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THE MACROECONOMIC IMPACT OF INFRASTRUCTURE INVESTMENT: A REVIEW OF CHANNELS

by Valerio Ercolani*

Abstract

This paper provides a critical review of the literature on the macroeconomic effects of public infrastructure investment associated with the main underlying transmission channels. Typically, this type of stimulus fosters economic activity in the medium-to-long run because the public capital stock needs time to build up and to exert its effects. However, under the current circumstances – such as considerable economic slack, policy rates constrained at zero and heightened uncertainty – the stimulus can be expansionary even at shorter horizons, i.e. from one to three years. Given the large infrastructure gaps in most emerging and advanced economies, infrastructure investment could have high returns in terms of individuals' welfare and productivity growth. Strengthening health infrastructures, supporting maintenance investment, and coordinating infrastructure stimuli across countries emerge as particularly appropriate policies today.

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1. Introduction[1]

Soon after the outbreak of COVID-19, governments in advanced economies implemented a massive fiscal response – surpassing 10 per cent of GDP in many countries – with the main objective of supporting the health sector and ensuring the viability of households and firms. Later on, governments started to consider how fiscal stimulus could most effectively get their economies back into gear, including through infrastructure investment. For example, during the summer of 2020, the US administration proposed a roughly $1 trillion infrastructure package focused on transportation projects (Mason and Shepardson, 2020). More recently, the new administration has advocated a large investment plan of around $2 trillion, with the aim, among other things, of building modern infrastructures (Lombardo, 2021). In Europe, a considerable share of the NextGenerationEU fund (€672.5 billion in total) will be targeted to infrastructure investment.

In principle, there are some good reasons for undertaking public investment projects. It has long been recognized that their potential is huge because they combine short-run Keynesian demand stimulus with positive medium-term supply-side effects. However, the reality is much more complex. Indeed, as this paper shows, this type of policy operates via a variety of channels, whose effects can also vary with the economy's cyclical position as well as with other factors.

The aim of this paper is to provide a review, though not an exhaustive one, of the transmission mechanisms triggered by infrastructure investment and of how they interact in driving the effectiveness of such policy. The review has a macro perspective, using as a framework the class of general equilibrium models mostly used in the modern macroeconomic literature, such the Real Business Cycle (RBC) model and its New Keynesian evolution. Besides theoretical considerations, the aim is also to provide hints about the quantification of the impact of public investment as seen in empirical studies too. While both the quantitative and the empirical parts of this survey mainly refer to the US, due to the fact that this country is the focus of most available studies, their relevance is wider and, in principle, can offer policy indications for any developed country.

The core variable of the present analysis is the gross fixed capital formation by governments (central or local), in particular that for infrastructures (such as transport, telecommunications, airports and roads) and equipment (the systems – such as plumbing or the electrical apparatus – that keep the infrastructure operative). These two categories account for more than two thirds of public investment in the US case, or roughly 2.5 per cent of GDP in 2019. The rest is represented by intellectual property goods (such as software and R&D) whose role, though it has gained importance in modern times, is outside the focus of the present paper (see Greenstein and Tucker, 2020 and references therein to explore this subject further).

The literature broadly agrees that infrastructure investment raises both economic activity and individuals' welfare in the long run. A higher stock of public capital can raise the productivity of the private factors of production, such as (private) capital and labour, incentivizing firms to invest and hire more, thereby raising output. For example, a new road or bridge, on top of the direct contribution of additional spending to GDP, can increase the productivity of firms operating in that area because it reduces transportation and trading costs. The available evidence, with rare exceptions, suggests output multipliers well above unity in the medium-to-long run, i.e. after three years. These effects can help mitigate a situation of secular stagnation and savings glut (Rachel and Summers, 2019). Furthermore, it has been shown that an efficient system of infrastructures, if maintained over time,

[1] I thank Andrea Finicelli and Pietro Catte for useful comments and suggestions.

increases the quality of life and the health of citizens, hence preserving human capital (Gordon, 2017, among others).

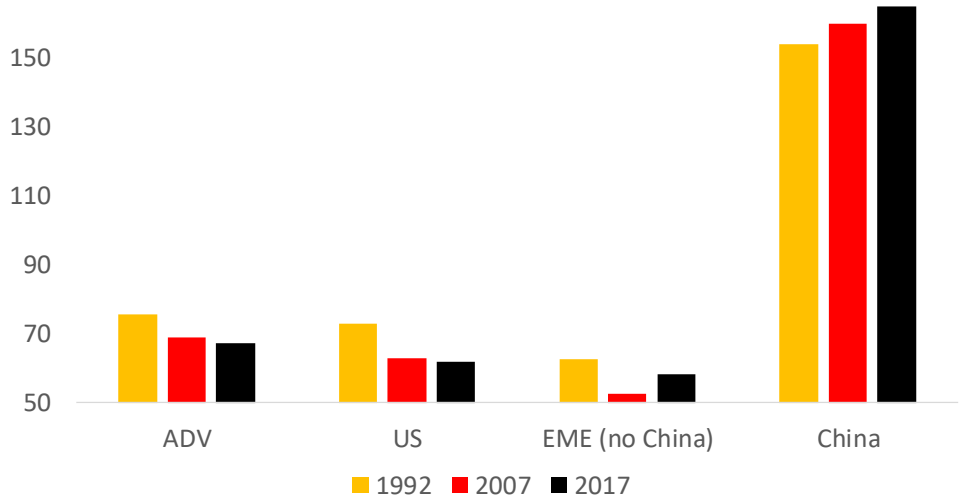
The short-run effects of the infrastructure stimulus are debated far more. Indeed, there are inherent mechanisms of infrastructure spending that compress short-run multipliers, such as implementation delays (i.e. the time needed for the new infrastructure to become part of the productive capital) or the fact that they (e.g. new highways) can interfere with the functioning of existing ones, with possible negative effects on local employment and demand. Furthermore, infrastructures are typically debt-financed, which can put pressure on the interest rates and thereby crowd out private investment. In addition, governments may end up increasing distortionary taxes in order to subsequently finance the service of newly issued debt. It is well known that the last two features may undermine the multiplier effects of public investment.

However, under some circumstances, larger effects can be observed even in the short run. For example, the COVID-19 crisis has caused the deepest recession since World War Two, with an extraordinary loss of jobs worldwide. Further, the zero lower bound (ZLB, henceforth) puts some constraints on how much monetary accommodation central banks can provide. Finally, extremely high uncertainty can be a persistent drag on household and firms' willingness to spend, given both widespread doubts about how rapidly the health crisis can be overcome and concerns about its legacies and 'scarring effects' (Kozlowski et al., 2020). Several authors, though not all, support the view that these three features can contribute to generating larger multipliers, well above unity, even over shorter horizons (1-3 years). In a nutshell, the high degree of slack of the economy and the ZLB make the Keynesian demand effect much stronger than in normal circumstances. Furthermore, a well-designed infrastructure stimulus plan may also have positive effects on confidence, by signalling a government's commitment to reviving growth, which can also support long-term financial stability and debt sustainability.

Due to the COVID-19 crisis, public debt-to-GDP ratios rose by 20 percentage points in 2020 compared with 2019 on average in the G20 advanced economies, reaching about 130 per cent, the highest level since World War Two (IMF, 2020a). In this context, it is obviously crucial for public resources to be used to finance projects that have high value added and can contribute to raising productive capacity, which ultimately expands the tax base in the medium term.

Some lines of intervention appear especially appropriate in the current situation. For example, strengthening health systems by raising their general quality and making them more resilient to future pandemics would not only improve citizens' welfare but could also mitigate the scars that the COVID-19 crisis will likely leave on individuals for years to come. It might ultimately reduce precautionary behaviour in consumption and investment, which is important for making the post-crisis recovery stronger. Furthermore, maintenance of existing infrastructures, as well as offsetting their natural deterioration, can also be a powerful countercyclical tool because it typically involves projects that are smaller, shorter and less complex, so that their shorter implementation lags make possible a prompter activation of resources and a faster impact on the economy. Moreover, improving the public investment management process raises the effectiveness of the infrastructure stimulus by reducing waste of resources. Finally, cooperation among countries remains key: a coordinated infrastructure stimulus could generate a considerable boost for economic activity thanks to trade linkages and global value chains.

Figure 1: *Public capital stocks for advanced (ADV) and emerging economies (EME) (percentage of GDP)*



Source: IMF public investment and capital stock database (IMF, 2019) and IMF (2020b)

Despite the existence of significant infrastructural gaps across a broad range of countries, well documented by the economic literature, public capital stocks have generally decreased during the last few decades both in advanced and emerging economies, with the exception of China (Figure 1). Both the well-known procyclical bias of fiscal policy (Alesina et al., 2008) and the cuts that occurred during past recessions have weakened public investment dynamics over time, with possible negative repercussions on individuals' welfare. Some authors, in order to counter this procyclicality in the future, have suggested drawing up contingent spending plans that could provide a safeguard to protect productive investment over the business and the political cycles.

The rest of this paper is organized as follows: Section 2 introduces the core channels associated with investment in infrastructure together with the presentation of fiscal multipliers. Section 3 focuses on the current conjuncture and describes the factors that can amplify the effectiveness of an infrastructural stimulus, also highlighting some possible policy actions. Section 4 discusses the possible implications of infrastructure investment for secular stagnation and for individuals' welfare, together with the causes of the observed trend of declining public capital across countries. Section 5 concludes.

2. The core channels and the associated measurements

This section provides an overview of the channels underlying the macroeconomic effects of public investment, and their quantification, e.g. the fiscal multipliers, as highlighted by the literature in the last few decades. The review is conducted with reference to the class of the macroeconomic general equilibrium models identified as RBC, i.e. the neoclassical workhorse models with flexible prices, and their New Keynesian evolution, which feature sticky prices.

The seminal paper of Baxter and King (1993), henceforth BK, was the first to outline the **supply-side effects** of an increase in public investment within an RBC model where public capital directly enters the firm's production function.[2] Conditional on public capital being productive, i.e. on a

[2] In short, this is a general equilibrium model that encompasses three sectors: (i) the households that maximize their lifetime utility by deciding how much to consume/save and to work, (ii) the firms that maximize profits by deciding the

positive elasticity of output to public capital (labelled as θ henceforth; see Box 1 for details), public investment exerts its effects through two channels: (i) the production of new capital goods that directly fuels output and (ii) the subsequent increase in the marginal productivities of production factors in the private sector. As for the latter point, the higher stock of public capital raises the marginal products of both (private) capital and labour, thereby encouraging firms to increase their own investment and hiring, ultimately boosting output. A more productive economy generates a positive wealth effect that in turn raises consumption as well.

Box 1. An overview on the estimation of the elasticity of output to public capital

In order to measure the degree of productivity of public capital, authors have typically estimated the parameter θ, i.e. the elasticity of output to public capital, in the production function (1):

$$Y = A\,K^{\alpha}\,L^{\beta}\,K_G^{\theta} \qquad (1)$$

where Y is private sector output, A is an index of factor productivity, K (K_G) denotes the stock of private (public) capital and L is employment. θ is usually assumed to be greater than or equal to zero. Public capital is said to be productive if θ is greater than zero, while it is not when θ is equal to zero. Few authors would allow θ to be negative, meaning that a rise in public capital decreases output because of, for example, efficiency losses implied by a too large public sector or by the presence of congestion externalities (see Evans and Karras 1994 or Pinnoi, 1994). As for the private inputs, constant returns to scale are often assumed, i.e. $\alpha + \beta = 1$.

Unfortunately, **the literature does not converge to a unique estimated value for θ**, mainly because the type of data, the econometric techniques and the countries considered vary across studies; it can even happen that different studies on the same country deliver different values for θ. For example, Aschauer's seminal paper (1989a), using an OLS estimation technique applied to the log-linear version of (1), finds a rather high elasticity, i.e. 0.39, for the US. Since then, dozens of papers have tried to estimate θ for several OECD and also for some developing countries (Ram, 1996), although the most analysed country has been the US.

In fact, Aschauer (1989a) was criticized for not properly accounting for stochastic trends and for the possible omission of reverse causation. Thus, for example, Finn (1993) adopts an instrumental-variable procedure (GMM) applied to a set of equations, including (1), using US data, and estimates much lower elasticities for various items of government capital (the largest is 0.16 for highways), surrounded by great uncertainty. Pereira and Frutos (1999) use a structural vector autoregression approach applied to US data, finding a θ very close to that of Aschauer (1989a).[3] Ercolani and Valle e Azevedo (2014) estimate an RBC model similar to Baxter and King (1993), characterized by a firm's production function of the form of (1). They further allow for (i) a non-separable relationship between private and government consumption and (ii) some forms of real rigidities (such as price and wage markups). Estimating the full model for the US delivers a θ equal

levels of investment and labour, given factor prices (wage and interest rates) and (iii) the government that levies taxes to finance its spending. The model is calibrated to the US economy.

[3] In fact, the authors cannot directly estimate θ because they do not explicitly include equation (1) in their empirical exercise. Ramey (2020) maps their estimated parameters into the θ parameter.

to 0.09 (though surrounded by high uncertainty); however, the model fit statistics favour a specification in which θ is constrained to zero.

Interestingly, Bom and Ligthart (2014) conduct a **meta-analysis on the parameter θ**. That is, they collect comparable estimations of θ contained in 68 studies for the period 1983-2008 across more than 20 countries (although US data are used in more than 40 per cent of the studies). On average, the contemporaneous output elasticity of public capital installed at the central level of government is estimated to be **0.083.** This value becomes larger, **up to 0.193**, if the studies consider (i) public capital installed at a regional/local level, (ii) only 'core' public capital (i.e. roads, railways, airports and utilities), and (iii) longer horizons.[4]

The above described mechanisms may fail to generate sizeable expansionary effects in the short run, as they require public capital to build up. For example, within the BK model, conditional on a plausible value of θ, which is 0.05 (see Box 1), a 1 per cent of GDP permanent increase in public investment – financed with lump-sum taxes – has an output multiplier lower than 1 on impact (around 0.4); it takes three years for the multiplier to rise above unity, while after twenty years it reaches roughly 2.5 (essentially its long-run value, which is 2.6).[5] Consumption goes down on impact because of the typical negative wealth effect generated by higher taxes, but subsequently – roughly after six years – it returns to its initial value, and then rises by 0.8 per cent of GDP after 20 years. At this horizon, the ratio of private investment-to-GDP rises by about 0.6 per cent and labour increases by roughly 1 per cent. Conditional on setting a higher level of θ, i.e. 0.1, BK finds a long-run output multiplier of roughly 4, which is close to the more recent estimate (3.6) provided in one version of the Ercolani and Valle e Azevedo (2014) model, conditional on an estimate for θ equal to 0.09 (see Box 1 for more details).[6]

As reaffirmed by IMF (2020b), public infrastructure projects are rarely performed directly by a public administration through its payroll; on the contrary, they are usually carried out through private or state-owned contractors, so that every dollar spent by the government goes to some company's revenue, which subsequently increases its payroll.[7] This generates the 'Keynesian multiplier': newly hired people or employees with a higher wage can buy more goods and services, which can boost economic activity, creating room for larger output effects in the short run too. It is well known that these **demand-side effects** are absent in an RBC model, such as the one in BK, because prices are fully flexible and hence output is driven by supply.

[4] Long-run estimates are usually associated with cointegration estimation techniques or with 'long-differences' through which the time series are differentiated by subtracting the initial value of the series to any value.

[5] There are two things to notice here; first, increasing public debt or not is irrelevant in this context because the Ricardian equivalence holds and second, the long-run value of the multiplier is calculated using the model equations in the steady-state formulation.

[6] To be precise, the multiplier presented by Ercolani and Valle e Azevedo (2014) is the cumulated discounted multiplier, at a 25-year horizon, as calculated in Uhlig (2010), which is arguably very similar to its long-run value. Furthermore, though the stimulus is not permanent as it is in BK, the government investment process is modelled as an autoregressive model of order 1, AR(1), and is estimated to be very persistent, with an autocorrelation coefficient equal to 0.94.

[7] There can also be cases in which private companies participate in the financing of the infrastructure, as for example in Public-Private partnership (PPP) arrangements, or infrastructures that are financed, built and operated by private entities but publicly regulated. The typical macro models, including those analysed in this survey, do not take these cases into account; indeed, the voluminous literature on the various financing methods for infrastructure is dominated by contributions from microeconomic theory and regulation, and thus lies outside the focus of the present paper. The interested reader is referred to Buffie et al. (2016) that, starting from microeconomic principles, shed light on the macroeconomic dimension of, among other arrangements, PPPs.

There have been various efforts to make private demand matter for output determination in general equilibrium models. For example, Ramey (2020) – expanding on the analytical framework of Galí et al. (2007) – develops a New Keynesian model in which, besides sticky prices, half of the households are rule-of-thumb or non-Ricardian (i.e. they always consume all disposable income) and the implied labour supply curve is quite elastic.[8] In the New Keynesian framework, a government investment shock is more expansionary than in the BK model; however, it typically generates an output multiplier only slightly above unity in the short term (e.g. roughly 1.1 in the first year within Ramey, 2020, using a θ equal to 0.05).[9] In order for firms to produce the required investment goods, they need to hire more labour by paying higher wages. This allows aggregate consumption to go up because of the presence of rule-of-thumb agents. Subsequently, the increase in aggregate demand puts upward pressure on inflation. Some circumstances, such as the ZLB feature, can magnify such a short-run multiplier (see Section 3.1 for more details). As for the long-run multipliers, conditional on θ equal to 0.1 (0.05), the author finds values between 2.8 (1.8) and 5 (3), i.e. the same order of magnitude as the multipliers obtained in the BK model.[10]

Governments bear the **funding costs** to exert a fiscal stimulus, which influences the effects of the policy itself. Indeed, expansionary policies are usually associated with an increase in public debt that typically goes hand in hand with a higher interest rate, which is what makes households willing to save more and hold newly issued bonds.[11] Furthermore, if agents fear that additional spending may put the sustainability of public finances at risk, then **sovereign risk premiums** may also rise. Both tend to reduce the impulse for economic activity, especially by crowding out private investment (see, among others, Busetti et al., 2019). The **response of monetary policy** to inflationary pressures stemming from the stimulus to demand eventually puts further upward pressure on interest rates.

An issue inherent to the way public investment exerts its demand- and supply-driven impact is represented by **implementation delays**. As Leeper et al. (2010) point out, there are two types of delays: *time-to-spend*, i.e. the time between appropriation or allocation of funds and actual outlays; and *time-to-build*, i.e. the period before new capital actually becomes part of production processes, e.g. when a bridge or a highway is open for use. For example, Leduc and Wilson (2017) quantify *time-to-spend* delays focusing on the American Recovery and Reinvestment Act (ARRA). This Act, passed in February 2009 by the US Administration and designed to counteract the consequences of the 2008-09 financial crisis, provided roughly $60 billion for infrastructures, including transportation, highway construction and maintenance (Drautzburg and Uhlig, 2015). By the end of June 2009, only around 10 per cent of these funds had been spent and 50 per cent in 2010, while it took until the beginning of 2013 for them to be almost entirely spent. As noticed in Ramey (2020), these delays

[8] The very elastic labour supply attempts to mimic an economy with some slack where small increments in wages are enough to generate positive and large deviations in employment; in practice, in the model calibration, the author sets the *Frisch* elasticity of labour supply to a large value, i.e. 4 (compared with the range of the available micro estimates, which are well below 1; see Chetty et al., 2011). Additional features of this New Keynesian model are worth mentioning. First, the presence of some forms of real rigidities such as wage and price markups together with investment adjustment costs. Second, the existence of a monetary authority that, following the typical Taylor rule, raises the policy rate as inflation increases. Third, a fiscal authority that increases lump-sum taxes over time when public debt rises.

[9] Tough taxation is lump sum, as in the above-discussed version of the BK model, the financing method (debt vs taxes) matters here because of the presence of rule-of-thumb consumers that breaks the Ricardian equivalence. For example, in Ramey (2020), the stimulus is initially financed through the issuance of new public debt, which is paid off by higher taxes later on. It should also be noted that the spending process is set to be very persistent; it follows an AR(1) with an autocorrelation coefficient equal to 0.95.

[10] To obtain long-run multipliers the author calculates the cumulative discounted multipliers (together with the undiscounted ones) at a 250-year horizon, following Uhlig (2010).

[11] Notice that even when the government budget constraint is always balanced, as in the presented version of the BK model, the interest rate reacts positively to a government spending shock, at least on impact, because (private) capital becomes equipped with more labour (since labour goes up as a consequence of the shock while capital is predetermined).

implied that most of the infrastructure stimulus was spent well beyond the end of the recession; on the other hand, since the unemployment rate was still above 8 per cent in mid-2012, infrastructural spending was still providing useful support for post-crisis recovery.

The abovementioned delays weaken the fiscal multiplier, especially in the short run. Ramey (2020) incorporates *time-to-spend* and *time-to-build* into the above described New Keynesian model.[12] The implication is that the 1-year output multiplier is reduced from roughly 1.1 to almost zero, while the long-run multiplier, as it is reasonable to expect, is almost unaffected (in the range between 2.5 and 4.9, using a θ equal to 0.1).

The literature has highlighted two additional mechanisms that can lower the multipliers, especially in the short run. First, Boehm (2020) shows that within an otherwise standard New Keynesian model with two sectors – one producing consumption goods, the other one investment goods (with two different opportunity costs, i.e. two different interest rates) – a short-lived government investment shock generates a small impact multiplier, lower than 0.2, while a government consumption shock triggers a larger one, close to unity; this is also confirmed empirically for a panel of OECD countries. Since the **demand for investment goods is more interest-elastic than consumption**, a government investment shock crowds out private investment much more than a government consumption shock does for private consumption, making the fall in overall private spending (including consumption and capital goods) much more pronounced in the former case.[13] Second, Gallen and Winston (2019) show that, to the extent that the new infrastructures **disrupt the existing infrastructures**, they could produce negative effects on local employment and consumption, hence lowering impact multipliers. Notice, however, that in some circumstances, larger multipliers may occur. For example, on the one hand, the government investment multiplier associated with the first-mentioned mechanism may exceed unity if the economy is at the ZLB; on the other hand, investing in maintenance of the existing infrastructures can limit the disruption issue (see details in Section 3.1 and 3.2 respectively).

Taxation may also alter the impact of infrastructure investment, and of fiscal stimulus more generally, in contrasting ways. At some point, debt-financed stimulus requires higher taxes so as to maintain the sustainability of public finances. Leeper et al. (2010) show that historically, public debt has been stabilized by the US government by raising **distortionary taxes**, especially on capital. This feature mitigates the effectiveness of the stimulus, because it curbs the dynamics of both private investment and labour. On the other hand, to the extent that the medium-to-long run multipliers of infrastructure investment are above unity, the resulting future **expansion of the tax base** may end up enhancing fiscal soundness (IMF, 2018); a sounder starting position of public finances makes fiscal policies even more effective, as shown by, among others, Huidrom et al. (2020) and Metelli and Pallara (2020).

3 Focusing on the current conjuncture

In the effects described so far, the following simplifying features were maintained: (i) monetary policy reacts to the state of the economy by using the policy rate; (ii) there is no conditioning on the state of the economy (i.e. expansions vs recessions); and (iii) uncertainty plays no role. These features are unlikely to be valid under the current circumstances. The COVID-19 outbreak has generated the

[12] The author sets the *time-to-build* delays to a year and half, which can be seen as a conservative figure, especially for large projects such as new highways or bridges. For example, Leeper et al. (2010) set three years for large projects. Further, the calibration of the time-to-spend delays is such that the abovementioned time profile of the ARRA is roughly matched.

[13] This result ultimately follows from the long-service-life property of capital goods. Indeed, unlike perishable non-durable goods, it is possible to postpone the demand for capital goods in reaction to an increase in their factor prices.

worst contraction since World War Two, and occurred at a time when many central banks were already constrained by the ZLB, or hit the limit shortly afterwards. Furthermore, uncertainty rose to extremely high levels (Altig et al., 2020) and is likely to be a factor for some time, owing to lingering concerns about the evolution of the pandemic and of the economic outlook, and the possible 'scarring effects' that may be left by this unprecedented crisis (see Kozlowski et al., 2020). Section 3.1 explores how these factors may amplify the effectiveness of infrastructure stimulus, especially in the short run. Section 3.2 outlines some possible lines of intervention.

3.1 The amplification factors

The literature has shown that when the economy is at the **ZLB**, the government consumption stimulus can be particularly powerful, because higher inflation expectations lower the ex-ante real interest rate. This boosts private consumption, spurring the economy and generating impact multipliers well above 1 (e.g. Christiano et al., 2011, using a New Keynesian type of model, find multipliers associated with a government consumption shock to be above 2 at the ZLB). The same reasoning applies to infrastructure stimulus. Boehm (2020) shows that when the economy is at the ZLB, unlike in normal times, the 1-year government investment multiplier is above unity, roughly 1.2. Furthermore, Coenen et al. (2012), taking simulations from several models, conclude that the 1-year government investment multiplier can be slightly above 1.5 when monetary policy is at the ZLB, versus only 0.9 otherwise.[14]

The previous section has shown that *time-to-build* tends to lower multipliers, especially in the short run: at the ZLB, such a prediction may change completely. Bouakez at al. (2017), within a New Keynesian model with productive public capital, document that, although the infrastructure stimulus is inflationary overall, its positive effects on supply are deflationary. That said, the authors show that the delays in the build-up of capital stock smooth the actual positive supply shock over time; this mitigates the associated deflationary pressures and – in a situation of ZLB – makes the stimulus more effective. These results have been inspired by the theoretical narrative of Eggertsson (2011) and Woodford (2011) on the possible expansionary effects of negative supply shocks (such as an increase in distortionary income taxes) at the ZLB. However, all these results must be taken with considerable caution, because they do not seem to find empirical support; for example, Wieland (2019) shows that the negative supply shocks that occurred in Japan at the ZLB (such as oil price shocks and the earthquakes) raised inflation but were nonetheless contractionary.

Some papers, focusing on the state-dependent nature of multipliers, show that they are larger during **recessions**. For example, Auerbach and Gorodnichenko (2012), using local projection methods applied to US data, study the effects of government purchases (of consumption and investment goods) and find multipliers as high as 2.5 during contractions. This could be reasonable: on the one hand, spare capacity and labour market slack in recessions make labour supply much more elastic, and the propensity to consume higher than in normal times; on the other hand, being at the ZLB in a recession further reinforces these effects, as already argued above.[15] Abiad et al. (2016),

[14] The presented multipliers are averages, across models, generated by a government investment stimulus lasting for two years while the economy is at the ZLB. As for the models, the authors take the structural models developed at the Federal Reserve Board, European Central Bank, IMF, European Commission, OECD and Bank of Canada respectively.

[15] Even the effect of public hiring on employment can vary according to the amount of slack in the economy. Michaillat (2014), using a New Keynesian model with a 'search and match' labour market, shows that when the government posts additional vacancies, job tightness then rises in normal times, and hence hiring new workers becomes more costly for firms, which could reduce their staff. However, when unemployment is particularly high, then the government needs a few vacancies to hire additional workers because the matching process is congested by job seekers. In this context, public hiring has little effect on tightness and hence the described crowding-out effect is tiny and aggregate unemployment may well decrease.

applying the same approach as in Auerbach and Gorodnichenko to a panel of 17 advanced countries (1985-2013), focus only on the investment part of government spending and find that a public investment shock (of 1 per cent of output) raises the level of output by about 1.5 per cent in the same year and by 3 per cent three years afterwards, during periods of economic slack; on the other hand, the reaction of output is not statistically different from zero during periods of economic expansion.[16] Furthermore, with slack, the fiscal shock tends to raise private investment and to lower unemployment and the debt-to-GDP ratio; in expansions, by contrast, private investment falls, while the effects on the debt-to-GDP ratio and on the unemployment rate are not statistically different from zero.

Leduc and Wilson (2013) study the dynamic effects of government investment as well as their interaction with the business cycle. In particular, by estimating the effects of Federal highway grants to US states using annual state-level panel data from 1993 to 2010, they find an impact multiplier around 3, a 6-year one roughly at 6 (the peak) and a 10-year one slightly below 2.[17] Importantly, while positive short-run multipliers only emerge in recessionary periods, the effects of a stimulus become state-independent at longer horizons. These multipliers, especially at their peak values, appear somewhat bigger than those typically found in the literature. However, since Leduc and Wilson's measures are generated by cross-regional variation, they define 'local' multipliers that, in principle, cannot be directly compared with the abovementioned 'national' multipliers. More specifically, a local multiplier is defined as the output effect in a state stemming from 'idiosyncratic' investment stimulus, i.e. spending one dollar above the national average: hence, its state-specific macroeconomic impact is by definition unaffected by country-wide factors such as monetary and federal fiscal policies.[18]

It is worth recalling that other papers do not find such large multipliers either at the ZLB or during recessions. For example, Drautzburg and Uhlig (2015) study the effect of the ARRA infrastructure stimulus in a New Keynesian model with productive public capital, distortionary taxation and the presence of rule-of-thumb consumers. They find multipliers below 1 both at short and longer horizons, which is mainly explained by the use of quite a small θ, 0.023, and by the increase in distortionary taxes that dampens the positive consumption reaction of rule-of-thumb agents. On the empirical side, Ramey and Zubairy (2018), by looking at historical US data (1889-2015), find that government purchases (of both consumption and investment goods) generate multipliers lower than 1 irrespective of the amount of slack in the economy, while they can reach 1.5 in some ZLB episodes.

Uncertainty is another potentially relevant factor for the effectiveness of fiscal policy. There are papers showing that, when uncertainty is high, fiscal stimuli can be barely effective because agents become more cautious about investing/consuming more (see, for example, Bloom et al., 2018 and Alloza, 2019). However, when the policy tool is specifically targeted to investment, things may change. A government investment stimulus may signal its commitment to pursuing a growth strategy consistent with long-run stability, by expanding the economy's productive capacity and overall productivity, with positive potential effects on confidence. As an empirical validation, for a panel of

[16] Following Auerbach and Gorodnichenko's strategy, the authors classify periods of slack or recession (expansion) as those with very low (high) growth in real GDP. Accordingly, during recessions (expansions) the output gap varies between -0.4 and -7.2 per cent (-1.1 and 8.5) of potential output, with an average output gap of –3.7 per cent (3.5).

[17] Subsequently, Leduc and Wilson (2017) have shown that the federal highway grants increased the actual spending on highways at state level more than proportionally, possibly because of some degree of complementarity between road projects that were eligible for federal reimbursement and those that were not.

[18] In this respect, Nakamura and Steinsson (2014), using cross-state variations in US military spending, argue that their estimated 'local' multipliers, around 1.5, are larger than the 'national' ones found by Ramey (2011) and Barro and Redlick (2011), on average below 1, because the latter might have been affected by episodes of particularly tight federal fiscal and monetary policies.

72 advanced and emerging economies, IMF (2020b) shows that a government investment stimulus is more effective during periods of high uncertainty.[19] In particular, an unanticipated shock of public investment of 1 per cent of GDP generates an output multiplier of roughly 2.5 at a 2-year horizon in periods of high uncertainty, while the unconditional multiplier is only about 0.5. Their analysis also highlights much larger responses of private investment and employment under high uncertainty. The results in terms of multipliers are confirmed overall by Bachmann and Sims (2012), who focus on the US case.

3.2 Some arguments for a selective boost to investment

This section outlines a set of possible policies that could be particularly appropriate today because they aim to strengthen some specific sectors of the economy, i.e. national health systems, and, in the meantime, to spur the economy and reduce the slack in the labour market. As for the latter point, Box 2 reviews some studies that analyse the effects of government investment on employment that occurred during the Great Recession.

Jones et al. (2008) and Harvard Global Health Institute (2018), among others, have long warned that the likelihood and severity of pandemics have been rising since World War Two and that the world was far from prepared to face similar health crises. Indeed, soon after the COVID-19 outbreak, several shortcomings became apparent; for example, many countries were lacking a sufficient number of intensive care units or an efficient territorial health system to treat the most fragile categories of people. Investing in **health infrastructures**, in order to make a national health system more resilient to a pandemic, would not only save future lives but would also diminish the associated expected economic costs, for example curbing job losses as compared with the size observed in the COVID-19 crisis, and hence also mitigating possible precautionary attitudes on the part of households and firms (Kozlowski et al., 2020). More generally, a better or more extended health system contributes to improving the health and quality of life of citizens (see Section 4 for more details) but can also attenuate the tendency of households to save more so as to be able to pay for private health care; this can encourage consumption, thereby helping the current recovery (see, for example, Ercolani, 2020a). These policies seem to be advocated by citizens themselves: as several studies show (Rees-Jones et al., 2020 and Foremny et al., 2020 for the US and the Spanish cases, respectively), COVID-19 has generated widespread support for a shift of public spending towards health care.

While **maintenance** investment normally aims at offsetting the natural deterioration of infrastructures, during a crisis it can also become a powerful countercyclical tool, because it typically involves smaller, shorter and less complex projects, whose shorter implementation lags can make possible a prompt activation of private production factors, including labour (IMF, 2020b). For example, GAO (2011) documents that 60 per cent of the funds for highways were allocated to maintenance projects under the ARRA and almost all of them were completed within two years. Furthermore, maintenance is not subject to the caveat that applies to brand new infrastructures, i.e. that they may disrupt existing ones and have adverse effects on the local economies. Finally, Bennett et al. (2020), focusing on the US, highlight a general need for strengthening maintenance, given that investment in some important basic infrastructures, like transportation, has barely kept up with the depreciation of the last few decades.

[19] The authors, following the identification approach of Auerbach and Gorodnichenko (2012), define the uncertainty variable as the standard deviation of GDP growth rate forecasts across professional forecasters, as published by Consensus Economics, using the spring vintage of the forecasts for each year.

Box 2. Employment effects during the Great Recession

Given the extraordinary loss of jobs at global level after the COVID-19 outbreak, this Box reviews some studies that analyse the effects of government investment on job creation during contractionary periods. Some of these studies exploit the **ARRA design**. For example, Garin (2019) studies whether counties that received relatively more funding from the government experienced more favourable employment growth than those that received relatively less. He finds that road spending has a significant effect on counties' construction employment, which is largest in 2010. In particular, $1 million spent in a given county increased construction employment in the same county by 6 job-years. Furthermore, in line with the theory, construction payrolls grew by roughly 30 cents for each dollar spent over the following five years. Notice that any additional construction job might also have a 'local multiplier effect' because workers may spend the additional income at local companies, thereby fostering hiring (Moretti, 2010). Despite this, Garin (2019) cannot find clear evidence for such a local multiplier: the (non-farm) employment multiplier – the effect of an additional job in the construction sector on local employment – is estimated to be less than 1, although the associated confidence interval is very wide.

In fact, there are some studies that find significant effects on local employment (exploiting the allocation schemes at the state level of the federal US funds). For example, Wilson (2012) focuses on some important spending items of the ARRA – including those relating to health, education and to repairing and building highways and bridges – and finds that each million dollars in these categories generated about 8 jobs, one year after the legislation was enacted. Similarly, Feyrer and Sacerdote (2011) find about 6 jobs per million dollars spent. Furthermore, Leduc and Wilson (2013) find a positive and significant effect of highway spending on employment but only later in time, namely around the sixth year after the occurrence of the policy shock.[20]

Popp et al. (2020) notice that roughly 17 per cent of the ARRA spending was directed towards **green investment**, such as energy efficiency audits and retrofits, investments in public transport and clean vehicles, and Environmental Protection Agency spending to clean up brownfield sites. The authors find that each $1million of green ARRA spending in a certain commuting zone created up to 15 new jobs there, which only emerged, however, in the post-ARRA period (2013-2017), while they do not find significant short-run employment gains.[21] Almost half of the jobs created by green ARRA investments were in construction or waste management and nearly all of the newly created jobs were in manual labour positions. Though Garrett-Peltier (2017) does not focus on the ARRA act, he shows that investing in clean-energy infrastructures can be labour intensive in the short-to-medium term. In particular, using Input Output US Tables, he finds that $1 million of spending on fossil fuels generates roughly 2.5 jobs, while the same amount of spending in renewables or energy efficiency would create 7.5 jobs.

Improving the governance of public investment projects would raise the efficiency of public investment, making stimuli more effective. Baum et al. (2020), using data on 164 countries (both

[20] Remember that Leduc and Wilson (2013) do not focus exclusively on the ARRA effects since their analysis covers the 1990-2010 sample.
[21] The commuting zone is based on journey-to-work data and defines clusters of counties with strong commuting ties.

advanced and emerging), document that more than one third of the resources spent on infrastructure are lost in the process of managing public investment. In particular, they show that public investment efficiency – defined as the ability to improve the volume and quality of infrastructure for a given level of spending – is positively correlated with the quality of public investment management, as measured by the IMF's Public Investment Management Assessment (PIMA) index, a synthetic indicator that considers the three stages of the investment cycle, i.e. planning, allocation and implementation. They also document that higher efficiency goes together with lower corruption. The same qualitative messages are provided by Busetti et al. (2019) for the Italian case. Together with this, Abiad et al. (2016) show that in countries with high-quality (low-quality) public management, a public investment spending shock (of 1 per cent of GDP) raises the level of output by about 0.8 per cent (0.2) in the same year and by 2.6 per cent (0.7) percent in four years. In the 'high-quality' case, there is also a boost to private investment, although it falls where the quality is low. These results are broadly confirmed by Miyamoto et al. (2020).[22]

Synchronized infrastructure spending among various countries could boost global GDP thanks to the positive spillovers arising from interconnectedness. The IMF (2020c) makes this case in a context of widespread spare capacity and of ZLB. They assume that G20 economies judged to have at least 'some fiscal space' raise infrastructure investment by 0.5 per cent of GDP in 2021 and 1 per cent in 2022, and then keep it at that higher level until 2025; the others – those with 'fiscal space at risk' – are assumed to spend one third of those amounts: as a result, the level of global GDP would increase by around 1.5 per cent by 2023 and 2024 and by 2 per cent in 2025.[23] In a counterfactual scenario where each country raises infrastructure spending on its own rather than simultaneously, then global GDP dynamics would be much weaker, increasing by just 1.2 per cent by 2025. Why can the occurrence of a contemporaneous stimulus abroad be particularly beneficial for a given home country? If the latter raises infrastructure spending then inflation rises, as noted above, but the supply component of the stimulus mitigates the overall inflationary dynamics. From the perspective of the home country, higher foreign spending on infrastructure only represents a positive demand shock – through, for example, higher exports of intermediate goods – that will further reinforce the inflationary pressures and hence, at the ZLB, the effectiveness of the stimulus.[24] The results in Cova et al. (2017), using a multi-region New Keynesian model of the world economy, also support a coordinated expansion of public investment.

4 Secular forces and welfare: preserving infrastructure investment

As discussed above, a key feature of public investment is its long-lasting consequences, which in turn can interact with **secular factors** hindering growth and affect individuals' welfare in a structural way. For example, Aschauer (1989a, 1989b) has argued that the widespread decline in infrastructure investment contributed to the productivity slowdown in the G7 countries during the 1970s and 1980s. Hence, in principle, raising public investment can help mitigate secular stagnation and the saving glut (Rachel and Summers, 2019), which have arguably been exacerbated by the COVID-19 crisis (see, among others, Blanchard, 2020 and Ercolani, 2020b). For example, Cova et

[22] The PIMI indicator was not available for all countries. Hence, both Abiad et al. (2016) and Miyamoto (2020) use alternative indicators for proxying public investment management, such as a survey-based measure of the wastefulness of government spending taken from the World Economic Forum's (WEF) *Global Competitiveness Report* or the World Bank's government effectiveness indicators.

[23] Following IMF (2020c), among the G20 countries, Austria, Germany and Korea have 'substantial fiscal space', Canada, China, France, Indonesia, Japan, Mexico, Russia, Saudi Arabia, Turkey, the UK and the US have 'some fiscal space', Brazil, Spain, India and Italy have 'fiscal space at risk', and finally Argentina and South Africa have 'no fiscal space'.

[24] Obviously, one should always take into consideration that the supply effects of the infrastructural stimulus could emerge with some delays.

al. (2017) show that a global infrastructure stimulus, accompanied by accommodative monetary policies, can enhance long-term world growth.

The **implications for welfare** are worth noting as well. First, strengthening the health service infrastructure aims at improving the health and the quality of life of citizens, and increasing life expectancy. As a consequence, improved health conditions can allow people to perform better both at school and at work, increasing human capital and productivity (see, among others, Currie and Madrian, 1999 and the OECD, 2019). Better living standards can also be achieved by providing citizens with efficient equipment (such as plumbing, heating and electrical apparatus) together with the continuous maintenance of existing infrastructures, which reduces waste (Gordon, 2017). Obviously, keeping the infrastructure system efficient would also contribute to the sustainable environmental transition. Gallen and Winston (2019) draw attention to another relevant spending category, i.e. improved transportation infrastructure, which can raise individuals' lifetime utility by reducing the time spent on work and leisure commuting.

Several authors stress the existence of large infrastructure gaps, especially in emerging economies (see, among others, Hellebrandt and Mauro, 2016, and Antonelli et al., 2014). Further evidence in this respect is provided by Bennet et al. (2020), who show that the remaining service life of most types of US infrastructure has been falling rapidly. Despite this, **the stock of government capital has in general declined** during the last few decades both in advanced and emerging countries, with the exception of China (see Figure 1 above). Among other factors, the **procyclical bias of fiscal policy** (Alesina et al., 2008) has been responsible for such a decline: while consumption spending provides immediate payoffs, the benefits of infrastructure often take more time to materialize and, especially in the presence of short political time horizons, the preferences of politicians tend to fall on the former spending category (Ardanaz and Izquierdo, 2017). Furthermore, Haughwout (2019) shows for the US that transportation infrastructure investment occurs disproportionately when macroeconomic conditions are strong and decreases when the **economy weakens,** and that periods of declining employment growth overlap with slower infrastructure spending. The former point is arguably generated by the fact that roughly 60 per cent of state highway funding is found through user revenues and other taxes and fees, which are themselves highly procyclical.

Contingent fiscal plans could provide a **safeguard** for protecting **infrastructure investment**. For example, Haughwout (2019) proposes the creation of an infrastructure spending plan for the US that would automatically be triggered during a recession, with the aim of reducing the abovementioned procyclicality. Similarly, Ardanaz et al. (2021), using a sample of 75 advanced and developing countries (1990-2018), show that in countries with *flexible fiscal rules*, e.g. with a *golden rule* for public investment, a fiscal tightening of at least 2 per cent of GDP is associated with an average reduction of 2 per cent in public capital expenditures. Instead, in countries with either no fiscal rule or with a rigid fiscal rule on fiscal targets, the same tightening triggers a much more marked decline in capital expenditures, of about 10 per cent.[25] Overall, it seems that if public investment is not adequately protected over both the political and the business cycles, then it will take the brunt of budget cuts, with possible negative repercussions on individuals' welfare.

[25] The authors define a flexible fiscal rule as one with at least one of three features present: (i) provisions that exclude public investment from the perimeter of the rule, (ii) the rule includes cyclically adjusted fiscal targets, and (iii) the rule contains well-defined escape clauses to accommodate exogenous shocks of various sorts, such as natural disasters. In contrast, a fiscal rule that establishes numerical limits on fiscal targets but lacks flexible features is considered a rigid rule.

5 Conclusions

The COVID crisis, though not concluded, has already produced many painful consequences, such as more than 2 million dead and 100 million infected people, as well as the most severe global recession since World War Two. In this context, many advanced countries have decided to direct a considerable part of their resources to infrastructure projects, also with the idea that a low interest rate regime would favour the persistence of quite accommodative financial conditions.

The literature seems to agree on the fact that an infrastructure stimulus is more effective in the medium-to-long run because the public capital stock needs time to build up and to exert its effects. However, under some circumstances, such as ample spare capacity, a constrained monetary policy or heightened uncertainty – which are among the features of the current conjuncture – the stimulus can be significantly expansionary even at shorter horizons, i.e. one to three years. The potentially high returns on infrastructure investment can ultimately strengthen fiscal sustainability, which is a crucial consideration in times of skyrocketing public debts. Infrastructure investment could also counteract secular stagnation and improve individuals' welfare.

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