The public investment multiplier in a production network

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Governments around the world have been responding to the aftermath of the Covid pandemics with the implementation of recovery plans featured by massive public-investment projects, best exemplified by the $1.2 trillion Infrastructure Investment and Jobs Act in the U.S. and the €800 billion Next Generation EU in Europe. Policy-makers motivate these packages with the need to strengthen supply chains and foster the development of specific industries[1]. However, these mechanisms are missing in the workhorse theoretical analysis of public investment. Indeed, the macroeconomic literature has studied the aggregate effects of public investment through the lens of one-sector models (Baxter and King, 1993; Leeper et al., 2010; Leduc and Wilson, 2013; Bouakez et al., 2017, 2020; Boehm, 2020; Ramey, 2021). In order to fill this gap, we build a sticky-price model with heterogeneous sectors that are connected by an Input-Output matrix. In particular, the economy is populated by 55 sectors —which reflect the 3-digit level of disaggregation of NAICS codes— that are calibrated to reproduce the U.S. economy with information from the 2019 U.S. Bureau of Economic Analysis (BEA) Input-Output Tables. Moreover, sectors are not only heterogeneous in their use and supply of intermediate inputs but they also differ in their: (i) factor intensities; (ii) output elasticity of public capital; (iii) degree of nominal price rigidity; (iv) contribution to private demand; as well as (v) contribution to public demand. Importantly in order to discipline the heterogeneous effect of public capital across industries, we provide novel estimates of the elasticity of gross output to public capital at the sectoral level. We extend Bouakez et al. (2017)'s estimation to a panel setting in two steps. First, we use KLEMS data over 1963-2016 to back out the utilization-adjusted TFP at the sectoral level, following the procedure of Basu et al. (2006) and Fernald (2014). Second, we regress the logarithm of sector-specific utilization-adjusted TFP on the logarithm of public capital, and recover the sector-specific elasticities with the heterogeneous cointegrated panel estimator of Pedroni (2001). Within this framework, the paper provides three main contributions to the study on the aggregate and sectoral effects of the public investment.

Our first contribution is to quantify to what extent sectoral heterogeneity and inter-linkages alter the aggregate effects of public investment. As reported in column 1 of the Table, we find that the production network economy implies a long-run present-value public-investment multiplier of 2.12, which is 68% (or 86 cents) larger than in the one-sector model. In addition, the amplification is twice as large as that of the public-consumption. More specifically, we show that although public consumption spurs relatively more GDP on impact (Boehm, 2020; Ramey, 2021), the production network closes the gap between the public-investment and public-consumption multipliers after 6 quarters, significantly faster than the 30 quarters required by the one-sector model. To investigate the sources of amplification of the aggregate value-added multiplier, we replicate the public investment shock in counterfactual economies in which we switch each potential source off at a time. As we can observe from the Table, the amplification of the public-investment multiplier fully depends on the interaction between the output elasticity to public capital and the Input-Output matrix. Given the production network, public investment benefits firms not only directly, but also indirectly. The increase in the stock of public capital not only enhances the efficiency of those sectors with the highest output elasticity to public capital (direct channel), but it also indirectly benefits downstream industries that can buy cheaper intermediate goods and expand the production. This mechanism would imply relatively larger public-investment multipliers if upstream sectors featured high public-capital elasticities. However, we do not observe this in the data: sectors' positions in the network barely correlate with their public-capital elasticities. Accordingly, as we can observe from column (8) of the Table, the heterogeneity in this dimension does not play a sizable role in the propagation of public investment. The amplification of the multiplier also

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Sources of Amplification of the Aggregate Value-Added Multiplier

	Alternative Production-Network Economies Without . . .						
Benchmark	IO Matrix	IO Matrix Heterogeneity	Price Rigidity Heterogeneity	Public Demand Heterogeneity	Final Demand Heterogeneity	Factor Intensities Heterogeneity	Output Elasticity to Public Capital Heterogeneity
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Panel A: Public-Investment Multiplier							
2.12	1.24	2.11	2.04	2.29	2.3	2.17	2.05
Panel B: Public-Consumption Multiplier							
0.45	0.4	0.43	0.41	0.49	0.44	0.44	0.45

NOTES: The table reports the public investment and public investment multiplier in economies where we abstract from: (2) use of intermediate inputs; (3) heterogeneity in the use and supply of intermediate inputs; (4) price rigidity heterogeneity; (5) heterogeneity in the contributions to public demand; (6) heterogeneity in the contributions to final demand; (7) heterogeneity in the factor intensities; (8) heterogeneity in the output elasticity to public capital.

depends on the way in which the production network alters the optimal level of public capital. Our production network doubles the socially optimal amount of public capital relative to the one-sector economy, and puts it way above the level observed in the data. Interestingly, we also find a substantial shift in the welfare costs associated to inefficient levels of public capital: while welfare losses in the one-sector economy mainly come when public capital is inefficiently high, the opposite applies in our model.

Our second contribution is to uncover novel sectoral implications of public investment. We document that public investment is relatively more concentrated than public consumption: just three industries —(i) construction, (ii) professional services, and (iii) computer services— account for 78% of it. In principle we could expect that the public investment benefits fewer industries than the public consumption. Surprisingly, this is not the case: the output gains of public investment are more evenly distributed across industries than those of public consumption. This result is as well a byproduct of the interaction between the output elasticity to public capital and Input-Output linkages as sectors may indirectly benefit from the higher efficiency in the provision of intermediate inputs, even when they do not directly contribute to the production of public-investment goods.

Finally, we empirically validate the sectoral implications of the model by testing whether the sectoral value-added responses to public-investment shocks vary less than those to public-consumption shocks with sectors' direct contributions to government spending. We adapt the estimation strategy of Ramey and Zubairy (2018) by extending the linear projection method of Jordà (2005) to a panel with annual observations, from 1963 to 2015, for the 55 sectors of our model economy. We regress sectoral value added on the interaction between aggregate defense investment expenditures and the associated sectoral contributions, as well as sector and year fixed effects. Following Ramey and Zubairy (2018), aggregate public spending is instrumented with both the military-spending news variable of Ramey (2011) and the timing restriction of Blanchard and Perotti (2002). We also consider an analogous regression for public consumption. We find that the coefficients on the interaction terms are positive and highly statistically significant, with the estimate of the public-consumption interaction doubling that of public investment. Moreover, the empirical estimates on how the sectoral relative multipliers vary with sectors' contributions to public spending are remarkably in line with the quantitative predictions of the model.

All in all, we study the aggregate and sectoral effect of public investment through the lens of a New Keynesian production

network model. At aggregate level, interaction between the output elasticity to public capital and intermediate inputs doubles the socially optimal amount of public capital relative to the one-sector model, leading to a substantial amplification of the public-investment multiplier. In addition, at sectoral level we find that although public investment is concentrated in far fewer sectors than public consumption, its effects are relatively more evenly distributed across industries.

While this work has considered public investment as a homogeneous good, in future research we will evaluate whether different types of public investment, such as expenditures on structures, equipment, and intangible, can generate heterogeneous effects at both the aggregate and sectoral levels.

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