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INVESTMENT IN INFRASTRUCTURE AS A KEY TO SUSTAINABLE ECONOMIC RECOVERY: THE ROLE OF THE BUILDING INDUSTRY

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Abstract. The focus of this paper is the role of the building industry in post-COVID-19 economic recovery plans. Investment in infrastructure forms a major part of many countries' strategies to engender economic growth and construction is the pivotal industry in enabling the implementation of the plans in a sustainable manner. This study looks at the effects of investment in infrastructure on the economy with reference to the role of the construction industry in delivering this investment. Basic issues are considered, particularly concerning how relevant investment can be measured and how the contribution of the construction sector can be realistically assessed. A review of data sources and empirically peer-reviewed papers is undertaken. Based on longitudinal time series data from national statistics agencies and international organizations, analysis is undertaken to discover the relationship between infrastructure investment and economic growth. The study focuses on the UK, but comparisons are made with other countries to consider alternative approaches to stimulus investment policies with digitalization, and sustainability and green investment being a growing feature of investment plans. Potential issues of these approaches are examined and the main barriers to their achievement are identified. Emerging trends and a set of policy agendas are proposed to guide future directions.

Keywords: COVID-19, construction industry, infrastructure, environmental policy, sustainable recovery, economic growth.

Introduction

After the end of World War Two, Germany and Japan were the star performers in the global economy. This did not happen by accident. One big factor driving that economic success was the rebuilding of the physical infrastructure of both countries after the devastation caused by the war. The rebuilding was costly. The investment share of GDP in both Germany and Japan was more than ten per cent higher in the 35 years after 1950 than in the previous 35 years but the new capital infrastructure resulting from this investment was the most modern and the most efficient that the world had to offer at the time. The world now faces a similar moment. We are emerging from the turmoil of COVID-19 into a world where working practices and lifestyles are changing, and physical infrastructure is set to be replaced or retrofitted on a grand scale.

The consequences of the COVID-19 pandemic have caused serious problems in many economies with growth expectations drastically curtailed and governments have put policies in place to stimulate economic recovery. The construction industry can play a vital role in such plans as the sector is able to provide a unique stimulus due to its spending multiplier effect being the highest of any industry sector in the economy (Chartered Institute of Building, 2020). Investment in building can lead to both direct and indirect effects that percolate through the whole value chain of the economy as this investment produces significant economic spillovers through the creation of value-added employment contributing positively to both regional and national economic growth. The International Energy Agency produced an estimate of the multiplier effect indicating that the creation of up to thirty jobs in the manufacturing and construction sectors could arise from every million US dollars spent on retrofit and energy efficiency measures in new buildings (International Energy Agency [IEA], 2020). Historically, infrastructure projects have been shown to accelerate economic recovery and create jobs during economic crises; the most notable example being the New Deal, which was implemented in the USA following the Great Depression in the 1930s. When it comes to stimulating growth in GDP, infrastructure spending offers the best value, and investments in this

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sector can pay for themselves by boosting the economy as a whole and the tax base.

Aschauer (1989) discovered evidence of a link between increases in the quantity of infrastructure stock and substantial rates of return in terms of economic growth, with pioneering research on the role of infrastructure in economic development as a sort of public asset. Since then, a slew of studies based on both national (Luoto, 2011; Khanna & Sharma, 2021) and international data (Easterly & Rebelo, 1993; Canning, 1998; Wang, 2002; Esfahani & Ramírez, 2003; Calderón & Servén, 2004; Kodongo & Ojah, 2016) have backed up the conclusion that infrastructure spending is critical to economic growth.

Estimates of the multiplier (by how much output increases due to a unit increase in infrastructure investment) vary greatly because of the very nature of the multiplier process. It operates in the short term but reaches its full strength only over time. This relationship is endogenous. Infrastructure investments cause economic growth, and economic growth, in turn, pushes up infrastructure investments, so that investments into infrastructure go hand in hand with general economic growth.

One of the most significant but underdeveloped parts of the economic analysis of infrastructure spending continues to be the macroeconomic argument for investment in this area. Macroeconomists, who support calls from politicians for higher infrastructure expenditure, believe that such spending has both countercyclical and possibly long-term growth advantages. Microeconomists use the well-practised techniques of cost-benefit analysis to approach infrastructure spending project by project. Benefits are primarily determined by effects on infrastructure users, though evaluations occasionally take rising local property values or business earnings into account. Costs in this type of analysis are primarily related to construction. Typically, for the majority of new large-scale infrastructure projects, this strategy often only produces small returns, whereas maintenance of already-built infrastructure often yields substantially better returns. The macroeconomic method frequently only produces generic recommendations to spend more on infrastructure during a downturn, in contrast to the microeconomic approach, which produces explicit policy tools for choosing infrastructure projects.

The macroeconomic viewpoint is strengthened by the way infrastructure investments are evolving. When Keynes presented his ideas in the 1930s, civil engineering and construction projects were very labour intensive. Masses of unskilled workers were frequently used on New Deal projects in the United States. The infrastructure of today requires significantly more capital and is much more likely to employ skilled workers who would be engaged in any event. As machines and equipment become more necessary as a replacement for less skilled workers for the creation of infrastructure, then there will be less room for infrastructure policy to have an immediate impact on employment. While revealing some of these policy levers' shortcomings, the pandemic has rekindled arguments for the use of infrastructure spending as a measure of macroeconomic stabilisation. The fact that there are available unemployed workers is one of the conventional justifications for supporting infrastructure investment during a recession but not one in which current labour shortages may prevail. Construction employment fell sharply in several nations in 2020, but globally it is continually starting to rise again as infrastructure expenditure plans are put into action.

Also, in contradiction to the conventional positive infrastructure investment – economic growth relationship, some research has suggested little evidence of an effect from infrastructure investment on income growth (Hulten & Schwab, 1991; Holtz-Eakin & Schwartz, 1995; Garcia-Milà et al., 1996) and a caveat to the notion of any short-term benefits from this investment stimulation, is that governments may invest in infrastructure as a countercyclical tactic to deal with the economic slump and anticipate that the investment would eventually spur future economic growth over the longer-term (Liu & Liu, 2022). In the initial years following their completion, many projects often fail to yield sufficient economic advantages. In the short to medium term, this could suggest a large waste of capital, despite the possibility that the idle capacity could be filled many years later.

An aim of this research is to evaluate the role of investment in built assets, through a scoping review and time series analysis of relevant data, in the achievement of a recovery programme based on the promotion of economic growth. An objective is to clarify the difficulties in identifying appropriate definitions and measures of infrastructure investment (quantity and quality aspects) from national and international statistical interpretations. Another objective is to identify and assess the new challenges arising from the urgent need to emphasise the green aspects of investment and digitalization in the overriding context of sustainability.

Recovery policies focus on infrastructure

Many governments have prioritised infrastructure investment in their post-pandemic recovery plans, and the UK government, like many others, has created and begun to execute post-COVID-19 strategies to salvage their wrecked economies. The UK government released a *National Infrastructure Strategy* in its Spending Review 2020, which aims to ensure that long-term infrastructure investment priorities are aligned with the shorter-term goal of supporting economic recovery from the pandemic. It involved setting multi-year capital budgets for important infrastructure projects such as High-speed Rail and the Road Investment Strategy (HM Treasury, 2020).

However, the UK government's engagement in infrastructure isn't restricted to providing funds for public-sector projects; in fact, because both the public and private sectors are involved in infrastructure provision, the government's position is multifaceted. It also aims to direct

investment towards projects it considers valuable and to support private investment through various mechanisms. Projects in the transport and social sectors are mainly publicly funded but the opposite is true of projects in the energy and utilities sectors which are mainly funded through the private sector. Therefore, an important aspect of the *National Infrastructure Strategy*, has been the setting up of a UK Infrastructure Bank to support private investment in infrastructure with the aim of backing substantial investment in projects such as housing, transport, renewable energy and waste management.

Plans for investment in infrastructure are being promoted in other countries with shovel-ready construction projects being instinctive for any government looking to kickstart the economy. For example, the United States Government has proposed plans to provide for massive investment in America's roadways, railways, and bridges with a focus on clean energy, modernising transit systems and investment in the removal of a growing backlog of Amtrak repairs as well as improvements and route expansion and President Biden signed off a $738 bn infrastructure package in the Summer of 2022. It is planned that airports, ports and waterways will also receive improvements (USA Today, 2022). Many examples of similar strategies exist, such as the UAE setting up a £3 bn package that has included measures to accelerate its major infrastructure plans (The Official Portal of the UAE Government, 2021) and Australia has planned a series of fast-track programmes worth more than £2 bn (Infrastructure Australia, 2021).

1. A scoping review

1.1. Defining infrastructure and infrastructure investment

In order to assess the relationships between infrastructure investment and economic growth, and the role of the construction industry in producing infrastructure, it is obviously necessary to firstly define and be able to measure what infrastructure means.

In an article "*What is Infrastructure?*", (The Economist, 2021), the Economist referred to infrastructure as the "economic arteries and veins (roads, ports, railways, airports, power lines, pipes and wires) that enable people, goods, commodities, water, energy and information to move about efficiently," and Infrastructure UK (now the Infrastructure and Projects Authority) had identified the infrastructure sectors as being: energy, transport, waste, flood, science, water and telecommunications. These interpretations define what is meant by "hard" infrastructure as opposed to "soft" infrastructure which can refer to organised structures like the government, laws, the emergency services, and other similar ones.

1.2. Data sources on infrastructure

Following on from its 2017 and 2018 papers (Office for National Statistics [ONS], 2017, 2018) attempting to define infrastructure, the UK ONS (2019) in *Experimental comparisons of infrastructure across Europe* indicated that there is no universally accepted definition of infrastructure, and it is not separately identified in any national accounts data. For example, Eurostat's estimates for European Union countries (Eurostat, 2021) are based on the stock of the "other structures" asset from national balance sheets. This is a reasonable predictor of infrastructure stock, albeit it contains some assets that are not related to infrastructure while leaving out some that are. Infrastructure expenditures refer to: "Constructions other than residential structures, including the costs of roadways, sewerage, and site clearance and preparation," according to the European System of National and Regional Accounts 2010 (ESA10).

In addition to the estimates of the stock of infrastructure, estimates of infrastructure investment might serve as another metric of infrastructure quality. High levels of infrastructure investment could be interpreted either positively (as a sign of a developing a well-maintained infrastructure stock) or negatively (as a sign of a subpar stock that requires upgrading and/or repair).

1.3. How much infrastructure does the construction industry build?

Every month, the UK's ONS conducts a targeted survey of the construction sector, sampling eight thousand businesses. The worth of new infrastructure building work and the value of repairs and maintenance to existing infrastructure assets that were completed during the month are both requested of respondents as part of the survey. Only a small portion of the repair and maintenance data gathered in the survey will fit the criteria for capitalization (i.e., investment); the remaining portion is classified as intermediate consumption in the national accounting system. Water, sewerage, electricity, gas, communications, air travel, railroads, harbours, and roads are all included in the survey's definition of infrastructure. However, for three main reasons, this data cannot be precisely equated to the overall value of the UK infrastructure supply.

Firstly, the survey data only accounts for the total value of construction work performed by businesses classified as belonging to the construction industry; it excludes any "in-house" construction work performed by businesses classified as belonging to other industries, such as organizations in the energy and mining sectors or government agencies, for their own use. For instance, it excludes work undertaken by Network Rail but will include work done for Network Rail by businesses in the construction sector. Secondly, because construction production data are calculated using basic pricing, they do not account for transfer fees, installation fees, or taxes minus subsidies on the pertinent building materials. These additional expenses are accounted for in the capital expenditure value, which is typically valued at purchasers' prices plus any costs of ownership transfer.

Thirdly, some infrastructure assets will also be developed through a combination of in-house creation of specialised machinery or software and outsourced construction work. A mobile phone mast, for instance, might be built by a construction company, but the specialised software that enables it to transmit and receive radio waves would probably be created and installed by the telecoms operator and thus not be picked up in the construction industry surveys. For these reasons, these construction data are likely to only be a lower bound for the construction industry's contribution to investment in the total infrastructure supply.

1.4. Value and components of UK infrastructure construction

From the UK National Accounts (ONS, 2021), the value of infrastructure construction work by the construction industry in 2020 was £22.4 bn, of which 50.5% was undertaken on behalf of public sector clients, and the remainder was carried out for private sector clients. Table 1 also illustrates that the trend over a decade was a notable rise in the share of the public sector.

Table 2 shows the share of investment work undertaken for the sub-sectors of infrastructure in 2020 with investment in energy infrastructure the major area of investment. There had been an increased share from 18% to 41% over the decade.

1.5. Comparing infrastructure investment across Europe

To make international comparisons of the level of investment in infrastructure levels across European countries, data on aggregate gross fixed capital formation (GFCF) in all assets in infrastructure-related industries (covering energy, water, waste, transport, and telecommunications) from the OECD Database (2021a) can be employed.

The range of infrastructure investment ratios in a number of other significant European economies (including Belgium, Denmark, the Netherlands, Norway and Sweden) can be contrasted with the percentage of total investment in the EU G7 countries (France, Germany, Italy, and the UK) from 1997 to 2018. The metrics for all the countries has been quite consistent with ratios between 10% and 20% over the twenty-year period.

The OECD data also shows that, with the exception of the UK in 2010, Italy's infrastructure investment as a percentage of overall investment was consistently the highest among the EU G7 economies. The UK experienced a dip from 14% in 2013 to 10% in 2015, although this increased to 12% in 2016, surpassing Germany and France. Compared to their Western European equivalents, investments in Central and Eastern Europe (CEE) were relatively higher and, outside Europe, it was notable that China had the highest rates of infrastructure investment in the entire globe. In 2018, China's average infrastructure investment (measured as a share of GDP) was ten times greater than that of the United States.

Table 2. Infrastructure by sub-sector 2020 (% of total) (source: ONS, 2021)

Sub-sector	
Water	4.4
Sewerage	4.0
Electricity	41.2
Roads	25.2
Railways	15.2
Harbours	7.2
Other (inc. air transport, gas, communications)	2.7
Total	100.0
of which – public	50.5
– private	49.5

2. Empirical analysis of the infrastructure-economic growth relationship

One method of comparison between countries of the infrastructure investment–economic growth relationship is to use time series data over a long-term period. Information on public investment comes from three sources: the OECD Analytical Database (2021a) for OECD countries and the IMF World Economic Outlook (International Monetary Fund, 2021) for non-OECD countries.

Employing data on investment rates in infrastructure and growth in Gross Domestic Product (GDP) over the period 2000–2019, the average annual rates over the twenty-year period can be calculated.

Figure 1 plots these averages for the forty-eight countries for which full series are available utilising these sources. The dataset includes countries at different levels of development. Developed economies in the OECD dataset comprise a half of the total number with the other twenty-four economies in the dataset classified as developing.

The regression line shown in Figure 1 suggests a relationship such that an increase in the share of infrastructure investment in GDP by 1% is associated with an increase in GDP growth rates by 1.6%. However, the effectiveness

Table 1. Infrastructure construction (new work), current prices (£ billion) (source: ONS, 2021)

	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Total	14.62	13.68	14.46	14.79	17.77	17.76	20.10	21.52	23.25	22.45
of which – public	4.91	4.11	5.54	5.42	6.67	7.35	7.83	12.05	13.67	11.33
– private	9.71	9.57	8.93	9.38	11.11	10.41	12.27	9.47	9.59	11.13

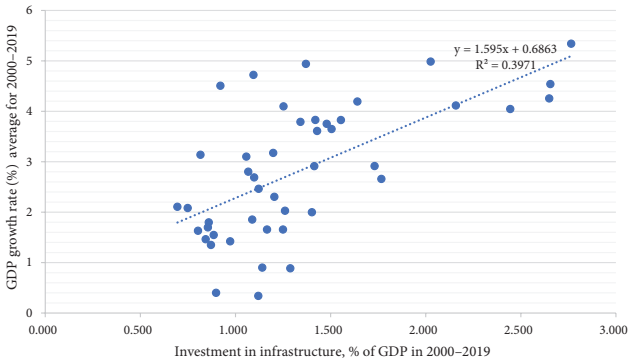

Figure 1. Average GDP growth rate and investment in infrastructure 2000–2019 (sources: OECD iLibrary, 2022; World Bank, 2022)

of infrastructure investments (growth in GDP per unit of investment) varies significantly by country, ranging from one to four in rich countries to five or more in countries classified as emerging markets (India, Mexico). In contrast, China had GDP growth rates of roughly 9% on average (not displayed in the graph due to some incomplete time series data) in 1995–2016, with the share of infrastructure investment in GDP of 2.7–3.4%, whereas many developed countries (including Austria, Belgium, France, Germany, Italy, the Netherlands, and Portugal) were growing at less than 2% per year with infrastructure investment of less than 1% of GDP.

The comparison supports the results of some earlier research. Han et al. (2021) examined the relative benefits of infrastructure versus non-infrastructure investment on output per worker in rich and developing economies over fifty-eight years (1960–2017) for more than 144 countries in a study for the Asia Infrastructure Investment Bank. The study provides evidence that developing economies are more significantly impacted by increased infrastructure per worker, which indicates that developing economies should allocate a larger portion of gross capital formation to infrastructure. Additionally, a study conducted for the World Bank (2019) supported the idea that developing nations should invest a bigger percentage of their GDP – roughly 6 to 10% – into infrastructure than do developed nations.

2.1. Underinvestment in infrastructure

In most circumstances, increasing infrastructure investment may increase the growth rate of the economy, regardless of how effective infrastructure investment is. So, why then might nations neglect to invest in their infrastructure? The answer is because of the amount of infrastructure funding that comes from the private sector. The return on infrastructure investments is frequently uncertain and the payoff period can be extremely long, to which private investors are typically averse. There are also significant externalities as infrastructure investments benefit not only the investor, but many companies and households all over the economy that do not pay for these investments, so there is a free rider problem. If left to the market alone, infrastructure investments would be at sub-optimal levels.

2.2. Infrastructure needs and quality

Despite the significance of infrastructure for a community's well-being, overall global infrastructure investment is lacking. It is predicted that projected infrastructure investment will fall short of actual spending requirements with the World Economic Forum (2019a) estimating that the world is heading for a shortfall of $15 trillion on much needed infrastructure investment by 2040.

Infrastructure requires upkeep and improvement over time and the issue of infrastructure decay has become particularly prominent in many advanced economies. The short-sightedness of delaying necessary infrastructure refurbishments means that critics have become concerned about any decline in spending on construction when projects are due for renewal.

For instance, the deteriorating infrastructure in the United States needs urgent repair in order to raise living standards. It is anticipated that countries classed as emerging markets will have the biggest spending shortfalls. It includes nations like Mexico, Indonesia, and Brazil with the WEF report projecting the gap between spending and estimated infrastructure requirement to be greater than 1% of GDP.

A contemporary economy cannot function without a functional infrastructure, and as a result, there should be a positive relationship between GDP and infrastructure quality. Of course, infrastructural requirements evolve as societal needs do. In the UK, the current investment strategy reflects the significance of energy and transportation infrastructure, with future investment plans mainly focused on these two areas. However, as societies continue to employ internet-based technology more and more, a completely new type of infrastructure is now necessary.

The World Economic Forum (2019b) undertakes a global assessment of the quality of infrastructure and ranks infrastructure on a scale of 1 to 100. The top three countries in the rankings are shown in Table 3 and compared to the G7 countries.

Table 3. Ranking of countries by quality of infrastructure (source: World Economic Forum, 2019a, 2019b)

Ranking	Country	Score
1	Singapore	95.4
2	Netherlands	94.3
3	Hong Kong SAR	94.0
5	Japan (G7)	93.2
8	Germany (G7)	90.2
9	France (G7)	89.7
11	United Kingdom (G7)	88.9
13	United States (G7)	87.9
18	Italy (G7)	84.9
26	Canada (G7)	80.8

One aspect of an assessment of ensuring the ongoing quality of infrastructure is expenditure on maintenance of the existing structures. Taking data from a 2021 survey that covers total gross investment, defined as new construction extensions, reconstruction, renewal, and major repair (Statista, 2021) maintenance expenditure on infrastructure is compared for the G7 countries in Table 4 alongside the global leader China.

Table 4. Global investments on the construction and maintenance of infrastructure as share of GDP in 2019 by country (source: Statista, 2021)

Country	%
China	5.57
Japan	0.95 (G7)
UK	0.92 (G7)
France	0.84 (G7)
Germany	0.68 (G7)
Canada	0.53 (G7)
USA	0.52 (G7)
Italy	0.42 (G7)

The level of variation for the G7 countries is considerable with particularly low rates in three of the countries.

3. Post-COVID-19 recovery policies: review of the challenges

3.1. Green investment

The need for new green infrastructure to transition to clean energy is creating vast new requirements for infrastructure investment. Among green and conventional stimulus initiatives, green energy investments have some of the strongest economic traits. Along with the shorter-term employment generated in construction, investments in green energy can create long-term, high-quality employment prospects in operations and management (Dvořák et al., 2017; Lehr et al., 2012; Wei et al., 2010). Additionally, green energy assets can have large long-term economic multipliers, especially when technological components are made in the domestic economy (Garrett-Peltier, 2017; United Nations Environment Programme, 2020). To ensure that targets are met for infrastructure investment, particularly for green investment, private investment is needed to bridge the infrastructure investment gap.

Institutional investors can be a critical pool of long-term private capital and governments need to find policy levers to scale-up institutional investment in green infrastructure. Even though governments have attempted to encourage institutional investment in infrastructure, it still only makes up a small portion of institutional portfolios in many economies. However, over the past ten years, persistently low returns on conventional financial assets like bonds and stocks have encouraged more institutional investors to look to alternatives, including infrastructure. This trend's momentum and institutional investors' growing interest in sustainability create a chance to increase institutional investment in green infrastructure.

3.2. Private sector involvement – inducing institutional investors

Concerned with the need to keep public debt low, over recent decades the UK Government has pushed responsibility for constructing and maintaining vital infrastructure as far as possible onto the private sector. In addition to the privatisation of utilities in the 1980s, which proved successful in ensuring routine capital expenditure but proved inadequate in driving forward new investment, other infrastructure models have also proved problematic. Public Private Partnerships were used to fund more than seven hundred projects but offered poor long-term value for money due to the inflexibility of the associated service contracts.

Persistently low yields on traditional assets and an increased appetite for risk among asset owners are two characteristics of the type of investment available to institutional investors. These factors point to increased availability of construction stage capital from institutional investors in the future. The building phase is when project risk is at its highest level. Nevertheless, project risk is reduced and is more tolerable to institutional investors after a project is operational. Although there has always been a preference for operating projects because of the reduced amount of risk they carry, institutional investors' interest in initial stage investments has grown over recent years.

For instance, the UK Government is setting up a new funding mechanism for financing nuclear power stations. In essence, it creates a framework for a Regulated Asset Base model (House of Commons Library, 2022) and it allows private investors such as pension funds to finance new nuclear projects and reduces the cost of capital by cutting back the construction risk to investors. It works if the regulator makes absolutely sure that the design and construction plans are rock solid before giving approval. Investors looking for greater yields may find construction stage projects, with their higher risk-adjusted returns, to be an appealing option.

A number of strategies can be used by policymakers to speed up institutional investment in green infrastructure. These include creating a supportive policy environment, outlining fiduciary responsibility, encouraging institutional innovation, actively mitigating the risks associated with public-private partnerships, and making it easier to securitize infrastructure assets.

Governments can expand green project pipelines to address the absence of enough investment-grade initiatives. Also, investors find it challenging to justify the expenses of expanding capacity for one-time investments and they would be better able to take calculated risks, invest in capacity building, and support the growth of a market for infrastructure investment if they had more assurance that follow-on projects would be available. Government and investor partnerships can be an efficient method to spread risks, achieve scale, and build a pipeline of investment-grade projects.

3.3. Job effects and macroeconomic potential of green investment

As indicated, the IEA's *Sustainable Recovery Plan* (IEA, 2020) predicts that for every million dollars invested in retrofits or efficiency measures in new buildings, between nine and thirty jobs in manufacturing and construction will be created. Local manufacturing jobs would be generated by the increased demand for building supplies and equipment like insulation, energy-efficient windows, and heat pumps, while construction jobs would primarily be local (IEA, 2020). As an example of such an effect, in the European Union in the immediate years after the 2008 financial crisis, investments in building energy efficiency resulted in the creation of an average of eighteen jobs for every million euros spent.

Many countries have been ready to pledge to a "green recovery" through the stimulus packages they were developing during the early phases of the COVID-19 epidemic. As the enormous volume of rescue and recovery spending has unfolded, determining the anticipated environmental impact of those packages has become increasingly difficult. To shed light on this, the OECD (2021b) has created a *Green Recovery Database* that tracks COVID-19 recovery policies that are anticipated to have beneficial or negative environmental consequences in forty-three countries. The findings demonstrated that while USD 336 billion has been given to ecologically favourable measures, spending on measures classified as having mixed or negative environmental impacts is currently evenly matched.

It is critical to consider this issue in light of overall COVID-19 recovery spending. O'Callaghan and Murdock (2021) estimated that only about 17% of recovery spending is classified as ecologically friendly. Together, mixed and negative measurements make up another 17% of the total. If the cost of COVID-19 as a whole is considered, the impact of green initiatives is even less significant: barely 2% of the overall budget for rescue and recovery goes to green initiatives. The modest share of green initiatives suggests that overall recovery packages are not yet poised to offer the necessary transformational investments.

3.4. Investment and financing for sustainable buildings

Expenditure on energy-efficient building in Europe has been growing at a modest rate over the past decade. However, with a rise of only 3%, it still lagged behind investment in traditional structures and construction. According to the IEA (2020), between 2014 and 2018, the annual rate of growth in building energy efficiency, as measured by the improvement in energy intensity, was at 3.5% which is in line with the 3% growth needed to meet the Paris targets and Sustainable Development Goal 7 (United Nations, 2015). This rate, however, is lower than the 4.5% growth rate of investment in new construction over the same time period, indicating that the development of investments in energy efficiency is not keeping up with the global construction of buildings, which has minimal impact on the total amount of energy used by buildings around the world.

3.5. Investment in "new" versus "traditional" infrastructure

Goldfarb and Tucker (2019) posited that that digitalization with its requirement of a "new", type of infrastructure is a crucial component of high-quality economic development. Other research studies have also found that expenditure on such "new" infrastructure will have a demonstrably good impact on the economy in the long- and short-term (Ren et al., 2020). However, an alternative view is that investing in such infrastructure, may not be appropriate to be utilised as a short-term stimulus programme to combat the COVID-19 epidemic (Liu, 2020; Wu et al., 2020).

In their study of the effects of infrastructure spending on economic growth in China, Meng et al. (2022) looked at whether the Chinese Government's massive post-2008 global crisis stimulus package made a telling contribution to alleviating the downturn in the economy. They distinguished between the effects of "traditional" and "new" infrastructure and concluded that it is "traditional" infrastructure, which provides the stronger effect as an engine of growth with longer-term benefits.

While traditional infrastructures like railways, highways, and dams are typically defined as public goods due to their positive externalities, digital infrastructures are seen as private commodities that are frequently provided by businesses (Fiorito & Kollintzas, 2004). The intangible benefits from asset formation are mostly influenced by "new" infrastructure investment but "traditional" infrastructure investment categories like building also dominate when it comes to the industries that are directly related to modern infrastructure, such as information transmission, software and information technology services, and scientific research and technical services.

4. Discussion and recommendations

4.1. Discussion

While the temporal analysis in this study has supported the view that there is a positive relationship between infrastructure investment and growth in GDP, previous studies using data on individual countries or regional groups have produced results which cast doubt on the universality of this general proposition.

Ansar et al. (2016) in their study of the infrastructure investment boom in China present a view that the benefits of investment in unproductive investment may be short-lived if the forecast benefits do not materialise and if over-investment is debt-financed.

Posing the question of whether China's economic growth has been a China's economic growth a consequence of its purposeful investment, the study concluded that far from being an engine of economic growth, the

typical infrastructure investment fails to deliver a positive risk-adjusted return. Investing in unproductive projects results initially in a boom, as long as construction is ongoing, followed by a bust, when forecasted benefits fail to materialize and projects therefore become a drag on the economy. Where investments are debt-financed, overinvesting in unproductive projects results in the build-up of debt, monetary expansion, instability in financial markets, and economic fragility.

A study of the effects of investment in transport infrastructure in the regional economies of China over a twenty-year period by Banerjee et al. (2020) found only a moderate positive causal effect on per capita GDP growth and emphasised the importance of factor mobility in maximising the benefits from the investment.

Several researches have given credence to the argument put forward by Flyvbjerg (2009) that large-scale megaprojects are often ill-conceived and mismanaged, which leads to massive delays in completion and cost overruns, often based on misleadingly optimistic cost-benefit estimates. Flyvbjerg (2009) cites the Damil Great Belt Road Tunnel, financed by international capital market loans with guarantees from the Swedish and Danish governments, as being non-viable before it was opened. He identifies the reasons for the cost overruns for megaprojects as being technical (uncertainty of the future and lack of forecasting experience), psychological (managers making decisions based on delusional optimism) and political-economic (project promoters deliberately overestimating benefits).

As another example, Anguera (2006) in an evaluation of the major investment in the England-France Channel Tunnel concluded that the British economy would have been better off if the project had not been undertaken.

Based on evidence from 245 large dams from 1934–2007 in sixty-five different countries, Ansar et al. (2014) studied whether the benefits of large new hydropower dams will outweigh costs. They found overwhelming evidence that budgets are systematically biased below actual costs – excluding inflation, substantial debt servicing, environmental, and social costs. This view suggested that in most countries large hydropower dams will be too costly in absolute terms and take too long to build to deliver a positive risk-adjusted return unless suitable risk management measures can be affordably provided. Capital sunk into building nearly half the dams could not be recovered data set the outcomes of large dams.

Khurriah and Istifadah (2019) examined the relationship of public capital, especially infrastructure to economic growth in Indonesia panel of data from thirty-four provinces in Indonesia, during the 2011–2017 period. The results of the study provide general evidence water and telecommunication have a positive contribution to economic growth but a negative one for road infrastructure. A similar finding arose from Shi et al. (2017), who investigated the relationship of infrastructure capital (roads, electricity, railway, telecommunications) to the economic growth of thirty provinces in China. All had a positive contribution to growth, except road infrastructure. A possible explanation may be a U-shaped relationship between infrastructure investment and growth which occurs through the existence of the crowding out effect of private capital when the infrastructure investment is too dominant.

The quality of infrastructure is as important as the quantity; any inadequate or poorly performing infrastructure may create obstacles for economies to meet their full growth potential. Quality telecommunications infrastructure will enable producers, businesses, communities to obtain information and knowledge. In a study of telecommunications infrastructure investment for the Asian Development Bank, Ismail and Mahyideen (2015) posited that such investment can increase community innovation and help facilitate trade so that it ultimately has the potential to increase economic growth.

Kodongo and Ojah (2016) estimated an economic growth model in their study of public capital infrastructure (roads, water, electricity, telecommunications) in forty-five Sub-Saharan Africa countries during the period 2000–2011. They found that efforts aimed at reversing Africa's infrastructure deficit, in order to enable economic growth, must be carefully nuanced. Current endowments may be insufficient to meaningfully impact macroeconomic activity so emphasis on the quality of current infrastructure stock appears not to be that critical. An exception was South Africa which, uniquely among the cohort possesses infrastructure endowment levels that have reached or surpassed an implied threshold level necessary for enabling incremental aggregate economic activity. A threshold level of infrastructure endowment may be necessary before infrastructure can fulfil its touted huge promise of enabling economic growth.

4.2. Recommendations

The employment of government-driven investment plans to mitigate the pandemic's effects has been a crucial component of the response to the COVID-19 epidemic. The construction industry is critical to the revival of the economy following the financial crisis. It accounted for 11–13% of global GDP in 2015 and involves a wide range of small and large company value chains. The sector supports localised employment and globally it accounts for 7% of worldwide employment, or 220 million jobs. By 2020, more than 25 million jobs (about 10%) in the sector had been lost or were at risk of being lost in the short term as a result of the economic crisis resulting from the pandemic. Programmes to stimulate the building and construction industry are a tried-and-true method of addressing economic crises. They have significant macroeconomic effects because to the high demand for new construction and renovations in many nations as well as the sector's high potential for energising regional value chains (IEA, 2020).

In addition to making a commitment to spending vast sums of money on a country's infrastructure, what else is needed to ensure the success of stimulus programmes?

– Adequate expenditure in skills training to go hand in hand with infrastructure spending. An enhanced

fully trained labour force with an adequate level of expertise is required to ensure that the programme delivery is not restrained by the inadequacy of such resources.
- If investments in green infrastructure are deemed to be an essential element for accomplishing the post-pandemic economic recovery, then packages must offer a chance to emphasise environmental sustainability.
- Measures are needed to encourage and create the environment necessary for both private as well as public sector investment activities.
- Construction industry stimulus packages should have "strings attached" and should reward energy and environmental improvement objectives in order to assist the decarbonization of the building sector. Due to their ability to address both the near and long term, green stimulus measures frequently offer advantages over standard fiscal stimulus packages (Hepburn et al., 2020).

Many governments have begun to successfully implement green building programmes since the 2008 economic crisis, providing blueprints for effective green building initiatives. The Global Alliance for Buildings and Construction launched at COP21 has started a database of best practise examples of green building programmes that effectively used financial incentives to stimulate investment and job creation (GlobalABC & PEEB, 2020). These programmes made use of a variety of instruments, including: green mortgages for households, bridging loans for developers, grants, and concessional loans for homeowners or developers.

Conclusions

As a starting point for consideration of the contribution of the construction industry in enabling strategies to accelerate economic recovery post-COVID-19 through investment in infrastructure, this paper considered the basic issue of how infrastructure investment is defined and measured. The contribution of the industry being based on what type of infrastructure is included by the official national statistics agencies. There is some general consistency between approaches by statistical agencies internationally regarding definition, but the study observes that capture of accurate data is also hampered by the methods for identifying construction output in industry surveys.

A common premise of economic growth theory is that there is a positive relationship between investment and economic growth. Based on longitudinal time series data from national statistics agencies and international organizations, an analysis was undertaken to validate the relationship between infrastructure investment and GDP growth. There was shown to be considerable variation in the growth impact experience between advanced and developing countries but generally within these country categories, there is consensus that developing economies would obtain the greatest benefit from infrastructure investment to raise their level of GDP and hence there is a greater need to commit a larger proportion of their resources to the construction sector.

Due to the timeframe associated with the impact of new infrastructure investment on the economy (particularly the level of GDP) there is great scope for further research based on an assessment of the alternative investment strategies and targets in different countries and settings. Some of the investment will meet the requirement to have an almost immediate impact in the short-term but governments will also expect that investment for the future will reap its longer-term rewards. Finally, alternative approaches to stimulus investment policies with digitalization, and sustainability and green investment have become a growing feature of investment plans, and potential issues of these approaches were examined with their implications for the construction sector and the delivery of the "new" infrastructure with its technological and environmentally sustainable requirements.

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