The Effects of Physical and Social Infrastructure Investment on Productivity.

A panel data study of 19 European countries, 1995-2019

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Abstract

This paper examines the effects of physical and social infrastructure investment on productivity. It uses panel data techniques (OLS and IV-GMM) to examine EU-KLEMS sectoral data from 19 European countries between 1995 and 2019. It does not find a consistent significant effect of physical or social infrastructure investment on productivity in this period as the estimations are highly sensitive to the specification and time period. This paper discusses limitations of the data and estimation techniques and recommends further avenues for research.

Introduction

It is important to examine productivity because it determines the long-run path of output, wages and employment; an increase in labour productivity (output per worker hour) can allow a business to produce more output with the same number of workers. This might lead to the business choosing to increase its overall output and maintain its workforce or to maintain its output and reduce its workforce. Therefore, it is possible for government investment to have a short-term effect of increasing output but a long-term effect of falling employment and output.

There is a case to classify spending on education, health and social care as social infrastructure investment because it provides vital services with a long-term impact on the economy. A well-educated and healthy workforce will be productive throughout their working lives. Providing strong social care reduces the burden of routine care on unpaid carers, allowing them to provide higher levels of care or return to the workforce. Rather than seeing social infrastructure as consumption that should be reduced, it should be placed at the centre of investment and economic planning (Bargawi, Cozzi and Himmelweit, 2017a; Women's Budget Group UK and Scottish Women's Budget Group (WBG), 2015). This paper follows Onaran, Oyvat and Fotopoulou (2022a) and defines social investment as spending on education, health and social work services and physical investment as spending on transport infrastructure, buildings, equipment and research and development (R&D).

Comparing the effects of social and physical infrastructure investment is an important issue in feminist economics as social infrastructure has a larger direct effect on services used by women and employing women yet is overlooked by traditional economic theory and policy making. In national accounting, most expenditure on health, social care and education is classified as consumption whereas expenditure on transport, construction and R&D is classified as investment. This classification implies that social spending does not have a long-term impact on the economy and suggests that physical purchases should be prioritised. Taking the UK as an example, physical investment expenditure has been relatively protected from austerity programmes and was prioritised in the COVID-19 recovery programmes (Institute for Government 2020; 2022) . The Labour party has committed to borrowing only for investment expenditure but not for day-to-day expenditure (Parker, 2021). This reflects mainstream economic theory that investment is a more efficient use of government money than consumption. As women and people of colour make up the majority of public service workers and the majority of public service users, an economic consensus that limits social infrastructure spending disproportionately disadvantages women (Bargawi, Cozzi and Himmelweit, 2017b).

Onaran, Oyvat and Fotopolou (2022a) found that public social infrastructure had a positive effect on productivity but that public physical infrastructure had an insignificant effect on productivity in the UK between 1970 and 2015. This paper investigates whether these findings are replicated when using a data set from 19 European countries between 1995 and 2019.

Defining productivity

Productivity is a slippery concept. Even its definition is disputed.

The Post-Kaleckians discussed below predominantly use productivity to refer to labour productivity (output per paid hour worked). If the level of capital and labour remains constant, any change in output is classified as an change in labour productivity. Technological change is assumed to be Harrod neutral; capital productivity is constant but the capital intensity of production rises (Hein, 2014). This paper uses 'productivity' to refer to labour productivity unless otherwise specified.

Mainstream economists use 'productivity' to refer to 'total factor productivity' or the Solow residual. Total factor productivity describes that change in production output assuming that that both labour and capital remain constant and are compensated on the basis of their marginal products. The Solow residual is "a measure of ignorance" of why output varies between countries and time-periods (Abramowitz (1956) cited in (Mazzucato, 2013). It is only possible to estimate total factor productivity using flawed neoclassical assumptions about marginal returns (Felipe and McCombie, 2020; Block, 2022).

It is difficult to quantify productivity. Theoretically output, wages and capital are volume measures but practically they are measured in prices. Across an economy it is impossible to accurately aggregate the volume of output using prices because of inflation dynamics. It is not possible to use prices to gain an accurate measure of output unless the goods are all the same quality and quantity (Felipe and McCombie, 2013). This issue is even greater for goods and services that are not sold. It is extremely hard to evaluate the output of public services, like education, because they are not traded on the market and there is no simple measure of quality. Statistically the output of non-market activities is evaluated by their cost. The outputs are assumed to be the same as the inputs. This means that labour productivity growth in these sectors cannot be calculated (Block, 2022).

There is also disagreement about how important productivity should be in economic theory and policy making. This stems from the fundamental criticism that growth subordinates other policy goals and endangers the planet (see Hickel & Hallegatte, 2022). Traditionally, productivity increases have been seen as the way to increase the total available material wealth, but this is dangerous on a planet with finite resources. It is important to understand productivity to understand how to achieve limited growth or degrowth policies and how they will influence the employment rate. Productivity increases could still allow a lower overall output and much lower working hours.

Literature Review

Post-Kaleckian models of productivity

This paper follows the Post-Kaleckian tradition where the distribution of income between capital and labour (functional income distribution) is at the heart of economic outcomes. The core Post-Kaleckian model looks at how an exogenous shift in the functional income distribution changes overall aggregate demand. An increase in the profit share can (i) increase demand by increasing investment and increase net exports by lowering export consumption and increasing export competitiveness but also (ii) reduce demand by reducing consumption out of wages and investment based on expected profit. The relative size of these demand effects determines whether an increase in the profit share has an expansionary or contractionary effect on output (Bhaduri and Marglin, 1990).

Post-Kaleckian models of endogenous productivity add an interacting productivity regime to the demand regime following Setterfield and Cornwall (2002). The functional income distribution then influences both productivity and output (e.g. Naastepad, 2006; Hein and Tarassow, 2010; Onaran, Oyvat and Fotopoulou, 2022a, 2022b). These productivity and demand regimes change separately in the short-run but combine in the medium-run (see Ch.8 in Hein, 2014 for detailed model).

Kaldor-Verdoorn effects

The Kaldor-Verdoorn effect describes the positive relationship between output and/or capital accumulation and productivity. Verdoorn observed that higher output could drive manufacturing productivity by allowing manufacturers to benefit from increasing economies of scale. Manufacturers could then reinvest to generate further productivity gains or merge with other manufacturers to benefit from further economies of scale (Verdoorn, 1949 cited in Hein, 2014). Similarly, Kaldor theorised that increasing use of capital in production would increase productivity growth because capital goods were the way that new, more productive technology entered the manufacturing process (Kaldor 1957, 1961). A higher growth rate meant a greater accumulation of productive technology. The Kaldor-Verdoorn effect is integrated into Post-Kaleckian models by showing a positive relationship between capacity utilisation and/or capital accumulation and productivity.

Wage-cost push

The wage-cost push effect describes the direct relationship between the functional income distribution and productivity. An increasing wage share reduces the profit share and increases the incentives to invest in technology to replace workers and lower the wage bill. Manufacturers are incentivised to invest in technology that will increase the productivity per worker. This follows the ideas of Marx (1867) and Hicks (1932) on the effects of labour market changes which threaten profits (cited in Hein, 2014). This is a significant departure from neoclassical growth theory (discussed below) that sees rising profits (and falling wage share) as the driver of innovation and investment.

The overall effect of a change in the wage-share on productivity is ambiguous in the Post-Kaleckian model as the wage-share is in both the productivity and demand equations. An increase in the wage share directly increases productivity by increasing the incentives to innovate and indirectly affects productivity through the demand regime effect (capacity utilisation or capital accumulation). The overall effect on productivity depends on the overall direction and relative strength of the Kaldor-Verdoorn effect.

In a profit-led demand regime, an increase in the wage share reduces overall capacity utilisation. This means that an increase in the wage share has a partially positive effect on productivity via the wage-push effect and a partially negative effect on productivity via the Kaldor-Verdoorn effect. It is possible that an increase in the wage share could increase productivity in the short run but lower output and productivity in the long-run (Onaran et al. 2022a).

Incorporating the government sector

The government sector is excluded from the core Post-Kaleckian models which reflects the Kaleckian and Kaldorian focus on production as the engine of the economy.

There is an implicit role for the government as an institution which can make the exogenous changes that influence the model. Setterfield and Cornwall (2002) incorporate the role of government by acknowledging that the demand and productivity regimes can be determined by an institutional regime. The government determines the labour market institutions which contribute to the relative strength of labour and capital. The government could also affect how the profit share feeds through to demand and productivity through taxation and innovation policies. This third regime is often simplified away as exogenous changes to the profit share.

In Post-Kaleckian models explicitly incorporating government *economic* activity, the productivity effect depends on the type of spending, model assumptions and the government budget.

Post-Kaleckian models distinguishing between government consumption and investment expenditure emphasise the broader long-run effects of investment. Dutt (2013), Commendatore and Pinto (2011) and Parui (2021) assume that government consumption expenditure only increases demand. This means that government consumption has no direct effect on productivity, only an indirect effect via output. They assume that government investment (i) has a larger demand effect as it 'crowds in' private investment and (ii) affects supply. Government investment has a variety of supply effects. For Dutt (2013) , government investment increases the rate at which innovation adjusts to tightness in the labour market. For Parui (2021), government investment expenditure directly raises productivity, through improvements in healthcare, education and infrastructure. For Commendatore and Pinto (2011) public capital increases capital productivity rather than labour productivity. In all these models, government investment has a long-run effect on productivity through interacting demand and supply effects.

Tavani and Zamparelli (2017b) argue that government consumption expenditure can also influence productivity via wage-cost effects. Government consumption includes wages for public servants so increasing the number of public servants increases employment and tightens the labour market, creating a stronger bargaining position for workers and a larger wage share. Under their model, productivity is a function of the ratio of public capital to private capital and the wage share so the optimal government budget would include both investment and consumption expenditure (Tavani and Zamparelli, 2017a, 2017b). Adding in the assumption that public sector workers might be productive further increases the optimal amount of consumption expenditure(Tavani and Zamparelli, 2017b).[1]

It is important to note that these definitions of investment do not automatically overlap with the definitions used in government accounts. For Dutt (2013) and Parui (2021), investment expenditure is simply expenditure that influences productivity. Parui (2021) explicitly includes education and health spending as investment because it increases labour productivity. He assumes that most investment is 'core infrastructure' with the potential to influence the current profitability of private investment.

Onaran et al. (2022b) distinguish between two types of investment - government physical infrastructure investment and government (and private) social infrastructure investment – and their effects on productivity in the market economy. *Social* infrastructure investment has a positive direct effect on productivity (akin to a human capital improvement for more efficient workers) and a negative indirect effect via the reduction in unpaid carework. The model assumes that the direct effect outweighs the reduction in unpaid care work. Government *physical* infrastructure has a positive effect on productivity in the model.

The long-run effect of government investment on growth depends on the model assumptions (in both productivity and demand regimes). Parui's (2021) model finds that government investment is unambiguously positive in a profit-led regime but is ambiguous in a wage-led model and depends on the relative elasticity of productivity to government investment and profitability to productivity. If productivity gains are not reflected in increased wages but instead kept by capitalists either as a falling level of employment or real wages then the reduction in demand can reduce long-run equilibrium output (Parui, 2021). Dutt (2013) assumes that productivity gains are equally shared between capitalists and workers. This means that an increase in government investment increases the equilibrium rates of capacity utilisation and growth. Onaran et al. (2022b) model how productivity influences employment and functional income distribution. A short-term increase in productivity can reduce employment and increase the profit share. The effect on output then feeds back into productivity in the medium run. Endogenising the effects on employment and functional income distribution allows them to explore a wider range of indirect effects of government investment.

In some Post-Kaleckian models, the overall productivity effect depends on how the government raises its revenue. If governments finance spending via taxation then the effect depends on the relative propensity to save between workers and capitalists and which group is taxed. If governments finance their spending by bonds then the effect depends on bond ownership and interest rate policy. In Palley's (2013) model, profits are reinvested, households save and governments spend all tax revenue and public capital increases the productivity of private capital, increasing private investment. A lump sum tax on workers does not change the growth rate but a lump sum tax on capitalists will boost growth by increasing aggregate demand. A tax on businesses profits has an ambiguous effect as it could decrease utilisation by reducing investment out of profits.

[1] Tavani and Zamparelli's long-run model is wage-led and government-spending-led regardless of the demand regime but they do not include a Verdoorn productivity effect which could potentially outweigh the induced innovation and public capital effects (see criticism in Parui, 2021)

Government investment financed by bonds will boost growth (Palley, 2013). Onaran et al.'s (2022b) model accounts for the potential of government debt to effect productivity by raising interest rates and crowding out private investment (as well as crowding in). This effect is accounted for by controlling for private investment in their specification. Blecker (2002: 129-141) and Obst, Onaran and Nikolaidi (2020) model government investment and taxation but only look at short-run effects on the demand regimes rather than the long-run so do not include productivity effects. In these models, government investment can increase output. This approach could be integrated into a productivity model and feed through into productivity via the output effect.

Neoclassical growth theories

Post-Kaleckians do not use the same definition of productivity as mainstream economists which means that their conclusions cannot be directly compared. Neoclassical growth theory (NCGT) is limited by ignoring demand and making unrealistic assumptions about production (see Hein (2014) for detailed discussion). However, it is useful to look at NCGT and government expenditure because they have a sharp focus on supply-side dynamics.

The potential role of the government depends on the NCGT model used. In the exogenous growth model, the government cannot influence productivity within the model. In the endogenous growth models, the government has a role in fixing market failures and providing public goods. For R&D models, the government should ensure there are institutions which allow R&D rewards to be privatised and government should invest in public R&D as the private allocation will be below the optimal level. For human capital models, the government should provide the public goods of basic education and health.

The effect of the government in endogenous NCGT depends on the type of government spending or finance and the existing the capital stock.

The NCGT papers surveyed by Romp and de Haan (2007) suggest that investment should be prioritised over consumption. Similar to Post-Kaleckian models, the expenditure is classified as investment if it has a supply-side effect. The NCGT classifications of government expenditure do not map onto national accounting definitions. Barro (2001) distinguished between the effect (basic) education and health expenditure and other government consumption. Because there is no role for demand, NCGT models render government consumption expenditure useless by design. Irmen and Kuehnel (2009) show that the optimum amount of "non-productive" government spending would be zero under a decentralised equilibrium although, assuming that there were congestion effects, a positive amount would be Pareto-optimal.

Government finance affects productivity. As savings determine investment in NCGT, all investment must be funded from the same pool of savings so, government investment must crowd out other investment (Canning and Pedroni (1999) in Romp and de Haan, 2007). This feeds into a strong focus on maximising the efficiency of government by ensuring that it provides only necessary investment. For neoclassical growth models, the cost of government expenditure has a negative effect on productivity if it reduces incentives to invest or to work. Irmen and Kuehnel (2009) argue that government should use a lump-sum tax rather than a consumption tax to fund its expenditure. They argue that a consumption tax would reduce the growth rate by distorting individuals' decisions to supply labour.

There are some NCGT models which examine how the return to public capital varies. There may be diminishing returns to additional capital above a certain level. Network effects mean that once the basic parts of the network are established the marginal productivity of further investment decreases, so the productivity of infrastructure investment depends on the existing stock and may vary over time (Fernald (1999) in Romp and De Haan, 2007). The effect of capital is similarly non-linear in models incorporating congestion effects. Low levels of investment alleviate congestion but investment above the level to alleviate congestion has a negligible effect (Sanchez-Robles, 1998 in Romp and De Haan, 2007). Capital returns also change depending on whether the capital expenditure is invested in maintenance or new projects. Rioja (2003) and Kalaitzidakis and Kalyvitis (2004) emphasise the importance of maintaining public spending to sustain the long-run effects of public capital (cited in Romp and De Haan, 2007). The varying return to investment is also present in the human capital literature where models suggest that the returns to society are larger for basic education, whereas the returns to society are smaller for higher levels of education (Rossi, 2020).

These NGCT models are significantly limited because they do not model demand effects nor the effect of investment and savings. The most useful studies are those looking at how the return to capital varies dependent on the existing private and public capital stock. This can be integrated into the supply side aspects of Kaleckian models by accounting for the ratio between public and private capital or the ratio between capital stock and output (Vergeer and Kleinknecht, 2010; Tavani and Zamparelli, 2017b).

Neo-Schumpterian

In contrast to Post-Kaleckian and NCGT, Mazzucato's neo-Schumpterian theories put the government at the heart of innovation and productivity. She goes beyond the role of 'crowding in' private investment to look at how governments shape productive structures of the economy and emphasises the importance of different types of spending.

For Mazzucato, government investment is crucial to innovation. Government investment and private investment are not substitutes. Only governments can bear the necessary risk of failure to foster innovation (Mazzucato, 2013; Mazzucato and Wray, 2015). Only governments can effectively deliver necessary investment and infrastructure that underpins innovation, for example the investment in technology and energy infrastructure for the green transition (Mazzucato and Semieniuk, 2018). She is clear that the government has a central role in private innovation through setting goals and picking winners. This is because unstructured competition will not create effective innovation but instead create a proliferation of un-coordinated innovation which is less than a sum of its parts. Productivity gains come from the interaction between the private and government sectors (Mazzucato, 2013).

Mazzucato follows Polanyi in emphasising how governments determine the economic structures and institutional settings for innovation (Mazzucato, 2018). Market concentration removes incentives for innovation and an undirected banking system channels money into speculation and short-term profit. Therefore, governments should prevent market concentration and shape financial markets to encourage patient capital invested in productive sectors (Mazzucato and Wray, 2015; Mazzucato, 2018). Governments should also manage the intellectual property institutions to prevent companies restricting innovation to maintain their advantage (Mazzucato, 2018).

Capital is not a homogenous input which leads to a set amount of innovation. Success is dependent on how the money is spent, the institutional context and luck (Mazzucato, 2013, 2016). Not all capital or innovation spending is created equal; money spent on mission-oriented innovation will be more effective (Deleidi and Mazzucato, 2019, 2021). Innovation takes place within a system of innovation rather than simply in individual firms (Mazzucato, 2016) . Innovation is 'path dependent and cumulative. Fundamentally innovation is subject to Knightian uncertainty. There is no way to guarantee success or predict the return on investment. That said, Mazzucato's work suggests that innovation is likely to be a positive function of government spending on innovation and government spending has a positive and persistent effect on output (Deleidi et al., 2020; Deleidi and Mazzucato, 2021).

There are Post-Kaleckian models which overlap with Mazzucato's ideas. Tavani and Zamparelli (2017b) incorporate Mazzucato's work by making labour productivity growth a positive function of the ratio of public to private capital stock. This allows Tavani and Zamparelli (2017b) to reflect that public infrastructure allows firms to innovate into their productivity function and that public investment in innovation is a key source of funding.

There are significant gaps between the Post-Kaleckian tradition and Mazzucato's ideas. First, it would not be possible to conceive of a Mazzucato model without the government but Kalecki situates productivity firmly in the private sector. Secondly, Post-Kaleckian models do not reflect the complexity of non-linear and unpredictable innovation that Mazzucato theorises. It is necessary to reduce it to equations to econometrically estimate but this simplicity risks losing the nuances of the theoretical ideas. Mazzucato focuses on the development of new technology but Post-Kaleckian models are more reflective of the adoption of technology than its invention. Increases in the labour share are far more likely to encourage the adoption of existing labour-saving technology in the short-term. In the long-term firms have to deal with the uncertainty of whether labour-saving technology will be available to reduce their workforce costs. Thirdly, Mazzucato's emphasis that the secular stagnation has come about due to endogenous changes in the government and business environment suggests that any model should incorporate endogenous movements akin to Setterfield and Cornwall's (2002) third institutional equation.

Table 1 : Summary of econometric studies estimating both the Kaldor-Verdoorn and wage-push effects

Study	Data set	Main estimation method	Further methods to address endogeneity bias	Control variables	Verdoorn Effect	Real Wage effect
Naastepad (2006)	Annual data, The Netherlands, 1960-2000	AR(1)			0.63	0.52
Hein and Tarassow (2010)	Annual data, 6 countries, US, UK, Netherlands, France, Austria, Germany, 1960-2007	VECM for Germany. Dynamic differences for others		Share of manufacturing in GDP, productivity gap with USA.	0.11-0.54[2]	0.25-0.67
Vergeer and Kleinknecht (2010)	Annual data, 19 OECD countries, 1960-2004	FE GLS/IV	Includes lagged values in estimation.	Share of services in GDP, capital/output ratio, productivity gap compared to technology leader	0.24-0.37	0.31-0.39
Storm and Naastepad (2011)	5-year averages, 20 OECD countries, (1984-2004)	3 stage least squares	5-year averages reduce short-run fluctuations.	Export growth, government deficit (% GDP), employment protection, labour market regulation, capital intensity	0.31	0.29
Hartwig (2013)	Annual data, Switzerland, 1950-2010	2 stage least squares, AR(1)	Uses lagged and contemporaneous values of growth of world demand, wage growth and unemployment rate as instruments		0.67	0.32
Vergeer and Kleinknecht (2014)	5-year averages, 20 OECD countries, 1960-2004	Aurellano-Bond GMM (1991) – Fixed Effects	Lagged values used as instruments. 5-year averages reduce short-run fluctuations.	Productivity gap compared to technology leader, wage share, capacity utilisation, share of services in GDP, unification of Germany	Not significant	0.46[3]
Onaran, Oyvat, Fotopolou (2022a)	5-year averages, UK sectoral data, 1970-2015	GMM-IV	Lagged rather than contemporaneous values. 5-year averages reduce short-run fluctuations.	Sectoral investment	Positive but not significant at 10%	0.65[4]

Source: Hein (2014, p.328-331) and Storm and Naastepad (2013, p.107), own extensions

[2] Estimated for each country separately.

[3] Esimtaion (i). Authors also find coefficient of 0.24 (significant at 1%) on share of wages in national income.

[4] Estimation of effect of increase in female wage on level of productivity in market economy (excluding social sector). Effect of gender pay gap between men and women is included and found to have coefficient of 0.622 (significant at 1%).

Review of the empirical literature

Post-Kaleckian

Estimating the drivers of productivity is complicated by endogeneity, omitted variable bias and country-specific differences. Post-Keynesian empirical analysis of productivity finds substantial evidence for the Verdoorn and real wage effects but there is less research on the role of government investment. Recent Post-Kaleckian econometric studies examining both the Kaldor-Verdoorn effects and wage-push effects are summarised in Table 1.

The key issue identified in the empirical literature is how to tackle the endogeneity issues when estimating productivity equations. There is potential reverse causality as productivity changes affect potential output which can feed through to real wages. Investment and the real wage might respond to productivity rather than vice versa. The estimations use lagged values of the independent variables in the estimation or as instruments to focus on what drives productivity rather than the feedback between productivity and the independent variables (Vergeer and Kleinknecht, 2014, 2010; Onaran, Oyvat and Fotopoulou, 2022a; Hartwig, 2013)

There is potential omitted variable bias as the business cycle is an external factor which influences all the variables. Productivity falls in a downturn as hourly employment is often more stable than output. Private investment also falls in a downturn. Government investment in capital, education and health may increase if the government implements counter-cyclical fiscal expansion. Conversely government might cut investment in response to a downturn in the business cycle, as seen in the austerity policies pursued in the aftermath of the 2008 financial crash and the sovereign debt crises. To adjust for the business cycle, estimations use instruments, lags of the dependent and independent variables and/or average out the data (see Table 1).

There are additional unobserved differences between countries - most importantly their economic structures and institutions. Hein and Tarassow's (2010) estimations, of productivity growth for 6 OECD countries 1960-2007, included share of manufacturing (output in manufacturing industries/total output) and Vergeer and Kleinknecht's (2010) estimations, of productivity growth for 19 OECD countries 1960-2004, included share of services (output in service industries/total output). [5] This allowed these authors to account for the potential effect of structural changes on productivity, following the Baumol argument that services have a lower productivity growth rate than manufacturing industries (Baumol, 1967). Vergeer and Kleinknecht, (2010) did not find any statistical effect or influence on other coefficients from including the service share whereas Hein and Tarassow (2010) found a significant effect of at least one lag of the manufacturing in their preferred estimations for 5 of the 6 countries they estimated (Table 3 in Hein and Tarassow (2010)). Hein and Tarassow (2010) and Vergeer and Kleinknecht (2010) also controlled for the gap from the technological frontier as countries that are further from the technological frontier have greater potential to catch-up. This captures the effect of adopting existing technology rather than developing new technology. Storm and Naastepad's estimations of productivity growth, in 20 OECD countries 1984-2004, suggest that the country-level variation in productivity may be caused by

[5] Naastepad (2006) acknowledges that the productivity estimation does not address the issue of structural change in the Netherlands 1960-2000.

institutional differences. They found significant regional differences when labour market institutions were not controlled for, however country dummies were not significant when they included a larger number of variables on the labour market conditions in each country (Storm and Naastepad, 2009b, 2009a).

Kaldor-Verdoorn effect

The Verdoorn effect has been identified in many studies using a wide variety of data and methodologies. The literature suggests that the Verdoorn coefficient is between 0.3 and 0.6, meaning that a one percentage point increase in output growth leads to a 0.3-0.6 percentage point increase in productivity growth (see McCombie, Pugno and Soro (2002) for summary of literature 1949-2001 and Hein (2014) for more recent studies).

The size of these effects does depend on the methodology used. Vergeer and Kleinknecht (2010) found that the estimation of the Verdoorn coefficient was highly sensitive to the inclusion of the capital stock/output ratio. Estimates of the Verdoorn effect may be inflated by the short-run Okun effect. Vergeer and Kleinknecht (2010) and Hein and Tarassow (2010) suggested that the inclusion of lags caused their estimates of the Verdoorn coefficient to be lower because the lags separated out the Okun effect.

Verdoorn coefficient estimates vary by country and time, perhaps dependent on the productive structure. The Verdoorn effect is less stable for advanced countries (McCombie, Pugno and Soro, 2002). Hein and Tarassow's (2010) estimations for 6 OECD economies 1960-2007 found that the Verdoorn effect varied over time and was stronger the period 1960-1984 than 1985-2007 for five of their six countries, but not for Austria.

Wage-cost push

There has been a more recent empirical focus on wage-cost effects (see Hein, 2014 for table). Most of the econometric studies on real wage growth effects in Hein (2014) found an elasticity of productivity growth to real wage growth of 0.3-0.4. The effect depends on the wage variable, country, and the period analysed.

Econometric studies looking at real wage growth have found a more consistent positive effect than those looking at wage-share. Naastepad (2006) and Verger and Kleinknecht (2007) use real wage data. Hein and Tarassow compared results from using real wage and wage share as variables and found that the wage-share effect estimates were less consistent than those of the real wage effect. Hein and Tarassow argue that profit-share is a better measure of wage-push effect as the real wage can rise without a change in the profit share, so the incentive for capitalists to innovate exists when the real wage rises above productivity growth and profit share falls. The profit-share can fall due to an increase in the real wage above productivity increases or due to a fall in output because of business cycle fluctuations. This study uses the real wage rather than the profit-share to focus on the real wage effects rather than business cycle effects. This means that the results will be more comparable to Onaran et al. (2022a).

The results vary by country and time period. Hein and Tarassow (2010) found that the real wage effect was positive across the period whereas there was a structural break in the effect of the profit share on productivity in Austria, Germany and Netherlands. An increase in the profit share and fall in the wage share increased productivity in the period 1960-1984 but not in the period 1985-2007. The results were consistent over the whole period for France, UK and US; the profit share did not have a statistically significant effect on productivity in France and it had a statistically significant negative effect on productivity in UK and US.

Investment

The majority of Post-Keynesian empirical analysis on productivity and growth acknowledges the exogenous role of government in creating variation in the variables of interest, however it does not estimate government expenditure as an independent variable. Government spending can stabilise output, reducing downwards fluctuations which feed through to productivity via a Verdoorn effect (Hein 2014). Government spending on an industrial strategy can influence the productive structure and therefore potential productivity gains (e.g Botta, 2014). The government can also strengthen the position of labour, creating employment and maintaining labour market institutions which keeps real wages high and induces innovation (e.g. Stockhammer and Klär, 2011; Storm and Naastepad, 2012). Storm and Naastepad emphasise that government investment (on research and development and education) are not the key variables but instead they must be put into the context of income distribution, aggregate demand and social relations of production (p.195, Storm and Naastepad, 2012)

There is limited Post-Kaleckian empirical work on the role of government investment or physical and social investment on productivity. There are more country-level analyses of government spending in the Post-Keynesian tradition (see Efthalitsidou et al., 2021 for a summary). Onaran et al. (2022a) found that spending on health and education had a positive effect on productivity but spending on physical infrastructure had an insignificant effect in the UK, 1970-2015. They were using sectoral data on output, business investment and employment but national data on government investment. The lack of variation in the data means that insignificant results are more likely. This limitation will be the case with the data analysed in this study. The use of panel data across a number of countries will increase the variation in the data on government investment but it is still more likely to be estimated as insignificant compared to data which varies by sector.

In the neo-Schumpterian tradition, Deleidi and Mazzucato (2021) estimate a Sraffian multiplier model using SVAR to analyse the effects of different types of government investment in the US 1947-2018. They use government military R&D expenditure as a proxy for mission-orientated spending and compare this to other government expenditure using a SVAR model. They find that mission-orientated spending has a larger positive effect on GDP in long-term.

Neoclassical

Neoclassical Mainstream empirical analysis uses a different framework and definition of productivity to the Post-Kaleckian (discussed above). It is based on neoclassical theory of the optimising firms and technology as the residual.

Demand

Mainstream econometric works based on strict neoclassical ideas do not acknowledge the link between real GDP and potential GDP because of the minimal role for demand. Transient productivity shocks (supply side factors) drive fluctuations in output. These models have now been extended to address the realities of growth differences across countries – differences in the level of growth and the persistence of shocks. Most relevantly to this study, there has been increasing acknowledgement of the positive effects of sustaining output in developed countries (via government intervention) in the event of a loss of GDP (e.g. Blanchard and Leigh (2013) cited in Fatás and Summers, 2018).

Mainstream empirical works focused on hysteresis examines how the level of real GDP influences future GDP levels and growth. The effect comes through the labour market and the multiplier effect of fiscal consolidation on private investment rather than through productivity and learning by doing (Blanchard and Summers, 1986) extended to fiscal multipliers in (Fatás and Summers, 2018). The positive elasticity of potential GDP to real GDP is comparable to the Verdoorn effect but the analysis of the real wage effect is the opposite of the Post-Keynesian framework as high wages reinforce low output and lower growth. Fatas (2000) focuses on explaining how the persistence of output is caused by the procyclical nature of capital and R&D investment. He endogenized productivity by modelling R&D expenditure falling in response to a shock and estimated the effect of growth on persistence of GNP in a cross-section of 120 countries, 1950-1990.

Investment

Meta-analyses of the neoclassical literature find a positive effect of public investment on productivity (Núñez-Serrano and Velázquez, 2017; Bom and Ligthart, 2014). This effect is larger in the long run than the short run. The productivity effect of public investment differs across economies, tending to have a greater effect when there is a smaller existing stock, more robust institutions and the investment is at a smaller geographical level.

Similar to the Post-Keynesian analysis, these studies have significant methodological issues with reverse causality (increasing GDP increasing public investment) and spurious correlation. The studies use lags and instrumental variables to address these issues (ibid.). The studies also struggle to capture spillover effects and are more likely to estimate a larger effect of investment if they aggregate data at a higher level (Mundell (1991) cited in Holtz-Eakin, 1994).

There is a significant body of mainstream literature on the microeconomic effects of human capital investment in education and health (see Flabbi and Gatti, 2018). The macroeconomic literature is in line with Barro (2001)'s conclusion that the quantity of education is not as important as the quality. Differences in education quantity do not explain the variations between countries however wider human capital measures, including the effects of out-of-school education and health care, can explain a large part of the gaps between countries (Rossi, 2020).

Data

We compiled a data set of labour productivity and key variables between 1995 and 2019 using data from Euklems & INTANProd database, OECD and Eurostat. Data sources and detailed description of the variables are in Annex 1.

Data availability

EU KLEMS provided data for 28 European countries but 8 countries had no sectoral investment data (Cyprus, Estonia, Croatia, Ireland, Lithuania, Malta, Poland and Slovenia). Latvia did not have any data on hours worked so we could not calculate sectoral productivity. This meant that the preferred specification could not be estimated for these countries. The data set was restricted to the remaining 19 countries - Austria, Belgium, Bulgaria, Czech Republic, Germany, Denmark, Greece, Spain, Finland, France, Hungary, Italy, Luxembourg, Netherlands, Portugal, Romania, Sweden, Slovakia and the United Kingdom.

Within the 19 European countries, some years are missing real wage, hourly employment or investment data which means that the productivity equation cannot be estimated (see Table 2 in Annex 1). This was exacerbated by taking 5-year averages as we only created averages if there was data present for all 5 years.

We had planned to run time-series regressions on individual countries but, because the physical and social investment data is national rather than sectoral, there were not sufficient data points for these variables. In order to overcome this lack of data, the specification was estimated on panel data.

Data quality

Expenditure classified as government investment includes a large range of purchases from aspects which might directly increase productivity like infrastructure to others which might have a more indirect effect like public buildings and leisure facilities. It can also include R&D incentives or public funded R&D – which may have a very uncertain pay off. Some proportion of government expenditure will go on maintaining existing capital rather than creating new capital. This heterogeneity means that the data simply reflects an amount spent rather than a particular type or quality of investment. This means that any conclusions are limited to understanding the relationship between total expenditure on capital not what types of capital are effective.

Infrastructure is a public good which can have a varied geographical effect from the very local or to the international. This might be particularly true of infrastructure investment which facilitates trade between countries or education investment where students travel between countries to study or work. Expenditure might be recorded in one country but have wider effects (Romp and de Haan, 2007). In this way, the true effect of infrastructure might be smaller or larger than the country boundaries which is particularly relevant during the period examined which was a period of growing trade and labour market mobility within Europe (Romp and de Haan, 2007). The effects are unlikely to be random. Infrastructure investment in smaller countries with many neighbours and more through traffic is perhaps more likely to have more spillovers than in a larger, isolated country. It is not possible to account for these non-random differences in investment effects within this estimation.

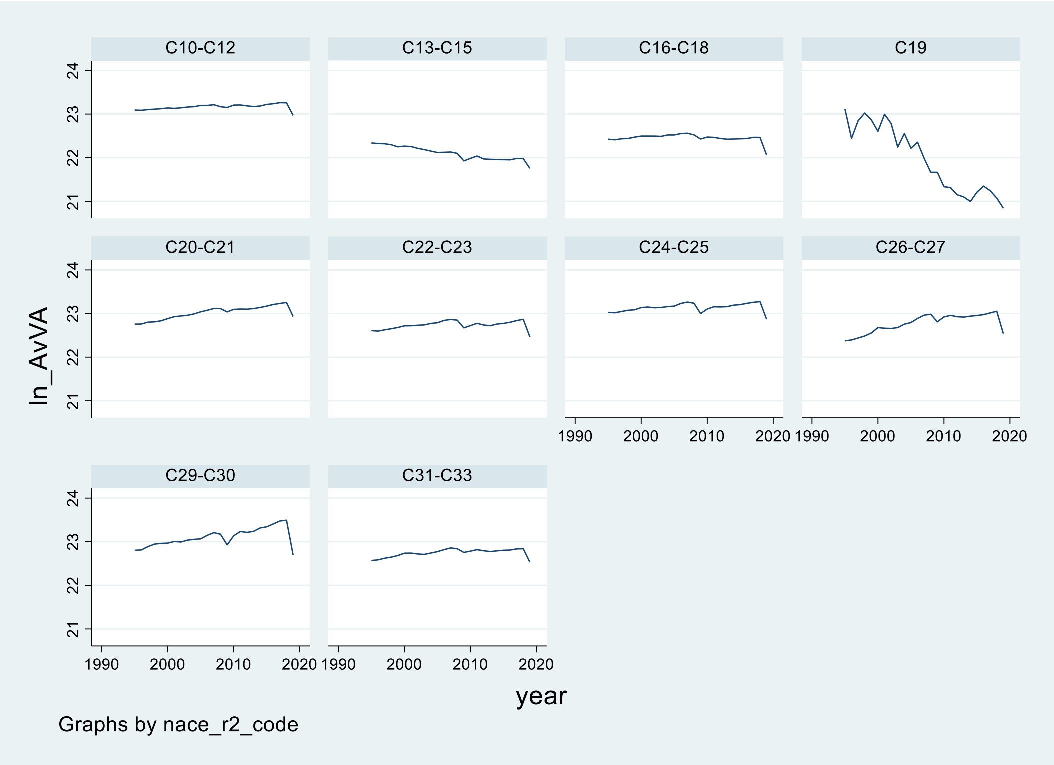
There may be an inconsistency in the infrastructure supplied by the government between countries. If private companies run public systems like water and electricity supply infrastructure then their investment is not counted in government investment expenditure (Romp and de Haan, 2007). For education and health, EU KLEMS provides data combining private and government spending on education and health. This means that the data is more comparable across countries because the amount recorded does not depend on differences in the proportion of private and public education or health care provision. There are still remaining issues of estimating inputs which are discussed below.

Using the monetary values to assess the volume of variables brings in aggregation issues (explained above). EU KLEMS estimates price indices by sector using changes in sector input and output costs, which creates a more robust measure of volumes in each sector. However, there is still likely to be a difference between prices and volume changes. Looking at the fluctuation in output for the petroleum refining industry (R2 NACE code - C19) shows the influence of international currency and supply fluctuations. Output measurement values for traded goods are strongly sensitive to accounting manipulation such as offshoring intellectual capital and declaring profits as capital gains income which is excluded from estimations of output (Block, 2022). Monetary values are particularly problematic when assessing volumes of social investment. An increase in real investment in education and healthcare does not necessarily mean that there is a higher quality of service. A change in cost could reflect a change in the delivery system from private providers to a public provision. Outcomes in healthcare are not directly proportional to countries' per capita expenditure.

Government investment has a particularly unpredictable and variable time horizon. Taking education as an example, spending can include short courses for workers which could quickly affect productivity and primary education for children really far away from joining the workforce. Similarly government physical infrastructure spending can include assets like IT equipment or long-term projects like railways. The direct effect can be spread out over a long time horizon even before accounting for indirect effects like increasing availability of workforce or allowing railway manufacturers to benefit from economies of scale. The estimations use averages of 5 or 3 years which focused on the medium term to the exclusion of short-run or long-run effects.

The literature suggested that there would be sector-specific effects in the data. Services and manufacturing have very different productivity regimes. Theories of productivity discussed above are more applicable to the manufacturing sector than the service sector. Even so, certain manufacturing sectors may react differently to an increase in output or might have greater fluctuation in output. Looking at the summary statistics for the data, the coke and petroleum refining sector (R2 NACE code - C19) has a very volatile output (see Graph 1). This is because its output is strongly dependent on fluctuations in the international energy market. The core regressions focused on manufacturing sectors excluding C19.

Graph 1 – Graph of ln of output (value added) in 10 manufacturing sectors for 19 European countries, 1995-2019



Estimation

The specification is an adaptation of the model used to estimate productivity in Onaran et al. (2022a), using overall real wage rather than separating out the male wage and wage gap between men and women.

$$logT_{it} = \beta_0 + \beta_1 \log\frac{(G^H{}_{t-1} + C^H{}_{t-1})}{N_{t-1}} + \beta_2 log\frac{(I^G{}_{t-1})}{N_{t-1}} + \beta_3 logY_{i(t-1)} + \beta_4 log\frac{I_{i(t-1)}}{E_{i(t-1)}} + \beta_5 logw_{it-1} + u_i + \varepsilon_{it}$$

$$T_{it} = Sectoral\ productivity\ (output\ per\ hour\ worked\ by\ employees)$$

$$\frac{(G^H{}_t + C^H{}_t)}{N_t} = Total\ (government\ and\ private)\ social\ investment\ per\ capita$$

$$\frac{(I^G{}_t)}{N_t} = Total\ government\ physical\ investment\ per\ capita$$

$$Y_{it} = Sectoral\ value\ added\ (output)$$

$$\frac{lnI_{it}}{E_{it}} = Sectoral\ investment\ per\ employee$$

$$w_{it} = Sectoral\ real\ wage$$

$$u_i = case\ specific\ error$$

$$\varepsilon_{it} = idiosyncratic\ error$$

Productivity as a function of social investment, physical investment, value added, private investment and the real wage.

Endogeneity issues

Labour productivity is calculated by dividing output by hours worked. Output is both part of the dependent variable and an independent variable. This means that the equation could suffer from simultaneous causality. Using the lagged values of output this reduces the reverse causality.

In order to look at the effect of investment and real wages on productivity rather than the reverse, the specifications include lagged variables of investment and real wage instead of contemporary variables.

To reduce the influence of business cycle variation, we created 5-year non-overlapping averages in order to focus on the medium term effects of investment without the business cycle variation, following Onaran et al. (2022a). Where the time period of my averages allowed, we also looked at the effect of 2008 to examine whether the effect of the global financial downturn influenced the estimation results.

Estimation Results

We tested the basic model using different dummy variables, instrumental variables and average lengths. We also conducted sensitivity tests on the choice of base year.

IV-GMM estimations

To address the endogeneity issues, we estimated the models using instrumental variables. Following Onaran et al. (2022a), we assumed that social and physical infrastructure were exogenous but output, investment and real wage were endogenous. We instrumented for these endogenous variables by using the 11-year lags of output, investment and the real wage and the contemporaneous 5-year average of US output. We used Instrumental Variable-General Method of Moments.

Most of the regressions suffered from weakly identified instruments shown by the low values of the Kleibergen-Paap rk Wald F statistics. This means that we cannot trust the coefficient estimates for these specifications. The baseline specification using to compare variations to is weakly identified but it provides a useful comparator estimation because it is a simple specification and most closely matches the specification used in Onaran et al. (2022a). The tests suggest that the instruments are valid for all the specifications. The p-values for the Hansen-J test statistic are larger than 0.10 so we cannot reject the null hypothesis that the instruments are overidentified.

Overall the results suggest that physical and social investment do not have a significant impact on productivity in this sample of 19 countries, using data from 1995 to 2019.

Many of the estimations suggest that output and real wage have a significant effect on the level of productivity. However these results are sensitive to the choice of time period and the inclusion of time dummy variables.

Lagged and contemporaneous independent variables

For the baseline specification, we used the lagged values of the independent variables. We compared this to the effect of using the contemporaneous values instrumented by their 5-year lagged value and the contemporaneous value of US output. These are reported in Table 4.

The estimation output recorded far more significant results, including a positive value of social infrastructure which was robust to including year effects. The results for private investment and physical infrastructure were negative but were only significant in one of the estimations. Private investment was only significant when including year effects and physical infrastructure investment was only significant when year effects were excluded. The values on output and real wages are positive and significant, as expected from the literature. The coefficient on real wage is higher than expected in specification (15). Including year effects reduces the real wage effect considerably suggesting that the real wage effect is interacting with other trends and year specific effects.

It is highly likely that these results were affected by endogeneity bias from simultaneous causation. These specifications suffered from weak identification so the results are not strongly robust.

3-year averages

For the baseline, we used 5-year averages of the data. We then tested the same specification on 3-year averages from 1995-2018 and 1996-2019, reported in tables 5 and 6. Using fewer years for the averages created more observations from the data but it meant that the business cycle fluctuations were more likely to remain in the data and effect the estimation results. The results were different from the 5-year estimations, particularly in terms of the output and real wage effects.

Specifications 17 and 19, using 3-year averages of the data between 1995 and 2018 and not including year effects, give a positive and significant estimate for social infrastructure. The effect is positive but not significant for similar specifications using 3 year averages of the data between 1996 and 2019. The estimates for the social infrastructure effect are negative and insignificant if time period dummies are included. Similarly the sign and significance of the estimations for physical infrastructure are sensitive to the time period and dummies included. This suggests that it is hard to unpack the relative contribution of changes in social and physical investment from business cycle or time trend effects

These results do not show a consistent effect. For the majority of specifications, the coefficients on physical and social investment were insignificant. The estimates are sensitive to the period chosen and the inclusion of year effects. This suggests that these specifications are not robust.

The output effect was positive and significant for all of these specifications and had a value of 0.279 (Specification 21) to 0.366 (Specification 20).

The real wage effect was sensitive to including year effects. This suggests that the year effects are picking up trends in the real wage as well as other unrelated year effects. We would want to find more effective instruments for the real wage and investigate specifications using growth rates and see whether the results changed.

Our preferred specification would include year effects to account for potential business cycle effects. The fit criteria are also better for the specifications including year effects. However the Kleibergen-Paap rk Wald F statistics are lower for the specifications which include year effects. We would want to investigate different instruments further to try and strengthen the identification of the endogenous variable and make the specifications more reliable.

Outstanding research questions

Many of the estimations suffered from weak instrumentation and the specifications were sensitive to changing the base year of the averages. We would like to replicate this study using a specification and variable set closer to the one found in Onaran et al. (2022a) as their specification was more robust to sensitivity tests and had less of an issue with weak identification. We would want to collect data on the male wage rate and the gap between male and female wages and to instrument for real wages using the average number of strike days.

The research could be extended by extending the samples further back to 1970, carrying out country specific estimations, carrying out estimations on subpools of the countries and using jack-knife sampling.

Extending the sample would increase the number of data points to make a more reliable estimation. Varying the estimations would allow investigation of the country-specific effects and how productivity and its drivers vary between countries or groups of countries. We could also explore the effect of physical infrastructure further to try and understand why its effect is insignificant or negative in these estimations when the literature suggests the effect should be positive.

This investigation is significantly limited because the effect of physical and social investment is only available at a national level and cannot be isolated by sector. It is likely that the effects of physical and social investment infrastructure are too dissipated to isolate their effects in a given time frame. Some investment may affect productivity very quickly, but other investment may take much longer to have an effect. It is likely that the variety of difference in productivity effects makes it unrealistic to isolate effect of infrastructure investment using 5- or 3-year time periods. The heterogeneity of infrastructure spending is a very large obstacle to empirically evaluating its impact.

It is possible to investigate the productivity effects at the micro-level instead of a macro-level by evaluating the productivity effects of individual projects. This approach is valuable but risks limiting the case for investment, particularly by government, to individual programmes with measurable outcomes rather than a systematic approach.

Conclusion

This study compared the effects of physical and social infrastructure investment on productivity using panel data from 19 European countries between 1995 and 2019. The econometric results are inconclusive as the results are sensitive to how the data is divided into time periods and whether time dummy variables are used. The econometrics could be improved by extending the data set and looking at how results vary for different countries, groups of countries or excluding countries systematically in a jack-knife sampling approach.

The results tentatively suggest that social infrastructure investment may have positive productivity effects and that the effects are larger than those for public physical infrastructure investment. The results are sensitive to the choice of specification so would benefit from further sensitivity analysis.

We would certainly caution against concluding that the lack of consistent results means that physical and social investment do not affect productivity and so investment in these areas should be reduced. This is particularly important as reducing social infrastructure investment would disproportionately effect women and people of colour. Theoretically there is a strong case for high-quality investment improving productivity, so this area merits much more empirical investigation.

Bibliography

Bargawi, H., Cozzi, G. and Himmelweit, S. (eds.) (2017a) *Economics and Austerity in Europe: Gendered Impacts and Sustainable Alternatives*, London, Routledge.

Bargawi, H., Cozzi, G. and Himmelweit, S. (2017b) Introduction: austerity and after – the case for a gendered approach, In Bargawi, H., Cozzi, G., and Himmelweit, S. (eds.), *Economics and Austerity in Europe: Gendered Impacts and Sustainable Alternatives*, London, Routledge, pp. 1–12.

Barro, R. J. (2001) Human Capital and Growth, *American Economic Review*, 91(2), pp. 12–17, [online] Available at: https://www.aeaweb.org/articles?id=10.1257/aer.91.2.12.

Baumol, W. J. (1967) Macroeconomics of Unbalanced Growth: The Anatomy of Urban Crisis, *The American Economic Review*, 57(3), pp. 415–426.

Bhaduri, A. and Marglin, S. (1990) Unemployment and the real wage: the economic basis for contesting political ideologies, *Cambridge Journal of Economics*, 14(4), pp. 375–393, [online] Available at: https://doi.org/10.1093/oxfordjournals.cje.a035141.

Blanchard, O. and Summers, L. (1986) Hysteresis and the European Unemployment Problem, In *NBER Macroeconomics Annual 1986, Volume 1*, National Bureau of Economic Research, Inc, pp. 15–90, [online] Available at: https://EconPapers.repec.org/RePEc:nbr:nberch:4245.

Block, F. (2022) Technology and productivity: a critique of aggregate indicators, *Journal of Post Keynesian Economics*, Routledge, 45(1), pp. 1–23, [online] Available at: https://doi.org/10.1080/01603477.2022.2029491.

Bom, P. R. D. and Ligthart, J. E. (2014) WHAT HAVE WE LEARNED FROM THREE DECADES OF RESEARCH ON THE PRODUCTIVITY OF PUBLIC CAPITAL?, *Journal of Economic Surveys*, 28(5), pp. 889–916, [online] Available at: https://onlinelibrary.wiley.com/doi/abs/10.1111/joes.12037.

Botta, A. (2014) Structural Asymmetries at the Roots of the Eurozone Crisis: What's New for Industrial Policy in the EU?, *PSL Quarterly Review*, 67, pp. 169–216.

Commendatore, P., Panico, C. and Pinto, A. (2011) THE INFLUENCE OF DIFFERENT FORMS OF GOVERNMENT SPENDING ON DISTRIBUTION AND GROWTH, *Metroeconomica*, John Wiley & Sons, Ltd, 62(1), pp. 1–23, [online] Available at: https://doi.org/10.1111/j.1467-999X.2009.04081.x.

Deleidi, M., de Lipsis, V., Mazzucato, M., Ryan-Collins, J. and Agnolucci, P. (2020) The macroeconomic impact of government innovation policies: A quantitative assessment, [online] Available at: https://www.ucl.ac.uk/bartlett/public-purpose/publications/2019/jul/macroeconomic-impact-government-innovation-policies (Accessed 19 September 2022).

Deleidi, M. and Mazzucato, M. (2021) Directed innovation policies and the supermultiplier: An empirical assessment of mission-oriented policies in the US economy, *Research Policy*, 50(2), p. 104151, [online] Available at: https://linkinghub.elsevier.com/retrieve/pii/S0048733320302262.

Deleidi, M. and Mazzucato, M. (2019) Putting Austerity to Bed: Technical Progress, Aggregate Demand and the Supermultiplier, *Review of Political Economy*, Routledge, 31(3), pp. 315–335.

Dutt, A. (2013) Government spending, aggregate demand, and economic growth, *Review of Keynesian Economics*, 1(1), pp. 105–119, [online] Available at: https://EconPapers.repec.org/RePEc:elg:rokejn:v:1:y:2013:i:1:p105-119.

Efthalitsidou, K., Zafeiriou, E., Spinthiropoulos, K., Betsas, I. and Sariannidis, N. (2021) GDP and public expenditure in education, health, and defense. Empirical research for Greece, *Mathematics*, MDPI, 9(18).

Fatás, A. (2000) *Do Business Cycles Cast Long Shadows? Short-Run Persistence and Economic Growth*, *Journal of Economic Growth*.

Fatás, A. and Summers, L. H. (2018) The permanent effects of fiscal consolidations, *Journal of International Economics*, Elsevier B.V., 112, pp. 238–250.

Felipe, J. and McCombie, J. (2013) *The Aggregate Production Function and the Measurement of Technical Change*, Edward Elgar Publishing, [online] Available at: https://EconPapers.repec.org/RePEc:elg:eebook:1975.

Felipe, J. and McCombie, J. (2020) The illusions of calculating total factor productivity and testing growth models: from Cobb-Douglas to Solow and Romer, *Journal of Post Keynesian Economics*, 43(3), pp. 470–513, [online] Available at: https://EconPapers.repec.org/RePEc:mes:postke:v:43:y:2020:i:3:p:470-513.

Flabbi, L. and Gatti, R. (2018) *A Primer on Human Capital*, [online] Available at: http://econ.worldbank.org.

Hartwig, J. (2013) Distribution and growth in demand and productivity in Switzerland (1950–2010), *Applied Economics Letters*, Routledge, 20(10), pp. 938–944, [online] Available at: https://doi.org/10.1080/13504851.2013.765538.

Hein, E. (2014) *Distribution and Growth after Keynes*, *Distribution and Growth after Keynes*, Edward Elgar Publishing.

Hein, E. and Tarassow, A. (2010) Distribution, aggregate demand and productivity growth: theory and empirical results for six OECD countries based on a post-Kaleckian model, *Cambridge Journal of Economics*, 34(4), pp. 727–754, [online] Available at: https://doi.org/10.1093/cje/bep066.

Hickel, J. and Hallegatte, S. (2022) Can we live within environmental limits and still reduce poverty? Degrowth or decoupling?, *Development Policy Review*, John Wiley and Sons Inc, 40(1).

Holtz-Eakin, D. (1994) Public-Sector Capital and the Productivity Puzzle, *The Review of Economics and Statistics*, The MIT Press, 76(1), pp. 12–21, [online] Available at: http://www.jstor.org/stable/2109822.

Institute for Government (2020) *Capital spending - Why governments fail to meet their spending plans*, [online] Available at: https://www.instituteforgovernment.org.uk/sites/default/files/publications/capital-investment-governments-spending-plans_0.pdf (Accessed 13 September 2022).

Institute for Government (2022) *Whitehall Monitor 2022*, [online] Available at: https://www.instituteforgovernment.org.uk/publications/whitehall-monitor-2022 (Accessed 13 September 2022).

Irmen, A. and Kuehnel, J. (2009) Productive Government Expenditure and Economic Growth, *Journal of Economic Surveys*, 23(4), pp. 692–733.

Kaldor, N. (1957): A model of economic growth, *The Economic Journal*, 67: 591-624, reprinted in Kaldor, N., *Collected Economic Essays, Volume 2, Essays on Economic Stability and Growth*, London: Duckworth, 1960.

Kaldor, N. (1961): Capital accumulation and economic growth, in: Lutz, F.A., Hague, D.C. (eds), *The Theory of Capital*, London: Macmillan, reprinted in Kaldor, N., *Collected Economic Essays, Volume 5, Further Essays on Economic Theory*, London: Duckworth, 1978.

Mazzucato, M. (2016) Ch.6 - Innovation, the State and Patient Capital, In *Rethinking Capitalism*, pp. 98–118.

Mazzucato, M. (2013) *The Entrepreneurial State: Debunking Private vs. Public Sector Myths*,.

Mazzucato, M. (2018) *The Value of Everything: Making and Taking in the Global Economy*, London, Penguin Books Limited, [online] Available at: https://books.google.co.uk/books?id=ERwXDAAAQBAJ.

Mazzucato, M. and Semieniuk, G. (2018) Financing renewable energy: Who is financing what and why it matters, *Technological Forecasting and Social Change*, 127, pp. 8–22, [online] Available at: https://www.sciencedirect.com/science/article/pii/S0040162517306820.

Mazzucato, M. and Wray, L. R. (2015) *Financing the Capital Development of the Economy: A Keynes-Schumpeter-Minsky Synthesis*, [online] Available at: http://ssrn.com/abstract=2603847.

McCombie, J., Pugno, M. and Soro, B. (2002) Introduction, In McCombie, J., Pugno, M., and Soro, B. (eds.), *Productivity Growth and Economic Performance*, London, Palgrave Macmillan UK.

Naastepad, C. W. M. (2006) Technology, demand and distribution: a cumulative growth model with an application to the Dutch productivity growth slowdown, *Cambridge Journal of Economics*, Oxford Academic, 30(3), pp. 403–434, [online] Available at: https://academic.oup.com/cje/article/30/3/403/1729970 (Accessed 16 May 2022).

Núñez-Serrano, J. A. and Velázquez, F. J. (2017) Is Public Capital Productive? Evidence from a Meta-analysis, *Applied Economic Perspectives and Policy*, 39(2), pp. 313–345, [online] Available at: https://onlinelibrary.wiley.com/doi/abs/10.1093/aepp/ppw012.

Obst, T., Onaran, Ö. and Nikolaidi, M. (2020) The effects of income distribution and fiscal policy on aggregate demand, investment and the budget balance: the case of Europe, *Cambridge Journal of Economics*, 44(6), pp. 1221–1243, [online] Available at: https://doi.org/10.1093/cje/bez045.

Onaran, Ö., Oyvat, C. and Fotopoulou, E. (2022a) A Macroeconomic Analysis of the Effects of Gender Inequality, Wages, and Public Social Infrastructure: The Case of the UK, *Feminist Economics*, 28(2), pp. 152–188, [online] Available at: https://EconPapers.repec.org/RePEc:taf:femeco:v:28:y:2022:i:2:p:152-188.

Onaran, Ö., Oyvat, C. and Fotopoulou, E. (2022b) Gendering Macroeconomic Analysis and Development Policy: A Theoretical Model, *Feminist Economics*, Routledge, 28(3), pp. 23–55, [online] Available at: https://doi.org/10.1080/13545701.2022.2033294.

Palley, T. I. (2013) Cambridge and neo-Kaleckian growth and distribution theory: comparison with an application to fiscal policy, *Review of Keynesian Economics*, 1(1), pp. 79–104, [online] Available at: http://www.elgaronline.com/view/journals/roke/1-1/roke.2013.01.05.xml.

Parker, G. (2021) Labour seeks to bury Corbyn's legacy with commitment to economic stability, *Financial Times*, [online] Available at: https://www.ft.com/content/0bf3c1ab-5fbf-4a44-a54b-004e6241d350 (Accessed 13 September 2022).

Parui, P. (2021) Government expenditure and economic growth: a post-Keynesian analysis, *International Review of Applied Economics*, Routledge, 35(3–4), pp. 597–625.

Romp, W. and de Haan, J. (2007) Public Capital and Economic Growth: A Critical Survey, *Perspektiven der Wirtschaftspolitik*, 8(S1), pp. 6–52, [online] Available at: https://EconPapers.repec.org/RePEc:bla:perwir:v:8:y:2007:i:s1:p:6-52.

Rossi, F. (2020) Human Capital and Macroeconomic Development: A Review of the Evidence, *The World Bank Research Observer*, 35(2), pp. 227–262, [online] Available at: https://doi.org/10.1093/wbro/lkaa002.

Setterfield, M. and Cornwall, J. (2002) A Neo-Kaldorian Perspective on the Rise and Decline of the Golden Age, In *The Economics of Demand-Led Growth*, Edward Elgar Publishing, [online] Available at: https://EconPapers.repec.org/RePEc:elg:eechap:1864_5.

Stockhammer, E. and Klär, E. (2011) Capital accumulation, labour market institutions and unemployment in the medium run, *Cambridge Journal of Economics*, Oxford University Press, 35(2), pp. 437–457.

Storm, S. and Naastepad, C. W. M. (2009a) Labor Market Regulation and Productivity Growth: Evidence for Twenty OECD Countries (1984–2004), *Industrial Relations: A Journal of Economy and Society*, John Wiley & Sons, Ltd, 48(4), pp. 629–654, [online] Available at: https://doi.org/10.1111/j.1468-232X.2009.00579.x.

Storm, S. and Naastepad, C. W. M. (2012) *Macroeconomics Beyond the NAIRU*, Harvard University Press, [online] Available at: http://www.jstor.org/stable/j.ctt24hhs5.

Storm, S. and Naastepad, C. W. M. (2009b) The NAIRU, Demand and Technology, *Eastern Economic Journal*, Palgrave Macmillan Journals, 35(3), pp. 309–337, [online] Available at: http://www.jstor.org/stable/20642494.

Tavani, D. and Zamparelli, L. (2017a) Endogenous Technical Change in Alternative Theories of Growth and Distribution, *Journal of Economic Surveys*, 31(5), pp. 1272–1303, [online] Available at: https://EconPapers.repec.org/RePEc:bla:jecsur:v:31:y:2017:i:5:p:1272-1303.

Tavani, D. and Zamparelli, L. (2017b) Government spending composition, aggregate demand, growth, and distribution, *Review of Keynesian Economics*, 5(2), pp. 239–258, [online] Available at: https://EconPapers.repec.org/RePEc:elg:rokejn:v:5:y:2017:i:2:p239-258.

Vergeer, R. and Kleinknecht, A. (2014) Do labour market reforms reduce labour productivity growth? A panel data analysis of 20 OECD countries (1960–2004), *International Labour Review*, John Wiley & Sons, Ltd, 153(3), pp. 365–393, [online] Available at: https://doi.org/10.1111/j.1564-913X.2014.00209.x.

Vergeer, R. and Kleinknecht, A. (2010) The impact of labor market deregulation on productivity: a panel data analysis of 19 OECD countries (1960-2004), *Journal of Post Keynesian Economics*, Routledge, 33(2), pp. 371–408, [online] Available at: https://www.tandfonline.com/doi/abs/10.2753/PKE0160-3477330208.

Women's Budget Group UK and Scottish Women's Budget Group (WBG) (2015) *Plan F. A Feminist Economic Strategy for a Caring and Sustainable Economy*, [online] Available at: https://wbg.org.uk/wp-content/uploads/2015/02/PLAN-F-2015.pdf (Accessed 22 September 2022).

Appendix 1– Description of the data

The initial data set comprised 28 counties (EU-27 plus United Kingdom) and 40 sectors between 1995 and 2019.

We then focused on 19 countries and 9 manufacturing sectors, 1995-2019.

Data Sources

Euklems & INTANProd database, (2021) - Available at https://euklems-intanprod-llee.luiss.it/ [14/06/2022]

Eurostat, (2022) - Available at: https://ec.europa.eu/eurostat/databrowser/explore/all

- Government Expenditure by Function (COFOG) – gove_10a_exp [22/04/2022]
- Total Population – nama_10_pe [29/06/2022]
- GDP at market prices - TEC00001 [28/06/2022]

OECD, (2022)

- COFOG Available at: https://stats.oecd.org/index.aspx?queryid=60702 [30/06/2022]

World Bank, (2022), World Development Indicators - Available at https://databank.worldbank.org/source/world-development-indicators (NY.GDP.MKTP.CN) [28/06/2022]

Variables

Data on output, investment, real wages, hours worked, number of employees and health and education spending, capital stock and USA output came from EU-KLEMS. We generated values for labour productivity using by dividing real output by hours worked by employees (VA_Q/H_EMPE).

Data on government gross fixed capital investment (COFOG) and population came from Eurostat. [6]

EU KLEMS data on sectoral output, investment and capital stock is available deflated by sector-specific price indices with 2015 as base year. We deflated current values of real wages and government gross fixed capital investment using the whole economy deflators from EU-KLEMS with 2015 as base year (VA_PI, Total).

Data was in local currency, so we converted any non-euro currency amounts from their real local currency values into euros using the 2015 ratio between nominal GDP in Euros and nominal GDP in local currency. Data in Euros came from Eurostat and data in local currency came from the World Bank World Development Indicators (both 2015 nominal GDP).

We created 5-year (and 3-year) non-overlapping averages to reduce T and reduce the chance of spurious correlation due to time-series dynamics in the data. Average values were only created if there were data points for all relevant years.

[6] Data on UK GFCF and tax rate was added using OECD data.

Table 2 - Significant data gaps in EU-KLEMS data

Focusing on core 9 manufacturing sectors (1995-2019) - 225 possible observations per country.

	Volume of output (2015 baseline)	Hours of employment	Volume of Gross Fixed Capital Formation (2015 baseline)
Austria			
Belgium			
Bulgaria		45	
Cyprus	9		225
Czech			
Germany	9	9	
Denmark			
Estonia		76	225
Greece			
Spain	9	9	9
Finland			
France		9	
Croatia			225
Hungary		135	
Ireland	50		225
Italy			18
Lithuania	9	9	225
Luxembourg	100	100	105
Latvia	9	225	9
Malta	70	34	225
Netherlands			9
Poland	9	9	225
Portugal	9	9	9
Romania		9	18
Sweden	33		33
Slovenia			225
Slovakia			
UK	9		

Those missing 9 observations were mostly the observations from 2019

Appendix 2 – Estimation Results

Table 3 – Descriptive statistics for manufacturing sectors (not C19) for 19 countries, 1995-2019[7]

Variable		Mean	Std. Dev.	Min	Max	Observations
Productivity (Output/Employment)	overall	37.67318	25.66804	0.213204	271.7499	N
	between		23.38604	2.616514	138.6595	n
	within		10.9008	-39.037	170.7635	T-bar
Output (Value Added)	overall	9.30E+09	1.43E+10	1.42E+07	1.56E+11	N
	between		1.41E+10	6.70E+07	1.01E+11	n
	within		3.07E+09	-2.45E+10	6.39E+10	T
Investment	overall	13423.43	14158.82	-1975.13	144356.4	N
	between		13098.95	412.2508	78482.02	n
	within		5422.846	-46493.7	79297.78	T
Real Wage	overall	22.23331	13.01667	1.199511	73.6688	N
	between		12.89779	1.870641	53.0361	n
	within		2.78925	7.718141	52.28149	T-bar
Health and Education Spending	overall	3338.222	2189.062	207.1734	8701.083	N
	between		2171.366	362.9764	7548.957	n
	within		309.9395	1377.552	4490.348	T
Government GFCF	overall	1023.202	786.8147	19.77149	4864.481	N
	between		759.2336	187.7687	3675.741	n
	within		214.1928	-235.589	2211.941	T
Per capita employment in Health and Education	overall	0.070092	0.026482	0.022802	0.135442	N
	between		0.025629	0.03107	0.127518	n
	within		0.006842	0.043104	0.092818	T
Capital Stock	overall	142958	103968	11734.97	823500.1	N
	between		98012.87	18734.89	703785.3	n
	within		29564.29	-97717.7	378057.7	T-bar
Output (US)	overall	1.36E+11	6.77E+10	2.07E+10	3.44E+11	N
	between		5.77E+10	3.01E+10	1.99E+11	n
	within		3.58E+10	-1.40E+10	2.84E+11	T

[7] Austria, Belgium, Bulgaria, Czech Republic, Germany, Denmark, Greece, Spain, Finland, France, Hungary, Italy, Luxembourg, Netherlands, Portugal, Romania, Sweden, Slovakia and United Kingdom

Table 4 – Lagged and contemporaneous independent variables[8]

IV-GMM regressions, Fixed Effects with cluster robust standard errors, 5-year averages, 1999-2018

Dependent variable - $logT_{it}$

	(5) Baseline (5-year lags) b/se	(15) Contemporary independent variables b/se	(16) Contemporary ind. variables plus year dummies b/se
log $Y_{i(t-1)}$	0.249*		
	(0.137)		
log Y_{it}		0.406***	0.459***
		(0.097)	(0.100)
log $I_{i(t-1)}$ /$E_{i(t-1)}$	-0.042		
	(0.170)		
log I_{it} /E_{it}		-0.173	-0.139*
		(0.119)	(0.083)
log $w_{i(t-1)}$	0.616**		
	(0.236)		
log w_{it}		1.385***	0.856***
		(0.183)	(0.309)
log $(G^H_{t-1}+ C^H_{t-1})/N_{t-1}$	0.110		
	(0.194)		
log $(G^H_t+ C^H_t)/N_t$		0.580***	0.318*
		(0.171)	(0.181)
log I^G_{t-1}/N_{t-1}	0.045		
	(0.157)		
log I^G_t/N_t		-0.093*	-0.051
		(0.049)	(0.049)
2014-2018 dummy			0.170**
			(0.068)
2009-2013 dummy			0.139***
			(0.048)
2004-2008 dummy			0.100***
			(0.024)
Number of observations	412	535	535
Model degrees of freedom	5	5	8
Log-likelihood	312.315	344.559	416.899
AIC	-614.629	-679.118	-817.798
BIC	-594.524	-657.706	-783.540
Kleibergen-Paap rk Wald F statistic for weak identification	4.040	6.727	7.968
Hansen J overidentification test (p-value)	0.305	0.629	0.793

Standard errors in parentheses * p<0.05 ** p<0.01 *** p<0.001

[8] Contemporary endogenous variables of Y_{it} , I_{it} /E_{it} , log w_{it} are instrumented with their five-year lagged values and the contemporaneous output in the corresponding sector in the USA (Y_{USt}). E.g. average level of productivity in 2014-2018 was regressed on the average values of the independent variables 2014-2018 instrumented by their values in 2013 and the average value of US output 2014-2018.

Table 5 –-Different average length (3 years)

IV-GMM regressions, Fixed Effects with cluster robust standard errors, 3-year averages, 1995-2018

Dependent variable - $logT_{it}$

	(17) Basic specification b/se	(18) Year Effects b/se	(19) Using lagged 3-year averages as instruments b/se	(20) Using lagged 3-year averages as instruments + years b/se
log $Y_{i(t-1)}$	0.300***	0.362***	0.327***	0.366***
	(0.086)	(0.086)	(0.088)	(0.096)
log $I_{i(t-1)}$ /$E_{i(t-1)}$	0.075	0.123	0.053	0.056
	(0.103)	(0.104)	(0.114)	(0.103)
log $w_{i(t-1)}$	0.901***	0.176	0.982***	0.326
	(0.128)	(0.241)	(0.122)	(0.217)
log $(G^{H}_{t-1}+ C^{H}_{t}-1)/N_{t-1}$	0.300*	-0.140	0.282*	-0.084
	(0.165)	(0.163)	(0.165)	(0.156)
log I^{G}_{t-1}/N_{t-1}	-0.064	0.011	-0.082	0.011
	(0.049)	(0.044)	(0.053)	(0.044)
2016-2018 dummy		0.271***		0.241***
		(0.059)		(0.052)
2013-2015 dummy		0.243***		0.212***
		(0.057)		(0.051)
2010-2012 dummy		0.174***		0.155***
		(0.038)		(0.035)
2007-2009 dummy		0.136***		0.123***
		(0.028)		(0.024)
2004-2006 dummy		0.112***		0.100***
		(0.021)		(0.018)
2001-2003 dummy		0.000		0.000
		(.)		(.)
1998-2000 dummy		0.000		0.000
		(.)		(.)
Number of observations	832	832	824	824
Model degrees of freedom	5	10	5	10
Log-likelihood	491.835	548.934	502.451	562.567
AIC	-973.670	-1077.867	-994.902	-1105.133
BIC	-950.051	-1030.629	-971.332	-1057.992
Kleibergen-Paap rk Wald F statistic for weak identification	7.454	6.651	10.703	9.733
Hansen J overidentification test (p-value)	0.596	0.900	0.615	0.768

Standard errors in parentheses * p<0.05 ** p<0.01 *** p<0.001

Table 6 –-Different average length (3 years)

IV-GMM regressions, Fixed Effects with cluster robust standard errors, 3-year averages, 1996-2019

	(21) Basic specification b/se	(22) Year Effects b/se	(23) Using lagged 3-year averages as instrument b/se	(24) Using lagged 3-year averages as instrument + years b/se
log $Y_{i(t-1)}$	0.279**	0.344***	0.289***	0.361***
	(0.108)	(0.110)	(0.096)	(0.113)
log $I_{i(t-1)}$ /$E_{i(t-1)}$	-0.195	-0.086	0.035	0.029
	(0.132)	(0.103)	(0.140)	(0.131)
log $w_{i(t-1)}$	0.906***	0.198	0.936***	0.130
	(0.133)	(0.245)	(0.133)	(0.327)
log $(G^H{}_{t-1}+ C^H{}_{t-}1)/N_{t-1}$	0.160	-0.208	0.112	-0.259
	(0.172)	(0.167)	(0.168)	(0.185)
log $I^G{}_{t-1}/N_{t-1}$	0.080	0.142**	-0.024	0.107*
	(0.079)	(0.069)	(0.072)	(0.063)
2017-2019 dummy		0.229***		0.240***
		(0.059)		(0.074)
2014-2016 dummy		0.226***		0.241***
		(0.054)		(0.069)
2011-2013 dummy		0.154***		0.171***
		(0.044)		(0.055)
2008-2010 dummy		0.098***		0.100***
		(0.025)		(0.028)
2005-2007 dummy		0.111***		0.115***
		(0.020)		(0.024)
2002-2004 dummy		0.000		0.000
		(.)		(.)
1999-2001 dummy		0.000		0.000
		(.)		(.)
Number of observations	790	790	768	768
Model degrees of freedom	5	10	5	10
Log-likelihood	455.375	545.482	492.770	561.685
AIC	-900.751	-1070.963	-975.540	-1103.370
BIC	-877.391	-1024.243	-952.321	-1056.932
Kleibergen-Paap rk Wald F statistic for weak identification	8.722	7.333	7.794	8.025
Hansen J overidentification test (p-value)	0.454	0.815	0.824	0.935

Standard errors in parentheses * p<0.05 ** p<0.01 *** p<0.001