAR(p) can be represented as follows in equation (13):

\[ B_0 y_t = a + \sum_{t=1}^{p} B_t y_{t-p} + w_t \]  \hspace{1cm} (13)

where \( B_0 \) represents the matrix of contemporaneous relationships between the \( k \) variables in \( y_t \), \( B_t \) is the \( k \times k \) matrix of autoregressive slope coefficients and \( w_t \) is the vector of serially uncorrelated structural shocks. The covariance matrix of structural errors is normalised: \( \mathbb{E}(w_t w_t^T) = \sum_w = I_k \). The identification of the structural model requires us to impose at least \( (k^2 - k)/2 \) restrictions on \( B_0 \), which are based on intuitions derived from economic theory (Kilian and Lütkepohl, 2017). To do this, we implement an identification scheme based on short-run exclusion restrictions and a recursive ordering (Bachmann and Sims, 2012; Bilbiie
et al., 2008). Specifically, by imposing a lower-triangular structure, the identification strategy used can be summarised as follows in equation (14):

\[
B_0 \gamma_t = \begin{bmatrix}
- & 0 & 0 & 0 \\
- & - & 0 & 0 \\
- & - & - & 0 \\
- & - & - & - \\
\end{bmatrix}
\begin{bmatrix}
G_{MO,t} \\
G_{R,t} \\
R&\&D_t \\
Y_t \\
\end{bmatrix}
\] (14)

where ‘−’ indicates an unrestricted parameter and 0 represents zero restriction. In the spirit of Auerbach and Gorodnichenko (2012), and of industrial economic literature (Moretti et al., 2019; Mowery, 2010, 2012), \( G_{MO} \) is regarded as the most exogenous variable. Within the quarter, \( G_{MO} \) is completely independent of other variables considered in the model as it is assumed to not respond to contemporaneous changes in \( G_R, R&\&D \) and \( Y \). Such a choice is dictated by the fact that military R&D expenditures are strategic investment, which can be considered as an exogenous component, as ‘allocation decisions were based on assessments by policymakers of the research needs of specific agency missions’ (Mowery, 2010, p. 1223). Specifically, changes in military R&D can be considered as exogenous variations reflecting political and military priorities that are independent of, for example, GDP and productivity shocks (Moretti et al., 2019; Mowery, 2012). In the second equation, the residual government spending \( G_R \) can be affected only by \( G_{MO} \). In the third equation, private R&D investment is affected within the quarter by \( G_R \) and \( G_{MO} \), but not by GDP. Here, we assume that firms – in order to change their investments in R&D – have to perceive permanent changes in the level of GDP that cannot be verified in one quarter only. Finally, the fourth equation defines that GDP is affected by all the other three variables within the same quarter.\textsuperscript{xiv}

After the imposition of restrictions on the contemporaneous matrix \( B_0 \), the SVAR estimation is implemented by means of the maximum likelihood estimator. Once we have estimated \( B_0 \), we calculate the impulse response function (IRF) as shown in equation (15):
\[ y_t = \mu + \sum_{i=0}^{\infty} \theta_i w_{t-i} \]  \hspace{1cm} (15)

where \( \theta_n \) represents the response of the variables in \( y_t \) to a 1% increase in one of the shocks contained in \( w_t \) after \( n \) quarters have passed.\textsuperscript{xv} As our variables are expressed in logarithms, the original IRFs are rescaled by an \textit{ex-post} conversion factor that allows us to convert elasticities into partial derivatives. Only after this transformation can we interpret coefficients as the response of GDP (\( Y \)) to a one-dollar increase in government spending. Finally, standard errors are estimated through a Monte Carlo procedure based on 1000 repetitions, and, following Blanchard and Perotti (2002), IRFs are reported with one standard error bound, namely a 68% confidence interval.\textsuperscript{xvi}

4. Findings

In this section, we report the findings of the estimated SVAR by showing impulse response functions (IRFs) as well as cumulative multipliers. Specifically, when the IRFs are estimated, the government spending shock is equal to one dollar at the impact, while the dynamic of the shock can change throughout the selected period. To be precise, an exogenous increase in government spending is usually accompanied by a persistent dynamic, implying that an initial government spending shock may build up over time, stabilising on a value greater than one. This clarification is necessary to comprehend the difference between the IRF, which shows the dynamic effect at some horizon of the response variable after an initial shock, and the cumulative multiplier, which represents the response of \( Y \) per unit of government spending. In our analysis, the cumulative multipliers are estimated through the ratio between the cumulative variation of \( Y \) and the cumulative change in the considered public expenditure
(Spilimberto et al., 2009). The cumulative multiplier can be expressed as follows in equation (16):

\[ M_{cum} = \frac{\sum_{j=0}^{n} \Delta Y_{(t+j)}}{\sum_{j=0}^{n} \Delta G_{(t+j)}} \]  

where \( \sum_{j=0}^{n} \Delta Y_{(t+j)} \) is the sum of the GDP response (from \( t \) to \( t + n \)) to the sum of the impulse of considered government spending \( \sum_{j=0}^{n} \Delta G_{(t+j)} \) (from \( t \) to \( t + n \)). In our analysis, the same estimations are carried out for private investment in R&D. Using this method, we can calculate the response of \( Y \) and \( R&D \) per unit of spending. In the main text, we report the value assumed by IRFs and cumulative multipliers after the ex-post transformation. The value of the elasticities is reported in Appendix B, Table B.1.

In Figure 2, the estimated IRFs show the dynamic response of \( Y \) and \( R&D \) to different exogenous public government shocks, namely \( G.MO \) and \( G.R \). Findings show that mission-oriented innovation policies \( G.MO \) generate a larger and positive effect both on GDP and on private R&D investment than \( G.R \). Moreover, in line with hysteresis literature (Fatás and Summers, 2018; Yellen, 2016), our results illustrate that demand management policies are able to generate permanent and persistent effects on the level of output. Particularly, an increase in government expenditures is found to create a positive and permanent effect both on the level of output and on private investment in R&D.

[INSERT HERE FIGURE 2]

IRFs in Figure 2 show that an exogenous shock to \( G.MO \) and \( G.R \) is found to be persistent: \( G.MO \) reaches a peak value of 10.63 after eight years, whereas \( G.R \) attains a value of 2.52 after 14 quarters and remains close to that level even after eight years. When we look at the effect of mission-oriented expenditure \( G.MO \) on \( Y \), reported in Table 3, the multiplier is
significant and equal to 23.957 on impact and reaches a peak after four quarters assuming a significant value of 54.941. The long-run multiplier, estimated at a horizon of 32 quarters, is not significant and equal to 43.402. The effect of $G_{MO}$ on private investment in R&D is significant at all considered horizons. Specifically, a $G_{MO}$ shock generates an effect of 0.745 at the impact and creates a peak of 6.015 after 32 quarters. In this case, the long-run effect on $R&D$ and the peak effect correspond. As shown in Figure 2, an exogenous shock to $G_R$, which represents an increase in government consumption expenditures and gross investment (excluded $G_{MO}$), yields a significant effect on $Y$ at all considered horizons. When the effect on $Y$ is analysed, $G_R$ creates an impact multiplier of 0.741, a peak effect after 10 quarters of 1.866 and a long-run multiplier of 1.545. The effect of a $G_R$ shock on $R&D$ is significant only after seven quarters; it reaches a significant maximum effect of 0.09 after 18 quarters and a significant long-run effect of 0.088 after 32 quarters. The IRFs reported in Figure 2 and Table 3 provide a clear picture: mission-oriented policies produce a positive effect both on the level of output and on the private investment in R&D, which is much greater than the effect produced by generic government expenditures $G_R$.xviii

[INSERT HERE TABLE 3]

Finally, cumulative multipliers on $Y$ and $R&D$ generated by a one-dollar increase in $G_{MO}$ and $G_R$ are summarised in Table 4. $G_{MO}$ generates a significant increase in $Y$ equal to 23.957 at the impact and a long-run cumulative multiplier of 5.764 after 32 quarters. When the effect of $G_{MO}$ on private $R&D$ is evaluated, a one-dollar increase in $G_{MO}$ leads to a significant peak effect at the impact equal to 0.745 and a long-run cumulative effect of 0.628 after 32 quarters. The effect per one-unit of spending generated by $G_R$ is lower than the effect generated by $G_{MO}$. Specifically, $G_R$ produces a peak cumulative multiplier at the impact equal to 0.741 and a long-run cumulative multiplier of 0.631 after 32 quarters.
effect per one-unit of spending generated by $G_R$ on R&D is negative and not significant at the impact, but reaches a peak effect of 0.03 after 32 quarters.

[INSERT HERE TABLE 4]

Our findings show that mission-oriented innovation policies generate a larger and positive effect both on the level of GDP and on private R&D investment, as compared to generic public expenditures. The high value assumed by the cumulative multiplier on impact and after four quarters might be motivated by the fact that mission-oriented innovation policies are based on contracts, partnerships and cooperative agreements between public-private organisations, which all reflect the focus these projects have on well-defined objectives (Mowery, 2010, 2012). The launch of this kind of public programme requires a co-investment between the private and public sectors to finance the large fixed initial costs, such as new physical structures (e.g. laboratories and equipment), the payment of highly skilled labour and the related research activities. A higher multiplier effect could be also motivated by the fact that a great part of R&D expenditure is salary payments for R&D workers (Goolsbee, 1998), who have a higher marginal propensity to consume compared to profits’ earners. Moreover, the massive peak effect of the cumulative multiplier on impact and the dynamics of the cumulative effect in the subsequent periods (see Table 4) are in line with Perotti’s (2004) findings, showing that the cumulative multiplier associated with total public investment in the US generates a peak effect on impact and declines in the subsequent time periods. Finally, the positive effect on private R&D produced by mission-oriented policies is significant on impact, whereas the effect of generic public expenditures is lower and becomes significant only after seven quarters. This confirms the idea that targeted innovation policies produce a strong and direct effect on the R&D investment decisions of firms, leading to new directions for technical change.
To sum up, our findings confirm the theoretical intuitions argued in Section 2 as well as in Deleidi and Mazzucato (2019). Specifically, mission-oriented innovation policies are able to produce a larger fiscal multiplier and to determine a stronger direct crowd-in effect than generic public expenditures. The crowd-in effect estimated on private R&D is in line with the findings put forward by Moretti et al. (2019). Conversely, our findings are in contrast with the idea that military R&D expenditures generate a crowding-out effect on private R&D investment (see, among others, Bronzini and Iachini, 2014; Goolsbee, 1998; Wallsten, 2000). Finally, consistent with the recent hysteresis literature (Fatás and Summers, 2018; Yellen, 2016), our findings show that changes in government spending produce positive and permanent effects on the output level.

5. Concluding remarks

In this paper we propose a theoretical macroeconomic model that combines the Sraffian supermultiplier framework, which sees GDP growth as determined by the rate of growth of the autonomous component of demand, with the Neo-Schumpeterian framework, which underlines the relevant role of the state in shaping and directing innovation. The model combines the multiplier and accelerator effect, and analyses the macroeconomic effect generated by alternative fiscal policies by showing that expansionary fiscal policies generate a permanent and positive effect on the output level. In the model, private investment in R&D is introduced and positively related to the classes of public expenditures oriented to promoting structural change, as in the case of mission-oriented innovation policies. A permanent increase in public expenditures, targeted toward strategic sectors and focused on the promotion of innovation and mission-oriented innovation policies, generates the largest effect in terms of output and investment growth. By directly stimulating private business
expenditure in R&D, such public policies create the largest supermultiplier and the largest effect on private investment.

Additionally, an SVAR model is estimated for the US economy for the 1947–2018 period to assess the effect on GDP and on private investment in R&D of mission-oriented innovation policies and generic government expenditures. Following Mowery (2010), mission-oriented innovation policies are approximated through defence R&D expenditures. Our estimates show that mission-oriented innovation policies generate a larger effect on the level of GDP than generic public expenditures. Similarly, such results are confirmed when the responses of private investment in R&D are estimated to different fiscal policy shocks: mission-oriented policies produce a stronger crowding-in effect on private R&D investment than generic public expenditures. Specifically, the estimated impulse response functions show that: (i) mission-oriented innovation policies generate an impact multiplier of 23.957 and a peak effect on GDP equal to 54.941, as well as a response of private investment in R&D of 0.745 on impact, which reaches a peak effect of 6.015; and (ii), conversely, generic public expenditures produce an impact multiplier of 0.741 and a peak effect of 1.866 as well as a non-significant effect on R&D on impact and a significant peak effect of 0.09. Our results confirm the thesis argued by the supporters of the hysteresis perspective, which states that aggregate demand and then fiscal policies produce permanent effects on the level of output (Fatás and Summers, 2018; Yellen, 2016).

Our findings suggest that governments should implement expansionary fiscal policies because they generate Keynesian effects, namely positive and permanent effects on GDP and on investments, both in the short and the long run. However, in addition to what the IMF (2014) affirms in a paper entitled ‘Is It Time for an Infrastructure Push? The Macroeconomic Effects of Public Investment’, we believe that fiscal policies should not stop at ‘shovel-ready projects’ but be targeted toward the financing of mission-oriented innovation policies, as
these will help solve problems while having a higher impact on output and investment growth. While the paper used Cold War military investments as the proxy for missions, modern mission-oriented policies are those aimed at societal challenges (Mazzucato, 2018a, 2018b). As Richard Nelson argued in his book *The Moon and the Ghetto* (Nelson 1977, 2011), these societal problems are even harder to address than purely technological ones, as they involve political, behavioural and regulatory changes. However, they are just as, or more, important as they help steer capitalism itself in a way that produces inclusive and sustainable growth. By looking at the multiplier of goal-oriented policies that stimulate cross-sectoral investment and innovation, the paper helps to go beyond the dichotomy between austerity policies and those aimed at infrastructure (Mazzucato and Skidelsky, 2020). These policies have the potential to kill two birds with one stone: to combine the standard Keynesian effects with those produced by the development and diffusion of directed innovation in the economic system.
References


Perotti, R., 2014. Defense government spending is contractionary, civilian government
spending is expansionary. NBER Working Paper No. w20179.
Appendices

Appendix A.

Appendix A.1.

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Table A.1. Descriptive statistics of the modelled variables

Appendix A.2.

Findings of the Phillips-Perron unit root test are represented in Table A.2. The test is carried out on all variables considered in the model: $G_{MO}, G_R, R&D,$ and $Y$.

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<td>P-value</td>
<td>Adj. t-statistic</td>
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<td>0.9145</td>
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</tr>
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</table>

Table A.2. Unit root test (Phillips-Perron): trend and intercept. $H_0$: variables at level and at first difference have a unit root

29
Appendix A.3.

Findings of the lag selection based on the Akaike information criterion (AIC) are represented in Table A.3.

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* Table A.3. Akaike information criterion
Appendix B.

The elasticities are presented in Tables B.1. To estimate fiscal multipliers, the elasticities are multiplied by *ex-post* transformation factors, which are reported in the main text.

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<th>$G_{R}$ Shock</th>
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<td>R&amp;D Y</td>
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<td>Q17</td>
<td>2.133 0.247</td>
<td>1.341</td>
<td>0.298</td>
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<td></td>
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<td>2.146 0.240</td>
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Table B.1. Elasticities of R&D and Y to $G_{MO}$ and $G_{R}$ shocks. Standard errors are reported in ( )
The supermultiplier model has been recently used by a number of economists from different backgrounds (e.g. Allain, 2015; Fazzari et al., 2020; Lavoie, 2016).

Total taxes depend both on an autonomous component ($T_a$) and an endogenous component related to the total output through the tax rate ($t$).

Following Girardi and Pariboni (2016), we assume that the actual degree of capacity utilisation is equal to the ratio between the actual level of output and the normal level of output. Therefore, the normal degree of capacity utilisation is equal to one. Subsequently $v = K/y^n$, where $K$ is the actual capital stock and $y^n$ is the normal level of output desired by entrepreneurs. In other words, $y^n$ is the desired output that firms would like to produce given the amount of capital $K$.

Additionally, investment changes when technical innovations occur (Garegnani, 2015). Specifically, innovation produces persistent effects on gross investment by changing the capital-output ratio ($v$) and the depreciation rate ($d$) as new technologies are principally embodied in new capital goods.

We define the degree of capacity utilisation ($u$) as the ratio between actual and normal output. It follows that normal utilisation ($u_n$) is equal to 1 (see also footnote 3). Furthermore, $u_n$ can be defined as the normal degree of capacity utilisation that minimises the costs of production (Girardi and Pariboni, 2019; Kurz, 1986).

As some fluctuations of demand are not considered permanent, entrepreneurs do not immediately undertake a full adjustment of productive capacity to effective demand; rather, such adjustments occur by a flexible accelerator process. A flexible degree of capacity utilisation allows firms to meet all expected peaks of demand with the current installed capacity (Ciccone, 1986).

For an in-depth study of National Institutes of Health investments in the biotechnology sector and the interrelation among universities and industrial sectors, see, among others, Kenney (1988).

In order to have an economically significant solution, the denominator of equation (7) must be positive.

Following equation (8), whereas the output trend growth rate is driven by the trend growth rate of the autonomous components ($Z$), a change in marginal propensity to consume causes a permanent level effect (Freitas and Serrano, 2015).

The process described by equation (9) allows the required adjustment in the capacity by means of changes in investment, and such a process ceases in the fully adjusted position where $u = u_n$ and $g_y = g_z = g_e$. For an in-depth review on the notion of a fully adjusted position, see, among others, Serrano (1995), Cesaratto et al.
(2003), Cesareto (2015), and Freitas and Serrano (2015). Additionally, for a review of the static and local dynamic stability conditions of the SSM, see Freitas and Serrano (2015) and Lavoie (2016). Furthermore, for the stability condition of this specific model based on the investment function as in equation (4), see Pariboni (2015) (Appendix A, pp. 87–89, equations A9–A11). Specifically, to have the local stability of the model, the marginal propensity to spend has to be less than one, namely \( v \cdot (x + d + g_x) + c \cdot (1 - t) < 1 \).

\[ \text{xi} \] For an in-depth review of the estimates of fiscal multipliers and the related identification strategies, see, among others, Caldara and Kamps (2008) and Deleidi et al. (2020a, 2020b).

\[ \text{xii} \] Following Auerbach and Gorodnichenko (2017), and Ramey and Zubairy (2018), taxes are not included in the model as these do not alter the estimates of fiscal multipliers, and the identification of an unanticipated shock to taxes has a higher data requirement compared to the identification of a government spending shock.

\[ \text{xiii} \] The ratios used in the \textit{ex-post} transformation from elasticities to partial derivatives are calculated as follows: \( R&D/G_R; R&D/G_{MO}; Y/G_R; \) and \( Y/G_{MO}. \) They assume the following values respectively: 0.067; 2.68; 5.05; and 187.26.

\[ \text{xiv} \] Our identification strategy has been also informed by using additional insights derived from additional sources (Kilian and Lütkepohl, 2017). First, due to information delays in releasing GDP data and more in general macroeconomic variables, governments know the value of GDP only a few quarters after the reference period, since data on GDP are collected quarterly and typically released two months after the end of a quarter (Jovanovski and Muric, 2011). Therefore, we can assume that governments cannot know the current level of GDP (at time \( t \)) when deciding on implementing a discretionary fiscal policy. Second, there exists an implementation lag and a discretionary fiscal policy takes more than one quarter to be decided, approved and implemented. Despite being unusual in the fiscal policy literature and not well-suited for uncovering economically meaningful structures, the graph-theoretic approach could be used to provide a different identification strategy (Kilian and Lütkepohl, 2017, Section 8.5.4, p. 233).

\[ \text{xv} \] IRFs and SVAR findings crucially depend on the reliability of the implemented identification strategy, which in turn depends on the consistency of economic theory informing the identification (Kilian and Lütkepohl, 2017). In our case, the chosen identification strategy is in line with the relevant literature on fiscal multipliers (see, among others, Bilbiie et al., 2008; Auerbach and Gorodnichenko, 2012; Bachmann and
Sims, 2012) as well as with the industrial literature on mission-oriented policies (Mowery, 2010, 2012; Moretti et al., 2019).


xvii The estimated elasticities of $Y$ to $G_{MO}$ and $G_{R}$ shocks are reported in Table B.1 and show close and similar dynamics. However, we have found a larger IRF since the $Y/G_{MO}$ ratio is very much larger than the $Y/G_{R}$ ratio (see footnote 13).
### TABLES

<table>
<thead>
<tr>
<th></th>
<th>Capacity-creating</th>
<th>Non–capacity-creating</th>
</tr>
</thead>
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<tr>
<td><strong>Autonomous</strong></td>
<td></td>
<td>Government expenditures, autonomous consumption, autonomous business expenditure</td>
</tr>
<tr>
<td><strong>Induced</strong></td>
<td>Gross investment</td>
<td>Induced consumption, induced business expenditure</td>
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Table 1. Classification of demand component

<table>
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<tr>
<th><strong>Data</strong></th>
<th><strong>Description</strong></th>
<th><strong>BEA code</strong></th>
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<tbody>
<tr>
<td>$Y$</td>
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</tr>
<tr>
<td>$G$</td>
<td>Total government consumption expenditures and gross investment</td>
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</tr>
<tr>
<td>$G_{MO}$</td>
<td>Federal national defense government gross investment, research and development</td>
<td>Y076RC</td>
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<tr>
<td>$G_R$</td>
<td>Total government consumption expenditures and gross investment (excluded $G_{MO}$) ($G_R = G - G_{MO}$)</td>
<td></td>
</tr>
<tr>
<td>$R&amp;D$</td>
<td>Gross private domestic investment (R&amp;D), research and development</td>
<td>Y006RC</td>
</tr>
<tr>
<td>$DEF$</td>
<td>GDP implicit price deflator, index 2012=100</td>
<td>A191RD</td>
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</table>

Table 2. US data and description

<table>
<thead>
<tr>
<th></th>
<th><strong>Shock $G_{MO}$</strong></th>
<th><strong>Shock $G_R$</strong></th>
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</thead>
<tbody>
<tr>
<td></td>
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</tr>
<tr>
<td>Q1</td>
<td>0.745</td>
<td>23.957</td>
</tr>
<tr>
<td>Q4</td>
<td>2.920</td>
<td>54.941</td>
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<tr>
<td>Q8</td>
<td>4.339</td>
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<tr>
<td>Q12</td>
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<td>51.949</td>
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<td>Q16</td>
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<td>Q28</td>
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<tr>
<td><strong>Peak</strong></td>
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<td>54.941</td>
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Table 3. Impulse response functions, significant estimates indicated in bold
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<th>Shock $G_{R}$</th>
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<td>0.628</td>
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<tr>
<td>Q32</td>
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<td>0.631</td>
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<tr>
<td>Peak</td>
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<td>0.030</td>
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<td>(Q1)</td>
<td>(Q32)</td>
<td>(Q1)</td>
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*Table 4. Cumulative multipliers, significant estimates indicated in bold*
**FIGURES**

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**Log-levels**

**G_MO**

**G_R**

**First differences**

**G_MO**

**G_R**

**R&D**

**Y**

---

*Figure 1.* Plot of the modelled variables. Variables at levels are in logarithmic form, while variables at first differences have been calculated as the difference of the log-level variables. 1947Q1-2018Q3 period.
Figure 2. Impulse response functions – 68% confidence interval bands estimated through a Monte Carlo procedure, 1000 repetitions.