On the Investment Network and Development *

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Abstract

Capital accumulation and sectorial reallocation are two salient features of economic development. They are interconnected through the means for production of different capital and heterogeneous uses of these capital across sectors, i.e. the investment network. Our paper introduces the first harmonized measures of the investment network across the development spectrum and documents novel empirical regularities, including systematic differences in the network along the income spectrum. We propose a simple theory linking these disparities to differences in income per capita across countries. We show that the elasticity of output to sectorial productivity, i.e. sectorial influence, is a function of the network and varies systematically with income. Sectorial influence is highest in the Construction sector in developing countries, and in the ICT and Service sector in developed countries. This is the result of forces related to structural change, sectorial productivity and shifts in sectorial linkages. For our sample of 58 countries, we show that 28% of cross-country differences in income per capita can be accounted for by disparities in the investment network. These differences are twice as large as the role of capital in income disparities from a standard development accounting.

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JEL classifications: E23; E21; O41.

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1 Introduction

Capital accumulation and the systematic reallocation of economic activity across sectors are two of the most salient features of economic development. Different sectors utilize various investment goods for production, which are either produced by other sectors of the economy or imported. As economic activity shifts across sectors, the economy's ability to produce new capital—or to export goods in exchange for this new capital—changes, facilitating further capital accumulation. The study of the nature of this continuous feedback is crucial for understanding the mechanics of economic development (Hirschman, 1958). Such a study requires measures of sectorial links in both the production and use of new capital, i.e., the investment network. This paper provides the first harmonized measures of investment networks across the development spectrum. We document novel facts about the characteristics of these networks and construct a theory to evaluate the impact of these differences on observed income disparities across countries.

Recent studies have documented systematic changes in the sectorial composition of inputs used for investment as countries develop, Garcia-Santana, Pijoan-Mas and Villacorta (2021); Herrendorf, Rogerson and Valentinyi (2021). Work has also examined how disparities in the bundles of capital goods used for sectorial production lead to structural change (Caunedo and Keller, 2023). We combine these two approaches and characterize the link between production and uses of capital, i.e. the investment network, and aggregate output. Through the lens of a neoclassical multisector open economy model, we show that the investment network is a key component of the elasticity of GDP to sectorial productivity. The extensive literature in networks labels this elasticity as "*sectorial influence*", Acemoglu, Carvalho, Ozdaglar and Tahbaz-Salehi (2012).

Sectional influence is a function of the input-output structure and the investment network, summarizing the direct and indirect impact of changes in sectorial productivity on aggregate economic activity. Our economy has several distinct features relative to other economies with sectorial linkages. First, welfare and GDP differ due to the presence of investment. Along a growth path with constant investment rates these two are proportional to each other. Second, Domar weights depend on equilibrium investment rates and therefore on the entire equilibrium path in an economy that displays non-trivial transition dynamics. Since welfare is a Domar-weighted sum of sectorial productivities, welfare also depends on the entire equilibrium path. This feature is a consequence of the durable nature of capital and a novel result in the production networks literature that, for the most part, focuses on nondurable inputs. Third, *sectorial influence* is independent of the investment rate and depends solely on the characteristics of the IO and investment network at each point in time. In other words, to assess the impact of sectorial productivity on aggregate GDP (consumption and investment), there is no trade-off between current and future consumption; by contrast, such a trade-off is central when evaluating welfare.

To bring empirical content to the roundabout effects summarized in *sectorial influence*, one needs measures of intermediate and investment networks, as well as factor shares and investment rates. While estimates of the input–output structure have become increasingly available across countries, estimates of the investment network are only available for the US (vom Lehn and Winberry, 2022) and a handful of years across OECD economies; see Ding (2023).[1] We advance previous measurement efforts by providing cross-country and time-series harmonized estimates of the investment network for 58 countries with income per capita levels between \$428 and \$81,599 constant 2015 PPP dollars and time spans that date back to the 1960s for a subset of countries. In our analysis, capital is disaggregated into multiple equipment types, including ICT, electronics, machinery, transportation and other durables, as well as structures, measured through construction investment.[2]

To create our harmonized measures, we exploit a methodology similar to that of the Bureau of Economic Analysis (BEA) in the US. The BEA combines the occupational composition of each industry and an allocation rule for capital to workers to estimate investment by capital type and sector (Meade, Rzeznik and Robinson-Smith, 2003). Unfortunately, the apportioning of stocks to workers is not publicly available. Hence, to ensure replicability, we opt for an allocation of capital across sectors that follows Caunedo, Jaume and Keller (2023) for equipment sectors and an allocation that follows intermediate inputs for construction and other sectors with positive investment in the national accounts. Our own estimates of the investment network for the US closely follow those published by the BEA, which yields confidence on our apportioning method. Still, the BEA and our apportioning depends on sectorial occupational compositions to impute capital uses. Ideally, one would like to have direct measures of investment by detailed categories in each sector. This data is broadly unavailable even within a country, let alone across countries and for long time series. There is a handful of countries with VAT data, that allow for measurement of firm-to-firm transactions, notably Chile between 2015-2024 **?**. We find that our estimates are fully consistent with VAT estimates which again is reassuring given the widely different sources of these estimates.

[1] These measures are self-reported by country offices to the OECD Statistics office, and it is unclear whether measurement is comparable across countries. Ding (2023) exploits these investment flows to estimate capital services in each sector from different sectors and countries. To do so, he uses bilateral import flows to input cross-country linkages and estimates user costs along a BGP. In other words, he treats the investment network as a primitive.

[2] Our benchmark estimates include 10 sectors, but estimates for as many as 19 sectors consistently defined across countries and time can be made readily available.

With our newly constructed measure, we document some novel facts. First, there are systematic changes in the composition of investment providers as countries develop, which we measure through *outdegrees*—the row sums of the network. Construction is the dominant provider at all income levels and follows a hump-shaped relationship with development; other services (including financial intermediation and real estate) are also major suppliers, but their importance declines with income and is overtaken by a strong increase in ICT, whose role nearly triples as countries get richer. Second, the bundle of capital goods that sectors use in production becomes more diversified as countries grow richer, with the exception of construction, where concentration rises. Finally, the investment network and the input–output tables differ substantially: sectors that are important providers of intermediate inputs are not necessarily those that matter for investment supply. This is the case of agriculture—a major provider of intermediate inputs (especially in low-income countries) that plays only a minor role in investment—and of construction, which is more than three times as important a provider of investment as of intermediate inputs. ICT is an important provider of both investment and intermediate goods. Moreover, homophily (the diagonal weight) is stronger in the input–output network, meaning sectors are more important providers of intermediate inputs to themselves than of investment goods. Hence, sectoral productivity shocks have different aggregate implications depending on whether a sector mainly supplies intermediates or investment.

A natural question to ask is whether sectors with high *outdegrees* in the investment network are also sectors where changes in productivity have the strongest impact on aggregate activity. The answer is no. Our theory predicts that their role is mediated by other features of the economy, including value added and capital shares in production, as well as the full input–output network. Hence, to assess the role of the investment network for income disparities, we exploit the characterization of *sectorial influence*.

Given an estimate of the roundabout effects as summarized in an "augmented" Leontief inverse (augmented by investment linkages), we can calibrate sectorial productivity differences to match disparities in value added across sectors within countries and across countries for a given sector. By construction, our model exactly matches the empirical variance of output per capita at baseline. We then study the role of the investment network in driving these disparities through counterfactual exercises. First, we drive the capital share in value added to zero, so that the investment network drops out from *sectorial influence*. Second, we only include the investment network in computing the augmented Leontief inverse, so roundabout effects from intermediate inputs are eliminated. In the former exercise, the role of the investment network is the difference between the variance at baseline and the counterfactual. In the latter exercise, the role of the network is the portion of baseline variance that is not explained by the intermediate input linkages. Our main finding is that, averaging across these counterfactuals, the investment network accounts for 28% of the observed disparities in income per worker. To place the magnitude of our finding in perspective, a standard development accounting exercise imputes approximately 13% of observed income differences to disparities in measured capital in our sample of countries. We conclude that accounting for roundabout effects in the technology for producing capital doubles its role for income disparities.

Our model rationalizes differences in the investment network through disparities in the frontier technology facing poor and rich countries. This frontier is characterized by a height, which intuitively summarizes the availability of better technologies across all capital types, and a gradient, which intuitively summarizes the availability of technologies that are more or less intensive in certain capital types relative to others. We can then account for the role of disparities in the height and in the relative intensity across capital types in driving income disparities. We find that the role of height of the frontier for the contribution of the investment network to cross-country income disparities varies across benchmark economies and can be as high as 2/5th of the induced variation from the network. The rest stems from the relative intensities of use of capital. We can also ask how different income levels would be if all countries operated some benchmark technology. For example, we explore the use of a technology consistent with the investment network of Korea in 1965, before the country entered a period of sustained economic growth. We show that poorer economies benefit relatively more from producing with this investment network, given their current input–output structures, sectorial productivities, and patterns of final expenditure shares. In contrast, richer economies are negatively affected by employing this technology.

Finally, since most of the capital in the world is produced by a handful of countries, it is likely that much of the investment used in an economy is imported from elsewhere. The imported nature of capital is potentially relevant to our accounting because the magnitude of the roundabout effect is sensitive to how much capital is locally produced and because countries may buy productive capital by generating exports. Our theory accommodates these channels by modeling investment goods as a combination of locally and foreign-sourced investment and by explicitly modeling exports of final goods as a source to finance investment imports. We run counterfactual exercises where we construct the loadings of the investment network including only the domestically produced share of investment and shut down the productivity amplification through the production of tradable goods. We find that the counterfactual economy induces a 44% decline in steady-state income per capita on average across countries and that the variance of income falls by 12% relative to baseline. In other words, trade accounts for slightly more than one-third of the variance in income accounted for by the investment network.

Contribution to the literature. There is a growing literature studying the relevance of sectorial linkages, mostly through intermediate input use, for differences in income per capita across countries; see Ciccone (2002); Jones (2011). This role is quantified in Fadinger, Ghiglino and Teteryatnikova (2022), who show that differences in the input–output structure amplify the role of sectorial productivity for differences in income per capita. We document that the input–output and investment networks are empirically different, leading to differential roles in driving income disparities across countries. The investment network, which summarizes the technology for producing new capital in the economy, can double the effect of measured disparities in capital on income disparities. This finding brings renewed attention to the ability to produce or source capital as a driver of income disparities.

Garcia-Santana *et al.*, 2021; Herrendorf *et al.*, 2021 document systematic shifts in the inputs used for investment as economies develop. In the US time series, Gaggl, Gorry and vom Lehn (2023) document disparate shifts in the composition of inputs for investment and consumption, while Caunedo and Keller (2023) show how differences in the investment bundles used by different sectors drive sectorial reallocation. Our paper completes the puzzle by documenting disparities in the investment bundle and the composition of investment along the development spectrum. The study of the role of the investment network in determining GDP is relatively recent. In the US, vom Lehn and Winberry (2022) focus on short-run fluctuations, while Foerster, Hornstein, Sarte and Watson (2022) study implications for long term growth. Our main contribution relative to Foerster *et al.* (2022) is that we model the endogenous allocation of labor, our network changes endogenously with shifts in sectorial relative prices and allow for equipment imports. Trade is an important driver of the level of output in steady state and the magnitude of *sectorial influence*.

A key novel finding of our theory is that sectorial investment rates mediate the impact of sectorial productivity on aggregate GDP and affect the rate of convergence of the economy to its BGP. As in Liu (2019), output elasticities to sectorial productivity are different from Domar weights. In our model, this difference arises from the presence of investment, i.e., sectorial value-added shares and consumption shares do not equalize. Indeed, because our economy is efficient, welfare is a Domar-aggregated measure of sectorial productivities. These Domar weights are a function of equilibrium investment rates, a channel that is absent in economies where inputs are nondurable, as in Acemoglu *et al.* (2012) and the extensive literature that follows. Buera and Trachter (2024) is the closest paper to our study, characterizing differential GDP responses to sectorial productivity. Their work emphasizes the role of distortions and nonconvexities for endogenous technology choices. Our paper instead emphasizes the intensive margin of the adoption of capital-embodied technology, i.e., investment, and documents systematic disparities in its nature along the development spectrum.

The remainder of the paper is organized as follows: Section 2 presents the model, Section 3 discusses the methodology to construct estimates of the investment networks and novel empirical regularities of the investment network; Section 4 presents the main result from income accounting exercises while Section 5 documents patterns of *sectorial influence* along the development spectrum. Section 6 concludes the paper.

2 A Model of the Investment Network and Economic Development

We describe an open economy version of Long and Plosser (1983) augmented to include a CES sectorial investment aggregator.

The economy consists of N sectors that combine capital, labor and intermediate inputs to produce output:

$$y_{nt} = \left(\frac{v_{nt}}{\gamma_n}\right)^{\gamma_n} \left(\frac{m_{nt}}{1-\gamma_n}\right)^{1-\gamma_n}, \qquad \text{for } \gamma_n \in [0,1],$$

with a measure of value added $v_{nt} = \exp(z_{nt}) \left(\frac{k_{nt}}{\alpha_n}\right)^{\alpha_n} \left(\frac{l_{nt}}{1-\alpha_n}\right)^{1-\alpha_n}$ that depends on TFP, z_{nt} and capital and labor allocations, k_{nt}, l_{nt}. The intermediate input aggregator is constant returns to scale (CRS) , $m_{nt} = \prod_{i=1}^{N} \left(\frac{m_{int}}{\mu_{in}}\right)^{\mu_{in}}$, and intermediate inputs from sector i used in sector n are m_{int}. This flow of intermediate inputs is summarized by an input–output matrix, M_t, with typical element μ_{in}. The rows of M_t sum to an indicator of the importance of a sector as an intermediate inputs provider to the rest of the economy, the columns describe the input composition of the intermediate input bundle in a sector, and $\sum_i \mu_{in} = 1$.

The capital stock used in each sector evolves according to the following law of motion:

$$k_{nt+1} = x_{nt} + (1-\delta_n)k_{nt},$$

for a composite of investment from different sectors.

There is a continuum of firms that produce sector-specific investment goods with a constant return aggregator of investment produced by different sectors. Firms maximize profits by choosing the amount of investment:

$$\max_{\omega_{int}, \chi_{int}} p^x_{nt} x_{nt} - \sum_i p_{it} \chi_{int}$$

subject to

$$x_{nt} = A^x_{nt} \left(\sum_{i=1}^{N} \omega_{in}^{\frac{1}{\iota_n}} \chi_{int}^{\frac{\iota_n - 1}{\iota_n}} \right)^{\frac{\iota_n}{\iota_n - 1}} \tag{1}$$

where ω_{in} is the loading for a investment from sector i in the production of capital for sector n; ι_n is the elasticity of substitution across different investment types; and A^x_{nt} measures investment-specific technological change in the production of investment for sector n.[3] The flow of investment across sectors is summarized by the investment network, Ω_t, with typical element $\frac{p_{int}\chi_{int}}{p^x_n x_{nt}}$. When the elasticity of substitution across investment goods is unitary, $\iota_n = 1$, the typical element is ω_{int}, but in general, entries in the investment network will change with shifts in relative prices. The rows of the investment network describe the production of investment in each sector, while the columns represent the use of investment by each sector. Since the technology is CRS, the column sum is unitary, $\sum_{i=1}^{N} \frac{p_{int}\chi_{int}}{p^x_n x_{nt}} = 1$. Finally, inputs from sector i into the production of investment in other sectors, χ_{it}, can be domestically produced or imported, $\chi_{int} = (\frac{\chi^d_{int}}{1-\phi_i})^{1-\phi_i}(\frac{\chi^f_{int}}{\phi_i})^{\phi_i}$, where ϕ_i is the expenditure share in foreign inputs for capital type i.

Each sector's output can be used for final goods production, c, intermediate uses, m, or domestic investment, χ^d:

$$y_{nt} = c_{nt} + \sum_i m_{nit} + \sum_i \chi^d_{nit}.$$

Sectorial output allocated to the production of final goods is combined with a homothetic aggregator, Y_t, and can be used for exports, ϵ, or for consumption by the representative household:

$$Y_t = \prod_{n=1}^{N} \left(\frac{c_{nt}}{\theta_n} \right)^{\theta_n}, \qquad \sum_{n=1}^{N} \theta_n = 1 \text{ and } \quad \theta_n > 0;$$

$$Y_t = C_t + \epsilon_t.$$[4]

The representative household derives utility $U(C_t)$ that satisfies usual regularity conditions and discounts the future at rate β.

We set up a small open economy that exports final goods in exchange for capital goods of different types, as in Jones (2011). We define the value of net exports in the economy as the difference in the value of exports and imports:

$$NX_t = p_{Yt}\epsilon_t - p_{\epsilon^f t}\epsilon^f_t.$$

[3]Sectorial ISTC is equivalent to an expenditure share weighted average of ISTC in the sectors that produce investment goods, A^X_{it}, and that are used for production of x_n. In such a case, the feasibility condition of the sector reads $y_{it} = \frac{1}{A^X_{it}}\chi_{it} + c_{it}$.

[4]Our findings are robust to having two different aggregators for exports and consumption. When the price of consumption is defined in units of exports, the results carry through. Alternatively, the amount of exports could be formulated as a constant fraction of final uses, Y_t.

The value of imports is the product of the price index of imports and a composite import value $\epsilon_t^f = \prod_{i=1}^N \frac{\chi_{it}^f}{\phi_i^f}^{\phi_i^f}$, as in Basu, Fernald, Fisher and Kimball (2005).[5] The terms of trade are given by the ratio between the price of exports and the price of imports $\tau \equiv \frac{p_{Yt}}{p_{\epsilon^f t}}$, where the price of imported goods is a CRS aggregator of the (exogenous) prices of imported investment for production.

2.1 Aggregate Growth Path

Definition *An aggregate growth path (AGP) is an allocation such that aggregate output, consumption, and wages each grows at a constant (possibly different) rate, and where the interest rate is constant.*

This equilibrium then poses no-restrictions on the sectorial allocation of resources, including capital and investment. As in Herrendorf *et al.* (2021), it is useful to first define investment in each sector as a function of effective productivity, and likewise for aggregate value added in the economy. Since the rental rates of capital are not equalized across sectors in our economy, it is useful to define adjusted sectorial productivity as $\tilde{A_{nt}} = \frac{A_{nt}}{R_{nt}}$. Since the rental rates are determined in equilibrium, adjusted productivity is endogenous.

Lemma 1. *Investment in each sector is*

$$x_{nt} = \mathcal{A}_{nt}^x \sum_i \frac{x_{int}}{\tilde{A}_{it}}$$

where effective productivity $\mathcal{A}_{nt}^x \equiv A_{nt}^x \left(\sum_i \omega_i \tilde{A}_{it}^{\iota_n - 1}\right)^{\frac{1}{\iota_n - 1}}$.

Therefore, investment in the sector is a function of the value of investment per unit of adjusted sectorial productivity and scales with effective productivity in the sector. The latter is a combination between investment specific technological change, and adjusted sectorial productivities.

The Euler equation for capital in the numeraire sector is

$$\beta^{-1} \frac{P_{ct+1} C_{t+1}}{P_{ct} C_t} \equiv R = R_{1t+1} + (1 - \delta_1)$$

and therefore, along the AGP, the rental rate of capital of the numeraire sector is constant and equal to $R_{1t} = P_1 \alpha A_{1t} \left(\frac{K_1}{N_1}\right)^{\alpha - 1}$

Lemma 2. *Aggregate value added in the economy follows*

$$v_t = \mathcal{A}_{1t}^x \left(\mathcal{K}_t\right)^{\alpha}$$

[5] Any unitary elasticity aggregator preserves the AGP properties discussed in the Appendix.

for an aggregate value of capital per worker ($\mathcal{K}_t$) *that satisfies,* $\frac{\frac{K_{1t}}{N_{1t}}}{\mathcal{K}_t} = \frac{1}{R_{1t}}$ *in units of the numeraire sector.*

Notice that effective productivity in the numeraire sector is constant by construction, and so is the equilibrium rental rate in that sector. In economy that displays aggregation, the capital-labor ratio of the sector equals the aggregate and when labor is in fixed supply, it suffices that (aggregate) capital grows at a constant rate for the growth rate of output to be constant. When capital-labor are not equalized, as it is the case in our economy, sectorial employment reallocation that is consistent with structural change prevents the growth rate of output to be constant. In other words, a constant growth path only exists in the limit, as in Acemoglu and Guerrieri (2008).

Proposition 1. *There exists an assymptotic AGP where aggregate GDP, wages and sectorial capital grows at a constant (possibly different) rate. Along the AGP, the growth rate of effective productivity in the investment sectors is constant, and the growth rate of capital equals that of investment. Sectorial output grows proportional to sectorial capital,*

$$g_{y_{it}} = g_{A_{it}} + \alpha g_{\mathcal{A}_i^x}.$$

and aggregate value added grows with capital in the numeraire sector,

$$g^{\nu} = \frac{1}{1-\alpha} g_{\mathcal{A}_1^x}$$

The proof of this proposition can be found in Appendix A.1. We use this result to detrend the economy and characterize equilibrium allocations.

2.2 Equilibrium Characterization, Detrended Economy

Domar weights. Let the Domar weight of sector n be $\eta_n \equiv \frac{p_n y_n}{p\nu}$, the share of value added allocated to the production of final goods be $\zeta_n \equiv \frac{p_n c_n}{p\nu}$ and the value-added share of each sector be $\tilde{\zeta}_n \equiv \zeta_n + \frac{p_n \chi_n^d}{p\nu}$. We also define adjusted sectorial depreciation rate in the detrended economy $\hat{\delta}_i \equiv 1 - \frac{1-\delta}{1+g_i^k}$, the (diagonal) matrixes of adjusted depreciation $\hat{\delta} = \text{diag}\{\hat{\delta}_i\}$, value-added shares $\Gamma_t = \text{diag}\{\gamma_n\}$, sectorial capital expenditure shares in value added, $\alpha = \text{diag}\{\alpha_n\}$, imported capital expenditure shares, $\phi = \text{diag}\{\phi_n\}$ and the discount factor $\tilde{\beta} = \text{diag}\{\hat{\beta}_i\}$ for $\tilde{\beta}_i \equiv \frac{1}{\beta} - (1 - \hat{\delta}_i)$. In what follows, I corresponds to the identity matrix.

Proposition 2. *The equilibrium Domar weights satisfy*

$$\left[I - \tilde{\beta}^{-1}\hat{\delta}\Gamma\boldsymbol{\alpha}(I - \boldsymbol{\phi})\Omega - (I - \Gamma)M\right]^{-1}\boldsymbol{\zeta} \equiv \boldsymbol{\eta} \tag{2}$$

In vector form,

$$\eta_n = \zeta_n + \sum_{i=1}^{N} \frac{\hat{\delta}_i}{\tilde{\beta}_i}\alpha_i\gamma_i\omega_{ni}(1 - \phi_i)\eta_i + \sum_{i=1}^{N}(1 - \gamma_i)\mu_{ni}\eta_i.$$

Along the transition to the steady state, Domar weights are functions of their full equilibrium path:

$$\left[I - \tilde{\beta}_{t+1}^{-1}\frac{x_{t+1}}{k_{t+1}}\Gamma\boldsymbol{\alpha}(I - \boldsymbol{\phi})\Omega\frac{g_{\eta_{t+1}}}{g_{x_{t+1}}} - (I - \Gamma)M\right]^{-1}\boldsymbol{\zeta}_t \equiv \boldsymbol{\eta}_t,$$

with elements of the discount factor $\tilde{\beta}_{it+1} \equiv \frac{1}{R_t} - (1 - \hat{\delta}_{it})\frac{p^x_{it+1}}{p^x_{it}}$.

Proofs to all propositions can be found in Appendix A.2.

Note that the role of the investment network for the Domar weight scales with the importance of domestic investment across sectors, $(1 - \phi_n) \in (0, 1)$. The lower the importance of domestic investment, the less relevant the investment network is for the roundabout effects on equilibrium Domar weights.[6] In our economy, equilibrium Domar weights are nontrivial functions of the investment rates along the AGP. In equilibrium, Domar weights are functions of the entire path of future Domar weights.

Welfare. We start by describing how aggregate welfare, W, in the economy depends on the investment network.

Proposition 3. *Along the equilibrium path, welfare satisfies*

$$W = \frac{\nu}{C}\boldsymbol{\eta}\Gamma\boldsymbol{z},$$

where $\boldsymbol{\eta}$ *are the equilibrium Domar weights.*[7]

The proof of this result follows from the envelope theorem and is analogous to the extensive literature on production networks studying the implications of roundabout effects on the aggregate economy. Value-added shares scale productivity levels because of productivity is scaled by the value added share when defining the technology for sectorial production. Proposition 3 is consistent with results in vom Lehn and Winberry (2022) for short-run fluctuations: Domar weights are scaled by the ratio between GDP and final consumption. Along the AGP,

[6] This is driven by our modeling of exports from a composite of final uses. If all equipment is tradable, then roundabout effects from the investment network will appear directly in GDP through trade amplification; see Φ in Proposition 4. If instead we model each sector's allocation of gross output to exports, these flows appear in the equilibrium representation of the Domar weight.

[7] The term Γ rescales the productivity vector TFP in the production technology is scaled by value-added share of gross output.

this ratio is a constant. In the transition, the welfare effect of sectorial productivity shocks can be amplified or dampened depending on the relative allocation of value added between consumption and investment uses.

Aggregate value added

Proposition 4. *The equilibrium level of GDP in the economy satisfies*

$$\ln(\nu) = \Phi\tilde{\boldsymbol{\eta}}'\Gamma(\boldsymbol{z} + \alpha\boldsymbol{\phi}\Omega'\tau) + \boldsymbol{\epsilon},$$

where $\Phi\tilde{\boldsymbol{\eta}}\Gamma$ is the vector of sectorial influence; $\Phi \equiv (I - \tilde{\boldsymbol{\eta}}\Gamma\alpha\boldsymbol{\phi}'\boldsymbol{\Omega}')^{-1}$ is an adjustment factor for the tradable nature of investment; and $\boldsymbol{\epsilon}$ is an adjustment factor that depends on the equilibrium Domar weights.[8] *Sectorial influence is the product of sectorial value-added shares, $\tilde{\boldsymbol{\zeta}}'$, and an adjusted Leontief inverse $\Xi \equiv (I - \tilde{\beta}^{-1}\Gamma\alpha(I-\phi)\Omega - (I-\Gamma)M)^{-1}$, i.e., $\tilde{\boldsymbol{\eta}} \equiv \tilde{\boldsymbol{\zeta}}'\Xi$.*

In vector form, GDP can be described as

$$\begin{aligned}\ln(\nu)(1 - \sum_n \tilde{\eta}_n\gamma_n\alpha_n \sum_i \omega_{in}\phi_i) \quad &= \quad \sum_n \tilde{\eta}_n\gamma_n z_n + \sum_n \tilde{\eta}_n\gamma_n\alpha_n \sum_i \omega_{in}\phi_i \ln(\tau) - \\ &\quad \ln(\sum_n \gamma_n(1-\alpha_n)\eta_n) \sum_n \tilde{\eta}_n\gamma_n(1-\alpha_n).\end{aligned}$$

Value added is therefore a function of sectorial productivities, $\boldsymbol{z}$, the terms of trade, $\boldsymbol{\tau}$, and a constant, $\boldsymbol{\epsilon}$. The first term showcases the impact of productivity on value added and the vector of sectorial influence $\Phi\tilde{\boldsymbol{\eta}}\Gamma$, similarly to Acemoglu *et al.* (2012).[9] This effect includes the impact of trade in investment, $\Phi \equiv (I - \tilde{\boldsymbol{\eta}}\Gamma\alpha\boldsymbol{\phi}'\boldsymbol{\Omega}')^{-1}$, as in Jones (2013). The reason is that when productivity increases within the economy, its export capacity also increases, and due to the trade balance, this implies higher imports of investment. The greater the dependence on imported equipment, ϕ, and the intensity of capital use in gross output, $\Gamma\alpha$, are, the stronger this amplification channel. The terms of trade enter as a channel directly affecting value added in the economy. Once adjusted for the role of imported investment, the capital share and the investment network, the terms of trade affect the economy similarly to a TFP shock. Note that as $\phi \to 0$, the economy loses its dependence on tradable investment, and Propositions 2 and 4 reduce to their closed-economy counterparts, which we describe in the Online Appendix.

[8] The term $\boldsymbol{\epsilon} \equiv -\Phi\tilde{\boldsymbol{\eta}}'\Gamma(1-\alpha)\ln(\Gamma(1-\alpha)\boldsymbol{\eta})$ maps onto the equilibrium distribution of employment and is quantitatively small, so for most of the analysis, it can be omitted.

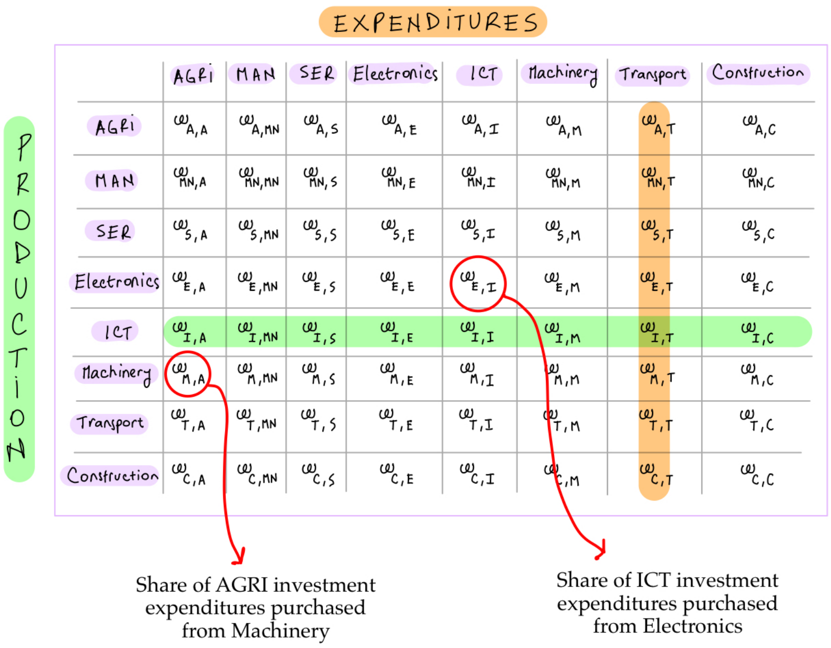
[9] Value-added shares also mediate this effect because productivity enters into the value added expression. If modeled through gross output, the factor Γ drops out.

3 Investment Network

We now set out the data and methods used to construct cross-country and time-series measures of the investment network. We begin by explaining the methodology to construct the networks, then describe the data sources, and finally characterize the main properties of the investment network across stages of development. Throughout, sectors are grouped into ten categories: five equipment types—information and communication technology (ICT), electronics, machinery, transportation equipment, and other durables—plus construction, agriculture, nondurables, transportation services, and other services (Appendix Table 5).[10] We use ten sectors because this classification can be matched across all datasets and years, ensuring comparability across countries and over time. Where more detailed data are available, the same method can be applied at a finer level.

3.1 Methodology

Figure 1: Example: Allocation of ICT Investment Flows



Notes: Illustrative example of the investment network. Columns indicate consuming sectors, while rows indicate production sectors. Entries are expenditure shares by consuming sectors in different investment types, ω.

Figure 1 presents an example investment-network table. Each entry (i, j) reports the total investment expenditures by column sector j purchased from row sector i. Summing across

[10] Computers are classified under electronics; software is included in ICT equipment. For years before 2000 and for countries in Sub-Saharan Africa, ICT investment includes professional services; to maintain comparability over time and across countries, we keep those services within ICT for all countries and years (Table 5). We exclude the Mining sector to avoid variation in value added driven by commodity endowments in our accounting exercise (Section 5.1).

columns yields the total production of investment by each row sector, while summing across rows yields the total investment expenditures of each column sector. For example, each element of the ICT row shows how much investment goods ICT supplies to each purchasing sector j, whereas each element of the agriculture column shows how much investment goods agriculture purchases from each supplying sector i. To express the investment network in terms of expenditure shares ω_{ij}, divide each entry in column sector j by that column's total investment expenditures. Then column shares sum to one: $\sum_i \omega_{ij} = 1$.

Estimates of investment produced by each sector—i.e., the sum of the rows in Table **??**—are readily available from *use tables*, which record how sectoral output is allocated between intermediate and final uses, including consumption and investment. Our contribution is to estimate how much of the investment produced (or imported and allocated to investment) by each sector is purchased by other sectors of the economy.

For the United States, investment-flow tables that record the dollar flows of investment goods from producing to purchasing sectors are widely available. Meade *et al.* (2003) describes the Bureau of Economic Analysis's procedure for imputing flows across sector uses, which proceeds in three stages:

1. direct assignment;
2. proportional to the sector's occupational composition;
3. proportional to sectorial capital expenditures (used only for structures).

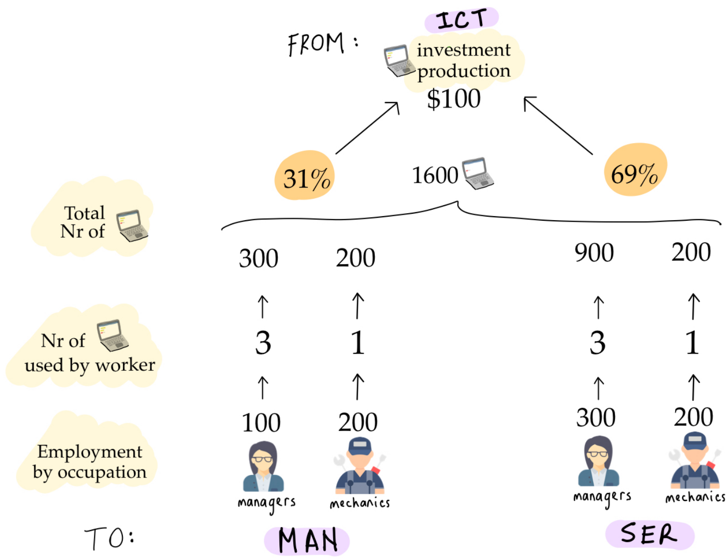
Direct assignment places all investment in a given category to its most likely use (e.g., nuclear plant investment to the utilities sector). The second method assumes that some occupations are informative about the type of capital used in a sector. For structures, the BEA assigns investment in proportion to sectoral capital expenditures.

Our approach follows the BEA's procedure where it is replicable and where information is available across countries and over time. To prioritize replicability, we avoid manual assignment of categories to user sectors (method 1), because it requires fine-grained investment data that are not consistently available. Relying on such detail would lead to different assignment rules across countries with different levels of disaggregation. We therefore use method (2) as our benchmark and adopt a variant of method (3) when (2) is not feasible. Since sectoral capital expenditures are not available in our cross-country data (the BEA imputes them using firm-level Census microdata), we instead assign expenditures in proportion to each sector's demand for intermediate inputs. We next describe these procedures in detail.

3.1.1 Allocation of equipment investment flows

Equipment-producing sectors include electronics, ICT, machinery, and transportation equipment. We allocate their investment flows following the BEA's methodology for the U.S. investment network. This approach uses the occupational composition of each purchasing sector and the types of capital those occupations are likely to use.[11]

Figure 2: Example: Allocation of ICT Investment Flows



Notes: Illustrative example of the allocation of investment flows across purchasing sectors obtained by exploiting the sectorial occupational composition and the equipment intensity across occupations from Caunedo *et al.* (2023).

Figure 2 illustrates how ICT equipment investment is allocated across purchasing sectors under our method. Suppose there are three sectors—ICT, manufacturing, and services—and the ICT sector produces $100 of new capital goods (computers). Our goal is to determine how much of this $100 is purchased by manufacturing and by services. We use the occupational mix of the purchasing sectors and the relative intensity with which those occupations use computers. In the example, manufacturing and services each employ 200 mechanics; manufacturing also employs 100 managers and services 300 managers. Relative to mechanics (normalized to one computer per worker), each manager uses three times as many computers. These relative-use weights come from the tool–occupation allocation in Caunedo *et al.* (2023) (details below). It then follows that the manufacturing sector demands 500 computers, with 300 used by managers and 200 by mechanics. The total demand for computers in the services sector is 1100, with 900 used by managers and 200 by mechanics. Thus, of the 1600 computers used in the economy, 31% are used in the manufacturing sector and 69% in the services sector. Accord-

[11] The BEA's allocation follows its public documentation; however, details of the exact assignment to occupations and sectors are not available. In Section 3.3, we validate our methodology by comparing our estimates with those of the BEA.

ingly, of the $100 worth of computers produced by the ICT sector, we assign 31% as purchased by the manufacturing sector and 69% as purchased by the services sector.

For simplicity, in the example there is a one-to-one mapping between equipment types (computers) and sectors (ICT). However, that mapping is not one-to-one in the data. In other words, a sector may produce multiple equipment types, and an equipment type may be produced by different sectors. This information is encoded in "bridge tables" that underlie national accounts. For example, using an average bridge table between 2000 and 2018 in the U.S., one can see that 78% of investment in computers is produced by the electronics sector, while 22% is produced by the ICT sector. Conversely, 28% of the output produced by the electronics sector is computer production, 34% is communication equipment, and the rest belongs to other equipment categories.

Our methodology then consists of mapping: (i) investment-producing sectors to equipment types using bridge tables, (ii) investment-purchasing sectors to equipment types using the occupation distribution and tools used on the job, and (iii) investment-producing sectors to investment-purchasing sectors (the investment network).

From investment-producing sectors to equipment types. To the best of our knowledge, bridge tables are not available across countries. Hence, we use the average allocation of sectoral production to equipment types from the U.S. bridge tables from 2000 to 2018.[12] To obtain the dollar value of investment in equipment type e produced by sector i in country c at year t, we multiply the share of investment in sector i that is allocated to the production of equipment type e in the U.S., b_{ie}^{US} (from bridge tables), by the dollar value of investment produced (or imported and allocated to investment) by sector i in country c at year t, x_{it}^{c} (from *Use tables*):[13]

$$x_{iet}^{c} = x_{it}^{c}\, b_{ie}^{\text{US}}. \tag{3}$$

From investment-purchasing sectors to equipment types. Our assignment follows the tools used in each occupation in the U.S., as described by O*NET. We implement the methodology introduced by Caunedo *et al.* (2023) to assign equipment investment (and therefore stocks) to workers in different occupations.[14] Following the example in Figure 2, the underlying identification assumption is that the number of computers used by a manager relative to that used

[12] The total production of a sector allocated to equipment types does not include replacement of used goods or trade margins. Hence, when we impute investment flows from a sector to equipment in other countries (which may include these margins), we are effectively distributing these margins equally across equipment types.

[13] Our results are robust to using a sector–equipment crosswalk that assigns each sector's total flow to its most common use. These results are available upon request.

[14] The methodology in Caunedo *et al.* (2023) crosswalks equipment categories to the tools used within each SOC occupation. We use Dingel and Neiman (2020)'s crosswalk between SOC and ISCO to map these tools to harmonized cross-country occupational definitions.

by a mechanic is the same across countries and equal to the U.S. value.[15] The amount of investment assigned to each purchasing sector still differs across countries because production of investment in ICT differs across countries and because the numbers of mechanics and managers working in manufacturing and services differ across countries, i.e., the occupational composition of the industry varies with development.

First, we compute the share of total production of equipment type e purchased by industry j in country c at time t, γ^c_{ejt}, as

$$\gamma^c_{ejt} = \frac{\sum_o \tau_e^{o,\mathrm{US}}\, n^c_{jot}}{\sum_j \sum_o \tau_e^{o,\mathrm{US}}\, n^c_{jot}}, \tag{4}$$

where n^c_{jot} is the number of workers in occupation o and industry j in country c at time t, and $\tau_e^{o,\mathrm{US}}$ is the number of tools of capital type e used by a worker in occupation o in the U.S. Because γ^c_{ejt} allocates a given equipment type across industries, the shares sum to one: $\sum_j \gamma^c_{ejt} = 1$.

Next, we estimate the dollar value of investment in equipment type e purchased by sector j in country c at year t, x^c_{ejt}, as the product of the value of investment in equipment type e produced by sector i in country c at year t, x^c_{iet} from equation 3, and the share of total production of equipyment type e purchased by industry j in country c at time t from equation 4:

$$x^c_{ejt} = x^c_{iet}\gamma^c_{ejt}. \tag{5}$$

From investment-producing sectors to investment-purchasing sectors. Finally, for each purchasing sector j, we sum across investment flows from all equipment types that are produced by sector i from equation 5, to obtain the dollar value of investment that sector j purchases from sector i:

$$x^c_{ijt} = \sum_{e \in \mathcal{E}_i} x^c_{ejt}, \quad \text{for } i \in \text{equipment sectors} \tag{6}$$

with $\mathcal{E}_i$ the set of equipment types that are produced by sector i. The investment expenditure shares ω^c_{ijt} that make up the investment network are defined as:

$$\omega^c_{ijt} = \frac{x^c_{ijt}}{\sum_i x^c_{ijt}} \tag{7}$$

[15] This identification restriction can be relaxed by projecting tool usage in each occupation to the tasks performed on the job. Then, cross-country variation in tasks for the same occupation, such as that documented in Caunedo, Keller and Shin (2021), can be used to predict tool usage for the same occupation across countries at different stages of development. The task projection is available in slightly more than half of our sample, mostly for middle- and high-income countries.

3.1.2 Allocation non-equipment sectors' investment flows.

There is no information on worker usage of capital goods produced by the construction (i.e., structures), agriculture, nondurables, transportation services, and other services sectors. Hence, we use each country's input–output structure and assign investment flows from these sectors in proportion to their role as intermediate-goods suppliers to other sectors.

Denote by $\tilde{\mu}^c_{ijt}$ the share of total intermediate inputs produced by sector i that are purchased by sector j. For the non-equipment sectors, we compute the dollar value of each entry in the investment table as

$$x^c_{ijt} = \tilde{\mu}^c_{ijt}\, x^c_{it}, \quad \text{for } i \text{ in non-equipment sectors.}$$

Finally, we compute the investment expenditure shares as in equation 7.

3.2 Data Description

Table 1: Investment Network: Data Sources

Data description	**Source**
Sector–equipment bridge	US Bridge Tables (BEA)
Number of tools per worker by occupation	Caunedo *et al.* (2023)
Investment production by sector	WIOD; OECD; Mensah and de Vries (2023)
Input–output structure	WIOD; OECD; Mensah and de Vries (2023)
Employment by occupation and sector	IPUMS; ILOSTAT; PIAAC

Notes: Data sources to construct investment networks. WIOD = World Input–Output Database; OECD = Organisation for Economic Co-operation and Development; BEA = U.S. Bureau of Economic Analysis; IPUMS = Integrated Public Use Microdata Series; ILOSTAT = ILO Statistics; PIAAC = Programme for the International Assessment of Adult Competencies. "Investment production by sector" and "Input–output structure" come from WIOD, OECD and national Supply–Use / IO tables (Mensah and de Vries (2023)). The sector–commodity bridge uses BEA bridge tables to map commodities to industries. "Tools per worker" by occupation is from Caunedo *et al.* (2023). Employment by occupation and sector combines household microdata (IPUMS), labor statistics (ILOSTAT), and skills microdata (PIAAC).

Based on the methodology described in the previous section, constructing the investment network requires five pieces of information: (i) sectorial production of investment goods, x^c_{it}; (ii) tools per worker by occupation, $\tau^{o,\mathrm{US}}_e$; (iii) employment by occupation and sector, n^c_{iot}; (iv) a bridge table mapping sector i to equipment type e, b^{US}_{ie}; and (v) the input–output structure, $\tilde{\mu}^c_{ijt}$. Table 1 summarizes the sources, and Appendix Table 4 provides a detailed description.

As explained in the methodology section, we use U.S. bridge tables (average 2000–2018) and estimate tool use by occupation in the U.S. following Caunedo *et al.* (2023), due to the lack of comparable data for other countries. We next describe the remaining data sources.

Investment production by sector and input–output tables. We obtain gross fixed capital formation (GFCF) by sector from the *use tables* that underlie the input–output accounts. The *use* *tables* report investment production by sector, whether produced domestically or imported. For our baseline investment network in each country, we use total investment production by sector (domestic plus imported).[16] We also construct a domestic investment network for each country based on domestic investment production by sector. For the nine Sub-Saharan African countries in our sample, we use data from Mensah and de Vries (2023). For the remaining countries, we use the World Input–Output Database (WIOD) and the OECD input–output tables.

Employment by occupation and sector. We use employment by occupation and sector from PIAAC, IPUMS International, and ILOSTAT. For countries with data from all three sources, we favor PIAAC over IPUMS International and ILOSTAT because PIAAC uses more detailed occupational categories.[17]

Country coverage. Our dataset covers 58 countries at different stages of development, with GDP per capita (PPP) ranging from \$428 to \$81599. For 20 of these countries, we construct time series of investment networks from 1965 to 2014; for the 9 countries in Sub-Saharan Africa, from 1990 to 2019. For the remaining 29 countries, the investment-network time series covers 2000–2014. See Table 4 in the Appendix for a full description.

3.3 Data Validation

3.3.1 Comparison with US Investment Networks

In this section, we compare our U.S. investment-network estimates to those constructed by vom Lehn and Winberry (2022) ("*VLW*"), which are based on the BEA capital-flows tables. We use 2012 as the primary reference year, as this is when data on employment by sector and occupation were collected by the PIAAC survey.[18] To control for potential disparities between BEA and WIOD in sectoral GFCF flows, we apply our methodology using the same sectoral investment-production estimates as in vom Lehn and Winberry (2022) (estimates are also robust to using WIOD investment flows). We then aggregate their 41-sector investment network to our 10 sectors, consistent with the ISIC Rev. 4 crosswalk in Table 5.

Appendix Table 6 compares estimates of (a) the sectorial outdegrees of the investment net-

[16]GFCF flows are reported in nominal currency; we deflate them using output PPP prices from the Penn World Table. To abstract from business-cycle fluctuations, we apply a Hodrick–Prescott (HP) filter to sectoral GFCF flows.

[17]PIAAC measures aggregated at the 1-digit level correlate strongly with IPUMS data; see Caunedo *et al.* (2021). In IPUMS International, the industry classification does not disaggregate equipment sectors within manufacturing; however, detailed industry classifications are available prior to their harmonization. For each country for which we use IPUMS, we manually construct crosswalks between the disaggregated (non-harmonized) industries and our 10 sectors. In PIAAC and ILOSTAT, sectors are classified according to ISIC Rev. 4 or ISIC Rev. 3, which we also crosswalk to our 10-sector scheme. All crosswalks can be found in the Online Appendix.

[18]The Online Appendix shows that the patterns observed in 2012 are largely consistent with those from 1972 and 1992. Since occupational composition has changed over time, it is surprising that the assignment works relatively well 20 and 40 years earlier.

work—a measure of each sector's relevance as an investment provider to other sectors—and (b) the homophily of the investment network—a measure of each sector's relevance as a provider of investment to itself. The *outdegree* is the row sum of the investment network, and *homophily* summarizes the diagonal elements of the matrix. Comparing the estimates in the second and third columns of Table 6, panels (a) and (b), we find that our methodology aligns closely with vom Lehn and Winberry (2022), especially considering that the only common inputs are sectorial investment flows.

For further comparison, we regress the elements of our investment-network estimates on those from VLW and report the mean squared error (MSE) as a measure of fit. The MSEs are 0.005 for 2012, 0.008 for 1992, and 0.017 for 1972, indicating relatively small differences between our estimates and theirs.

3.3.2 Comparison with Chile's Investment Networks

A potential concern with ours and the BEA estimates of the investment network is that the allocation of investment to its uses depends on the occupational composition of the sector demanding equipment, rather than on information on actual investment in each sector. This data is rarely available. Chile provides a rare opportunity because of the availability of data on the universe of firm-to-firm transactions through the VAT system. We use investment networks estimates from **?** based (on domestic) firm-to-firm transactions for comparison.

We compare our estimates with theirs through summary statics of the network, including outdeegres and homophily, see Table 7. We find that for all sectors, except for ICT and Services our estimate of domestic investment networks align very well with their estimates from firm-to-firm transactions. The difference for services is that their methodology overestimates the effects of wholesale trade which are intermediaries of imported good and therefore show up as "traded" component in our series but domestic in theirs. The differences for ICT arises from disparities in the capitalization of certain investments, in particular software.

3.4 The Investment Network in the Development Spectrum

We start by showing how the composition of sectors that are important provider of investment goods changes with development. Then, we show how the investment network diversifies with income, and how it differs substantially from the input-output network of intermediate inputs. Last, we compute each sector's influence based on the theory provided in Section 2.

3.4.1 Investment Network Outdegrees

We begin by documenting each sector's *outdegree*—the row sum of the investment network. In Table 2, we group countries by the World Bank income classification and report the average sectorial outdegree for each group.[19] Several patterns emerge. Construction is the dominant supplier of investment goods across the distribution and follows a hump-shaped relationship with development. Other services—including financial intermediation and real estate—are also major suppliers, but their importance declines with income. The sector with the strongest increase is ICT: high-income economies exhibit outdegrees nearly three times those of low-income economies. Transportation equipment also rises with income, though more moderately. Electronics and transport services display hump-shaped profiles, whereas durables and nondurables fall from low to middle income and then tick up slightly at high income. Finally, Agriculture is a minor supplier in all groups, and its importance diminishes sharply with development.

Table 2: Investment Network Outdegrees

Sector	**Low income**	**Middle income**	**High income**
Agriculture	0.45 (0.06 0.48)	0.22 (0.05 0.32)	0.13 (0.05 0.21)
Construction	3.18 (2.69 3.89)	3.39 (3.07 3.63)	2.98 (2.55 3.35)
Durables	0.90 (0.24 0.97)	0.39 (0.31 0.48)	0.49 (0.30 0.70)
Electronics	0.69 (0.20 0.96)	0.97 (0.64 1.13)	0.78 (0.57 0.95)
ICT	0.41 (0.01 0.90)	0.46 (0.28 0.58)	1.21 (0.84 1.38)
Machinery	1.42 (0.36 1.80)	1.31 (1.08 1.68)	1.29 (0.99 1.64)
Nondurables	0.32 (0.08 0.43)	0.16 (0.05 0.26)	0.18 (0.14 0.22)
Services	1.75 (1.26 2.38)	1.61 (1.28 1.76)	1.58 (1.16 1.95)
Transportation	0.72 (0.55 1.01)	1.08 (0.92 1.24)	1.20 (0.84 1.53)
TrptServices	0.14 (0.00 0.12)	0.41 (0.15 0.44)	0.16 (0.08 0.18)

Notes: Data for 2005, for low-, middle-, and high-income countries (World Bank classification). Outdegrees are sectoral row sums in the investment network. Entries report means; values in parentheses are the 25th and 75th percentiles. Average GDP per capita (PPP): low 2587; middle 11110; high 35056.

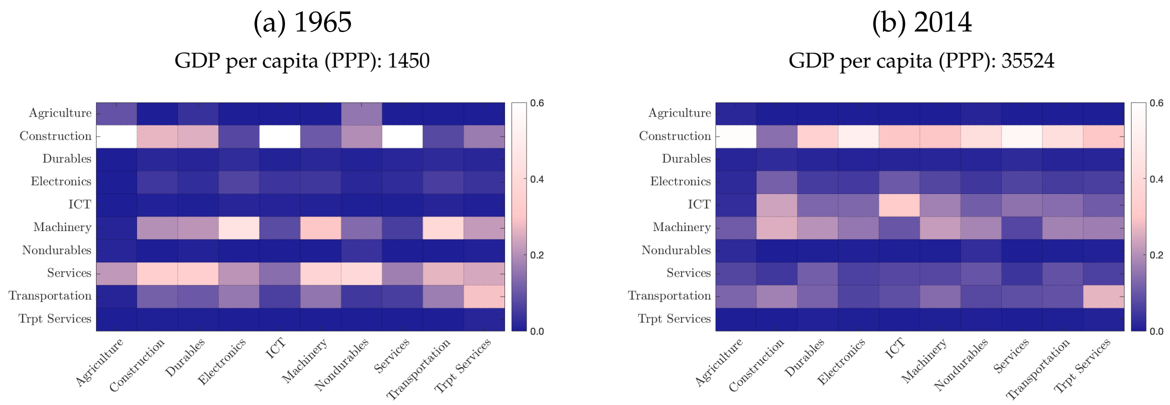
Similar patterns emerge when we examine South Korea's evolution over time—from 1965, when GDP per capita (PPP) was 1450 (comparable to our low-income group), to 2014, when income per capita increased 24-fold, placing Korea in the high-income group. Figure 3 depicts

[19] Country lists appear in Table 8. For cross-country comparisons we use 2005, the year with PPP deflators; results are similar with other reference years or when pooling all country–year observations.

the investment network in both years. Comparing panels (a) and (b), the same patterns as in Table 2 hold: construction is a prominent supplier of investment goods at all stages of development; agriculture is a minor supplier; the role of ICT rises with income; and the importance of other services declines with development.

The investment network of Korea also becomes more diversified as the country grows richer, in the sense that each sector sources investment goods from a broader set of capital types. In the next section, we show that this diversification is not specific to South Korea but also characterizes the cross-section of countries along the development spectrum.

Figure 3: South Korea: Investment Network Over Time



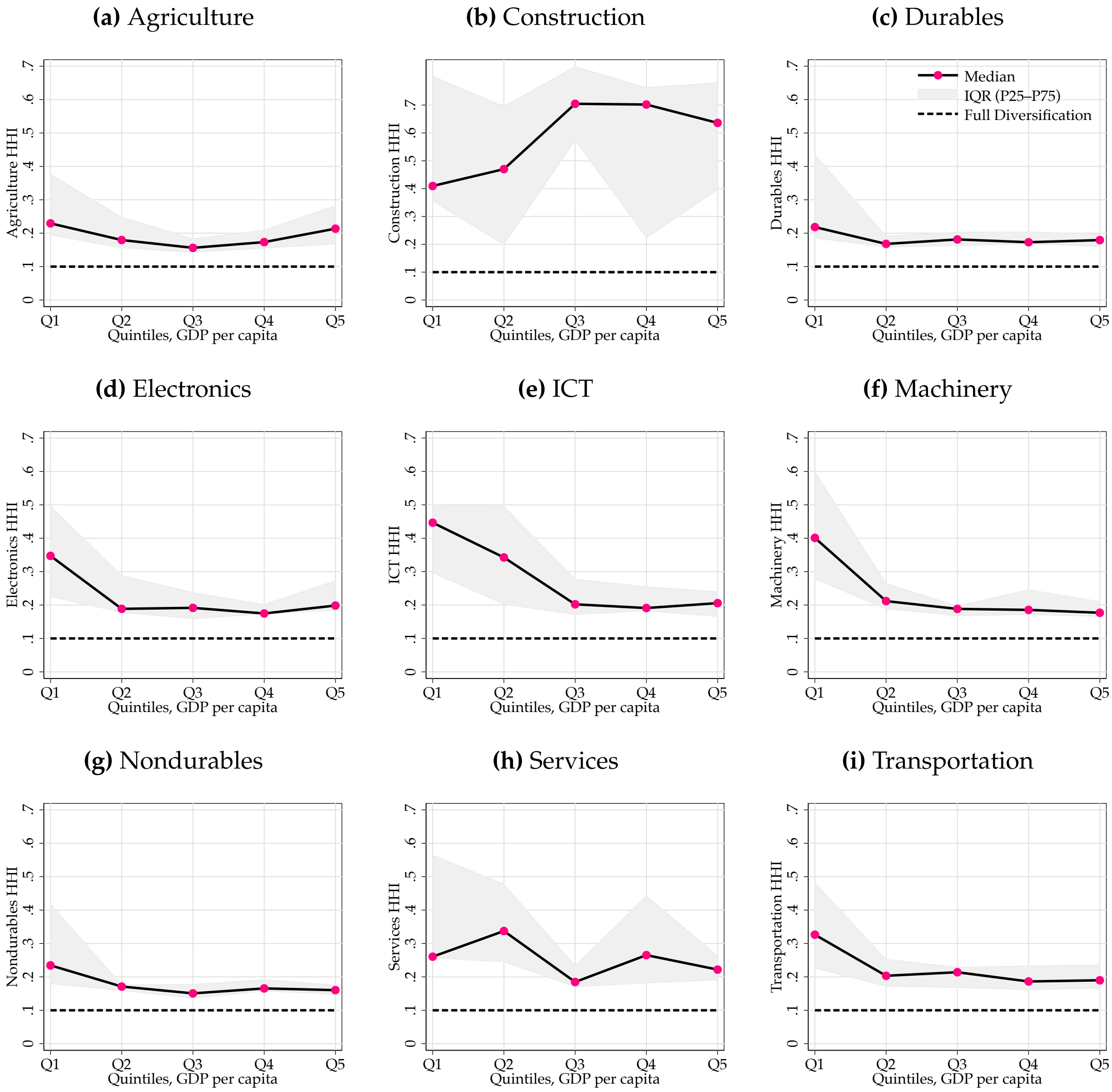
Notes: Estimates of South Korea's investment network over time. Each cell reports the investment-expenditure share of the *column* sector, as defined in Figure 1.

3.4.2 Investment Network Diversification

Figure 4 plots the Herfindahl–Hirschman Index (HHI) for each (column) sector that uses capital across quintiles of income per capita. Lower values indicate that a sector combines a more diversified bundle of capital types to produce. How does this structure change with development? For most sectors, the bundle of capital goods becomes more diversified as countries grow richer, moving closer to a fully diversified benchmark. The exception is construction, where concentration rises (about 56% from low to high income), largely because construction increasingly sources capital goods from its own sector. Diversification gains are most pronounced in capital-intensive activities—electronics, ICT, machinery, services, and transportation. In ICT, for instance, the HHI falls by roughly one-half (from about 0.45 in low-income to 0.19 in high-income countries), approaching the 0.10 value associated with full diversification.[20]

[20]Table 10 reports, for each sector, the mean and the 25th and 75th percentiles of the HHI for the low-, middle-, and high-income country groups.

Figure 4: Investment Network HHI



Notes: Data for 2005. The concentration index is the Herfindahl–Hirschman Index (HHI), computed as the sum of squared shares in each *column* of the investment network. Panels report medians and interquartile ranges of sectorial HHIs across quintiles of GDP per capita. The dashed line denotes the equal-split (full-diversification) benchmark, where investment is sourced equally from all capital types.

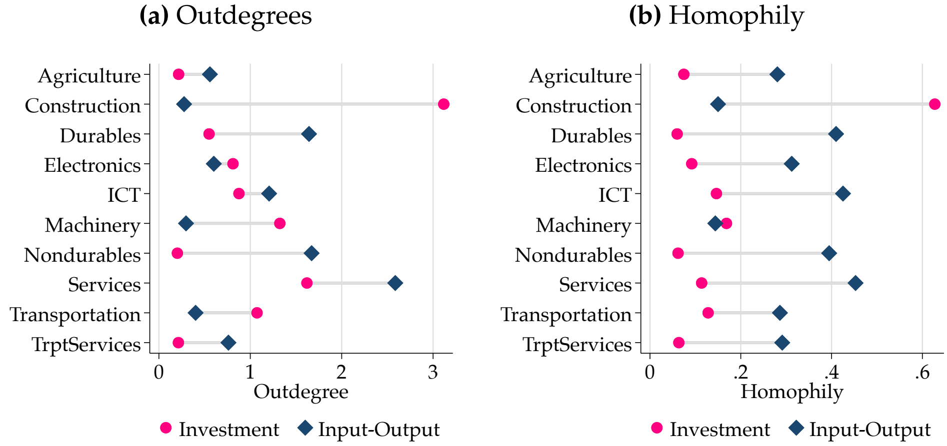
3.4.3 Investment Network vs. Input–Output Network

While the characteristics of the investment network were not known prior to this paper, there is considerably more evidence about the features of the input–output structure (see, for example, Fadinger *et al.* (2022)). Figure 5 documents differences between these two networks for the average country, as measured by (a) outdegrees, and (b) homophily. Moreover, we report these statistics in the Appendix for countries at different stages of development.[21]

Outdegrees. Several patterns stand out. Agriculture is a major supplier of intermediate

[21] Figure 9, reports the same statistics for low, middle, and high income country groups.

Figure 5: Investment Network vs. Input–Output Network



Notes: Data for 2005, averaged across countries. Circles denote the investment network; diamonds denote the input–output network. Panel (a) reports sectorial outdegrees (row sums); panel (b) reports sectorial homophily (diagonal elements of each network).

inputs—especially in low-income countries—but a minor provider of investment. Construction has the highest investment outdegree yet is among the least important intermediate suppliers; its investment outdegree falls slightly with income, while its input–output outdegree rises. ICT outdegrees increase with development in both networks, with a large gap in low-income countries that narrows at high income. Electronics and transport services are hump-shaped, and transportation is predominantly a supplier of investment goods. Other services (including transport services) and nondurable manufacturing mainly supply intermediates rather than investment.

Homophily. Comparing diagonal entries across the two matrices reveals a clear pattern: sectors heavily self-supply *intermediate* inputs (high input–output diagonals) but rely more on other sectors for *investment* goods (lower investment-network diagonals). Two exceptions stand out: construction, which contributes little to its own intermediates but is a major supplier of investment goods to itself, and machinery, which shows similar homophily in both networks. These patterns hold across the income distribution and within countries over time.[22]

4 Income Accounting

Differences in the investment network across countries over time or across income levels could prima facie reflect systematic disparities in production technologies. As a first step to highlight the implications of these newly uncovered patterns for income differences across countries, we

[22]Figure 11 compares Korea in 2014 and shows that diagonal loadings are systematically lower in the investment network than in the input–output network.

now combine the structural predictions of the model with our newly constructed measures of the investment network to conduct an income accounting exercise.

Recall from Proposition 4 that aggregate value added is

$$\text{GDP} \;=\; \boldsymbol{\eta}^{\text{GDP}}\, \boldsymbol{a}, \tag{8}$$

the inner product of sectoral influence and the vector of sectoral "productivity-like" shifters, $\boldsymbol{a} \equiv \boldsymbol{z} + \boldsymbol{\alpha}\,\boldsymbol{\phi}\,\boldsymbol{\Omega}^{\top}\boldsymbol{\tau}$, which depend on both sectoral TFP and terms of trade. As in the model economy, terms of trade operate like a sectoral TFP shock. Both objects can be inferred residually using the model's structural restrictions.[23]Then,

$$\boldsymbol{a} \;=\; \left(\mathbf{I} - \boldsymbol{\Gamma}\,\boldsymbol{\alpha}\,\boldsymbol{\phi}^{\top}\boldsymbol{\Omega}^{\top}\right)^{-1} \boldsymbol{\Xi}\,\boldsymbol{\Gamma}\,\ln(\boldsymbol{\nu}), \tag{9}$$

where $\ln(\boldsymbol{\nu})$ is the vector of logs of sectoral real value added. We use (9) to infer relative productivities across sectors and then pin down the level of productivity to match each country's observed income per capita. To ensure cross-country comparability, the accounting is conducted for 2005—the only year with PPP sectoral prices we use to convert nominal sectoral value added into real units in the WIOD sample. For countries not in WIOD, we use GDP PPP price deflators from the Penn World Table (PWT).

Equipped with estimates of sectoral influence and the implied sectoral productivities for each country, we address the following question: How important are cross-country differences in the investment network for observed disparities in income per capita?

Given the nonlinear effect of the investment network on GDP, we study two counterfactual scenarios: one that includes only the investment network and another that removes the investment network altogether (including its effect through trade amplification, Φ). Intuitively, we compute the change in the variance of income to the investment network at two different points. The role of the investment network for income disparities can then be assessed as the average across the two counterfactual orderings.

Table 3 presents the results. We normalize the *Baseline* scenario to the model-implied income from Equation 8, which matches observed income per capita by construction. When we include only investment links (second row), the model accounts for 37% of observed income disparities. This counterfactual isolates the contribution of the investment network, abstracting from roundabout effects through intermediate inputs. Some of this variation likely reflects

[23]These residuals could be further decomposed into TFP and terms-of-trade components; doing so would require constructing equipment-specific terms of trade.

cross-country differences in capital intensity. When we impose a common output elasticity of $\alpha = 1/3$ across countries (fifth row), the share explained by the investment network rises by 6 percentage points, suggesting that cross-country variation in output elasticities plays only a minor role. We then consider a counterfactual economy with no capital (i.e., $\alpha = 0$), so that roundabout effects arise solely from intermediate-input linkages. Consistent with Fadinger *et al.* (2022), intermediate inputs play a strong role, explaining 81% of the variance in income per capita. The residual implies that the investment network accounts for the remaining 19% of observed disparities. Averaging across the two counterfactuals, we conclude that the investment network accounts for 28% of observed income differences in our sample.

Table 3: Development Accounting

	Income variance	Contribution of Ω (%)
Baseline	1.00	—
Only investment network	0.37	37
Only intermediate-input network	0.82	18
$\alpha = 1/3$		
Only investment network	0.43	43
Other counterfactuals		
Only investment network + TFP_{US}	0.22	22
Investment network $\equiv$ VA shares	0.85	15
Domestic investment network	0.93	7

Baseline is normalized to 1 and refers to the income variance when GDP per capita is given by Equation (8), matching empirical observations.
Only investment network includes investment linkages and excludes intermediate-input linkages; i.e., $\boldsymbol{\eta}^{\text{GDP}}\boldsymbol{a} \equiv \Phi\,\tilde{\zeta}'\left(I - \tilde{\beta}^{-1}\Gamma\alpha(I-\phi)\Omega\right)\Gamma\,\boldsymbol{a}$.
Only intermediate-input links excludes investment linkages and retains only intermediate linkages; i.e., $\boldsymbol{\eta}^{\text{GDP}}\boldsymbol{a} \equiv \Phi\,\tilde{\zeta}'(I-(I-\Gamma)M)^{-1}\,\Gamma\,\boldsymbol{a}$.
Only investment network + TFP_{US} includes investment linkages and excludes intermediate-input linkages, and fixes sectorial productivity to US; i.e., $\boldsymbol{\eta}^{\text{GDP}}\boldsymbol{a} \equiv \Phi\,\tilde{\zeta}'\left(I - \tilde{\beta}^{-1}\Gamma\alpha(I-\phi)\Omega\right)\Gamma\,\boldsymbol{a}_{US}$.
Investment network $\equiv$ VA shares includes investment linkages and excludes intermediate-input linkages, and replaces columns of investment network with sectorial value added shares; i.e., $\boldsymbol{\eta}^{\text{GDP}}\boldsymbol{a} \equiv \Phi\,\tilde{\zeta}'\left(I - \tilde{\beta}^{-1}\Gamma\alpha(I-\phi)\Omega_{VA}\right)\Gamma\,\boldsymbol{a}$.
Domestic investment network includes only domestic investment linkages and excludes intermediate-input linkages; i.e., $\boldsymbol{\eta}^{\text{GDP}}\boldsymbol{a} \equiv \Phi\,\tilde{\zeta}'\left(I - \tilde{\beta}^{-1}\Gamma\alpha(I-\phi)\Omega_{DOM}\right)\Gamma\,\boldsymbol{a}$.

We benchmark the magnitude of this result against the role of measured disparities in capital–output ratios across countries using a standard income–accounting exercise (Jones, 2016); the Online Appendix provides full details. Following that methodology, we find that capital accounts for 13% of income disparities in our sample. Alternatively, comparing the observed variance of output per worker to that implied by measured inputs (Caselli, 2005), we find that measured capital disparities explain 7%; when we also include the covariance between productivity and measured inputs, as in Klenow and Rodríguez-Clare (1997), measured capital disparities explain 17%. We conclude that incorporating the investment network—i.e., the technology for producing capital—at least doubles the role of capital accumulation in accounting for income disparities.

4.1 Additional Exercises

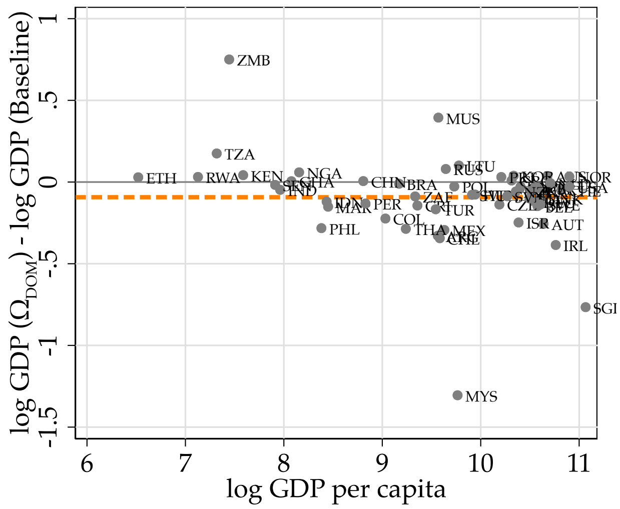
The role of sectoral productivity differences. We ask how much of the investment network's contribution to income differences operates through cross-country differences in sectoral productivity. To this end, we consider the counterfactual with only investment linkages and fix sectoral productivity to the U.S. level for all countries, thereby removing cross-country productivity differences (Table 3, seventh row). In this case, the network's contribution is 22%. Compared with the "only investment network" case (second row, 37%), this implies that roughly 40% of the investment network's contribution to income differences is due to cross-country differences in sectoral productivity.

The role of investment–network heterogeneity. We quantify how much of the investment network's contribution to income disparities arises from cross-country heterogeneity in the composition of investment bundles, as opposed to a common investment technology across sectors within a country. To assess this, we consider a counterfactual in which, within each country, all sectors use the same investment bundle: every column of the investment network is set equal to that country's sectoral value-added shares (Table 3, last row). In this homogeneous-network economy, the network explains 85% of income differences, leaving 15% attributable to heterogeneity. Relative to the network's overall contribution of 28%, this implies that about 54% of the investment network's role is due to cross-country heterogeneity in the investment network.

The role of trade. Given that capital goods—especially equipment—are produced in a small set of countries (Eaton and Kortum, 2001), a natural question is whether trade shapes the contribution of the investment network to cross-country income gaps. We would expect a role for trade if exposure to imported capital differs systematically across development levels and equipment types.

We quantify this channel by shutting down the trade amplification term, Φ, and recomputing the investment network using only *domestic* sectoral investment flows. Average GDP per capita declines by 9% in our sample (Figure 6). The decline is larger in high-income economies than in low-income economies, consistent with a 7% reduction in the cross-country variance of income (Table 3, last row). Hence, trade accounts for roughly one quarter of the investment network's contribution to income disparities. The relatively muted effect on variance—despite substantial gross imports of equipment—is partly explained by the wide dispersion of import shares across countries (Appendix Figure 12).

Figure 6: Counterfactual: Domestic Investment Network

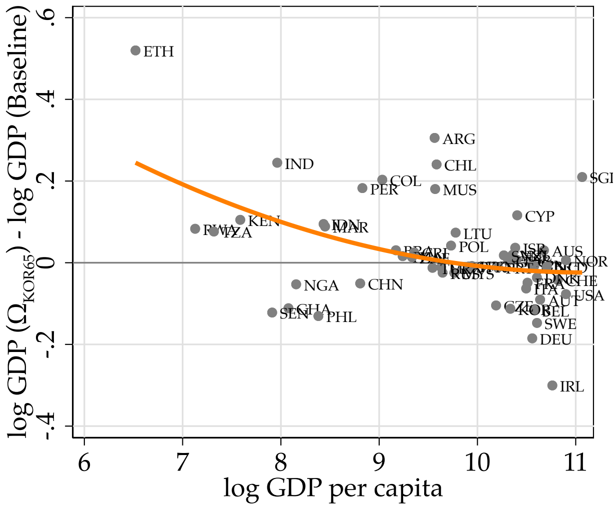


Notes: Income per capita computed using domestic investment network for each country, relative to the baseline.

Alternative investment networks. As noted above, investment networks can be interpreted as technologies for producing new capital goods. These technologies reflect endogenous production choices given endowments, comparative advantage, and (potential) distortions. One interpretation of the cross-country disparities in investment networks is that countries face different technology frontiers over which they choose how to produce investment.

We ask what happens if each economy adopts an investment technology resembling South Korea's at the outset of its growth episode in 1965, when income per capita was $1450 (PPP), more than thirty times below today's level. Thus, this counterfactual sets, for every country, a low technology frontier and a composition of investment bundles tilted toward construction, machinery, and services. Figure 7 reports the change in income per capita relative to baseline (positive values indicate gains; negative values indicate losses). Poorer countries tend to gain from producing with Korea's 1965 investment network, whereas most others experience losses.These patterns suggest that investment technologies shift systematically with development, potentially in a direction that is optimal. We leave to future work the analysis of countries' endogenous investment-technology choices and their relationship to development.

Figure 7: Counterfactual: South Korea's Investment Network in 1965



Notes: Income per capita under South Korea's 1965 investment network, measured relative to the baseline. Countries with outlier changes are omitted: Zambia is excluded (log GDP per capita 7.4; change of 154%).

5 Sectorial Influence

Thus far, we have characterized key features of the investment network across the development spectrum as well as the importance of these disparities for aggregate income per capita differences. But what is the differential role of sectors in determinining aggregate income levels? Our theory summarizes their role as sectorial influence, Proposition 4, which we repeat here for convenience:

$$\eta^{\text{GDP}} \equiv \underbrace{\Phi}_{\substack{\textbf{trade}\\ \textbf{amplification}}} \quad \underbrace{\tilde{\zeta}'}_{\textbf{exp share in VA}} \quad \underbrace{(I - \Gamma\alpha(I-\phi)\Omega - (I-\Gamma)M)^{-1}}_{\substack{\textbf{augmented}\\ \textbf{Leontief inverse } \Xi}} \Gamma, \tag{10}$$

The influence vector characterizes how changes in productivity in a given sector contribute to aggregate value added. It is disciplined by the sector's direct contribution to value added and its indirect contribution through investment and intermediate-input linkages, and it is amplified by trade via the imported fraction of investment goods.

Next, we describe the data sources for each component of sectorial influence and characterize them across the development spectrum.

5.1 Data Sources

To estimate sectorial influence in equation 10 we need data on sectorial value-added shares in gross output ($\mathbf{\Gamma}$), sectorial value-added shares ($\tilde{\boldsymbol{\zeta}}$), capital shares in value added ($\boldsymbol{\alpha}$), and the sectorial imported share of investment ($\boldsymbol{\phi}$), together with estimates of input-output linkages ($\boldsymbol{M}$) and our newly estimated investment networks ($\mathbf{\Omega}$), both already described in Section 3.2.

Value-added shares in production (Γ) and sectorial value-added shares ($\tilde{\zeta}$). We compute sectorial value-added shares in gross output and sectorial value-added shares using the same data sources as the input-output tables for each country: Mensah and de Vries (2023), WIOD, and OECD.

Capital share in value added (α). We exploit data from PWT version 10.01 to compute the labor expenditure share. We estimate capital shares as residuals from labor expenditure shares, under the assumption of CRS value-added production technologies. The capital expenditure share is computed at the aggregate level and therefore country specific but common across sectors.[24]

Sectorial imported investment shares ($\boldsymbol{\phi}$). For each sector and country, we compute the share of sectorial investment that is sourced from abroad using the *use tables* described in Section 3.2, which contain information on imported and domestic sectorial investment.

5.2 Sectorial Influence Along Development

Figure 8 shows sectorial influence for country-year observations using our full sample. We highlight the development path of South Korea from 1965 to 2014, which aligns surprisingly well with the fitted average across the sample.

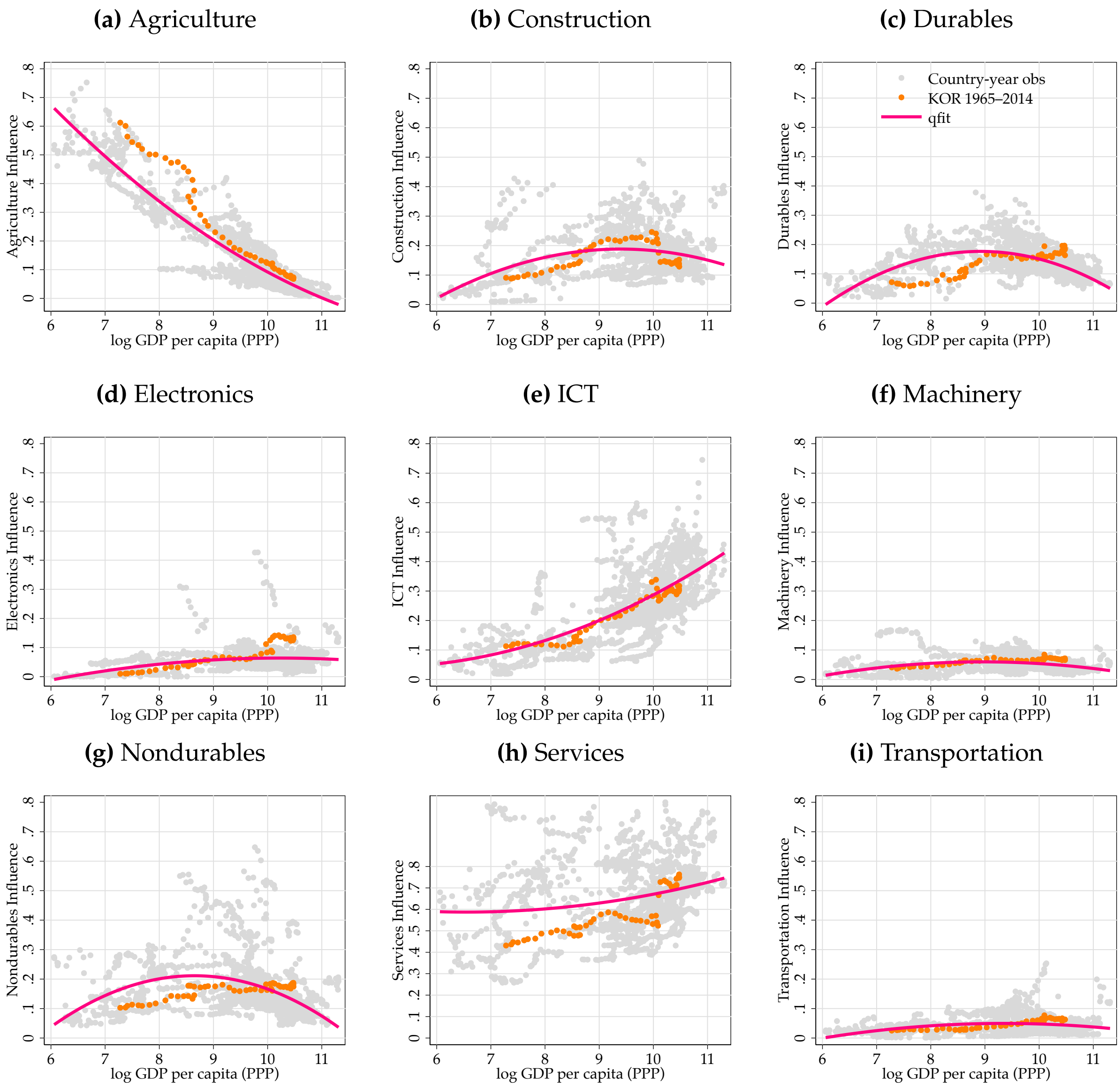
Some patterns emerge. A 1% increase in the productivity of the construction sector translates into a 0.13% increase in GDP among low income countries. This influence almost doubles among middle income countries. Sectorial influence for durable goods follows a similar trajectory and magnitude as that of the construction sector despite its lesser role as a producer of investment to other sectors. Sectorial influence for electronics, machinery and transportation is smaller in magnitude and common along the development spectrum.

In some sectors, the importance of productivity gains changes substantially as countries develop. The influence of agriculture declines sharply with development, from 0.3% on average in low-income countries to 0.04% in high-income countries. Moreover, a 1% productivity

[24] Some high- and medium-income countries have data on sectorial capital shares in value added from WIOD. However, we lack this information for more than half of the countries in our sample. For consistency, we use country-specific aggregate capital shares.

improvement in ICT is linked to a 0.12% increase in GDP per capita in low-income countries, but a much larger 0.34% increase in high-income countries. In other words, the same productivity improvement in ICT can have different contribution GDP depending on a country's stage of development. This likely reflects complementarities and linkages with the rest of the economy, which we explore further below. The influence of other (non-ICT) services deserves special mention, as they exhibit the highest level of influence across countries at all stages of development. Their contribution to aggregate GDP rises with development—from 0.6% to 0.7%—despite a reduction in their role as providers of investment inputs as countries become richer, as documented in Table 2.

Figure 8: Sectorial Influence Along Development



Notes: Data for all country-years in the sample. Sectorial influence is defined as $\Phi\tilde{\eta}\Gamma$ in Proposition 4, and measures the change in aggregate value added following a change in sectorial productivity. Dots represent country–year observations; South Korea (1965–2014) is highlighted.

One concern with pooling country–year observations across income levels is that the technologies available fifty years ago differ from those available to countries catching up more recently. Our new data also allow further exploration of how investment paths vary across development trajectories. As a first step, in Figure 10 we highlight the paths of India and China, two countries that have experienced relative rapid growth since 2000s, when the technologies available for production were arguably different than those available in the 1960s. Even for these cases, the path of sectoral influence—especially for newer technologies such as ICT—tracks the pattern predicted by their income levels.[25]

Counterfactual Sectorial Influence. Prima facie, these patterns could be driven entirely by standard structural-transformation forces—namely, the reallocation of sectorial value added ($\tilde{\zeta}$) as countries develop—or even by changes in the composition of intermediate-inputs use. To disentangle these forces, in Figure 13 we divide the full sample into quintiles of income per capita and re-compute sectorial influence under two counterfactual scenarios where we fix the investment network across countries. We do so for the investment network in South Korea in 1965 (square line) and in South Korea in 2014 (triangle line). These counterfactual isolate the component of influence that is driven by variation in the investment network, as a residual between baseline influence and the counterfactual scenario.

Differences under the fixed-network counterfactuals are largest in investment-producing sectors—construction and ICT—and, to a lesser extent, electronics and transportation. For a country in the *third quintile* of the income distribution, imposing the investment network of a rich economy raises the ICT multiplier by about 0.05 percentage points (roughly 20% above baseline), whereas imposing the network of a poorer economy reduces it slightly. Construction moves in the opposite direction: with a poor-economy network, its multiplier increases by about 0.01 percentage points (around 5% of baseline) and changes little under a rich-economy network. Services also show meaningful shifts. In the *third quintile*, imposing a poor-economy network increases the services multiplier by roughly 0.05 percentage points (just under 10% of baseline), while a rich-economy network reduces it by about 0.01 percentage points. Thus, the direction of change in sectorial multipliers is sector-specific and ultimately depends on complementarities with the rest of the economy.

Notably, the overall income gradient of multipliers is largely preserved when a common network is imposed—except, possibly, in ICT and construction. For agriculture and services, systematic movements over development closely track shifts in value-added shares, i.e., standard structural change.

[25]One exception is other services, where sectoral influence lies below the average path for China and above it for India.

Future versions of the paper will include general-equilibrium counterfactuals that isolate the effect of the investment network from primitives, i.e., sectorial productivities. Changes in these productivities induce joint movements in the investment network, the input–output structure, and value-added shares.

6 Final Remarks

We have constructed novel measures of the investment network for 58 countries across the development spectrum and time-series estimates that cover the period 1965 to 2014. Our analysis reveals systematic disparities in the sectors' roles as providers of investment goods as economies progress. We also document significant empirical disparities between the investment network and the input–output network for countries at different income levels.

Leveraging our estimates of the investment network across countries at different development stages, we conduct an income accounting exercise, finding that disparities in the investment network can account for 28% of observed differences in income per capita across countries, almost double the effect of capital in the standard income accounting exercise.

We argue that this role relates to systematic shifts in the investment network as countries develop. The extent to which comparative advantage, distortions, or variations in human capital endowments explain shifts in the network is an exciting avenue for future research. Is there a systematic ladder in the type of investment required to transition an economy from low to high income levels? We hope that this work can serve as a foundation for studying this and other critical questions.

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A Proofs & Derivations

A.1 Aggregate Growth Path

Proof of Proposition **??**. Let us start by defining GDP in the economy, ν, as the value of consumption and investment expenses plus net exports, $p_Y C + \sum p_n^x x_n + NX = \nu$. Let $p_1^x = 1$ so that investment sector 1 is the numeraire in the economy.

Wages are proportional to GDP, $\nu_t = \frac{w_t}{1-\alpha}$, thus both grow at a common rate.[26] The growth rate of value added is the growth rate of the capital labor ratio in the numeraire sector, which is constant absent structural change, i.e. $g^{N_1} = 0$.

$$g^{\nu} = g^{K_1} - g^{N_1}.$$

The definition of sectorial investment requires,

$$g_{x_{nit}} = g_{A_{it}} - \alpha g_{R_{it}}.$$

for the growth rate of investment to be constant and equal to $g_{\mathcal{A}_i^x}$. Given the feasibility constraint for output, this should also be equal to the growth rate of sectorial output.

$$g_{y_{it}} = \alpha g_{k_{it}} + (1-\alpha) g_{nit} + g_{A_{it}} = g_{x_{nit}} = g_{A_{it}} - \alpha g_{R_{it}}.$$

Hence, the growth rate of the rental rate of capital satisfies,

$$g_{R_{it}} = g_{k_{it}} - (1-\alpha)/\alpha g_{n_{it}}.$$

From the optimality condition with respect to capital,

$$g_{R_{it}} = g_{P_{it}} + g_{A_{it}} + (\alpha - 1)(g_{k_{it}} - g_{n_{it}})$$

Hence, combining these two expressions along the assymptotic AGP (where $g_{n_{it}} = 0$) we obtain

$$g_{P_{it}} = -g_{A_{it}} - \alpha g_{k_{it}} = -g_{A_{it}} - \alpha g_{\mathcal{A}_i^x}$$

which implies that the rental rate of capital falls proportional to investment-specific technical

[26] If output elasticities to capital are different across sectors, this factor share corresponds to the output elasticity to labor in the numeraire sector.

change, as in Greenwood, Hercowitz and Krusell (1997).

$$g_{R_{it}} = -g_{\mathcal{A}_i^x}$$

In the numeraire sector, there is an additional restriction from the Euler equation that requires $g_{R_{1t}} = g_{\mathcal{A}_1^x} = 0$, or in other words, aggregate value added does not grow **(in units of investment)**. Sectorial output is proportional to Hicks-Neutral productivity and can be therefore growing. Since prices grow at the same (but opposite rate) as sectorial value added, the expenditure shares in units of investment are constant along the BGP.

A.2 Equilibrium Outcomes, Open Economy

Proof Proposition (open ec) 2. Use the optimality conditions of the firm, and rewrite the expenses in different intermediate and investment goods as a function of gross output, i.e.,

$$\mu_{ni}(1-\gamma_i)p_{it}y_{it} = p_{nt}m_{nit}$$

$$\alpha_i\gamma_i p_{it}y_{it} = r_{it}k_{it}$$

$$(1-\phi_{jt})\omega_{ji}p^x_{it}x_{it} = p_{jt}\chi^d_{jit}$$

Under no arbitrage, the user cost of capital satisfies

$$r_{it} = p^x_{it-1}\left[\frac{1}{R_t} - (1-\hat{\delta}_i)\frac{p^x_{it}}{p^x_{it-1}}\right]$$

where $1-\hat{\delta}_i$ corresponds to the adjusted undepreciated value of a unit of capital adjusted along the BGP, i.e., $1-\hat{\delta}_i \equiv \frac{1-\delta_i}{1+g^k_i}$, and $R_t = \beta\frac{U'(c_t)}{U'(c_{t-1})}$ is the interest rate in the economy.

Combining the optimality conditions for capital and investment, as well as the steady-state level of capital

$$\alpha_i\gamma_i p_{it}y_{it} = \left[\frac{1}{R_t} - (1-\hat{\delta}_i)\frac{p^x_{it}}{p^x_{it-1}}\right]\frac{p_{jt-1}\chi^d_{jit-1}}{(1-\phi_{jt})\omega_{ji}}\frac{x_{it}}{x_{it-1}}\frac{k_{it}}{x_{it}},$$

which we can use to write the feasibility constraint in each sector n,

$$p_{nt}y_{nt} = p_{nt}c_{nt} + \sum_i p_{nt}\chi^d_{nit} + \sum_j p_{nt}m_{njt}.$$

Then,

$$\zeta_{nt}\frac{y_{nt}}{c_{nt}} = \zeta_{nt} + \sum_i \frac{\alpha_i\gamma_i(1-\phi_{nt})\omega_{ni}}{\frac{1}{R_t}-(1-\hat{\delta}_i)\frac{p^x_{it+1}}{p^x_{it}}}\frac{x_{it+1}}{k_{it+1}}\frac{x_{it}}{x_{it+1}}\frac{p_{it+1}y_{it+1}}{p_{it}y_{it}}\zeta_{it}\frac{y_{it}}{c_{it}} + \sum_j(1-\gamma_j)\mu_{njt}\zeta_{jt}\frac{y_{jt}}{c_{jt}}.$$

This is a system of equations across sectors that can be solved for the Domar weights $\eta_n \equiv \zeta_n\frac{y_n}{c_n}$.

Along the BGP, the solution satisfies

$$\left[I - \tilde{\beta}^{-1}\hat{\delta}\Gamma\alpha(I-\phi)\Omega - (I-\Gamma)M\right]^{-1}\boldsymbol{\zeta} \equiv \boldsymbol{\eta} \tag{11}$$

where $\tilde{\beta}$ is a vector of effective discount factors, with typical element $\tilde{\beta}_i \equiv \frac{1}{\beta} - (1-\hat{\delta}_i)$, and the vector of depreciation rates contains typical element $\hat{\delta}_i$. □

Proof Proposition (open ec) 3. The planner's problem associated with our economy is

$$W \equiv \max_{C_t,Y_t,\omega_{int},\chi_{int},x_{nt},k_{nt+1},m_{int},\epsilon_t,\epsilon^f_t} \sum_{t=0}^{\infty}\beta^t\ln(C_t)$$

subject to

$$y_{nt} = \left(\frac{\tilde{z}_{nt}\left(\frac{k_{nt}}{\alpha_n}\right)^{\alpha_n}\left(\frac{l_{nt}}{1-\alpha_n}\right)^{1-\alpha_n}}{\gamma_n}\right)^{\gamma_n}\left(\frac{m_{nt}}{1-\gamma_n}\right)^{1-\gamma_n}, \qquad \text{for } \gamma_n \in [0,1],$$

$$k_{nt+1} = x_{nt} + (1-\delta_n)k_{nt},$$

$$x_{nt} = \prod_{i=1}^{N}\left(\frac{\chi_{int}}{\omega_{int}}\right)^{\omega_{int}}, \quad \sum_{in}\xi_{in}\omega_{int}^{\iota_n} = B_n,$$

$$y_{nt} = c_{nt} + \sum_i m_{nit} + \sum_i \chi^d_{nit},$$

$$Y_t = \prod_{n=1}^{N}\left(\frac{c_{nt}}{\theta_n}\right)^{\theta_n}, \qquad \sum_{n=1}^{N}\theta_n = 1 \text{ and } \quad \theta_n > 0;$$

$$Y_t = C_t + \epsilon_t, \qquad \epsilon_t - \frac{\epsilon^f_t}{\tau} = 0$$

$$\epsilon^f_t = \prod_{i=1}^{N}\frac{\chi^{f}_{it}}{\phi^f_i}^{\phi^f_i} \qquad \chi^f_{it} = \sum_n \chi^f_{int},$$

$$\chi_{int} = \left(\frac{\chi^d_{int}}{1-\phi_i}\right)^{1-\phi_i}\left(\frac{\chi^f_{int}}{\phi_i}\right)^{\phi_i}.$$

where we have defined $\tilde{z} \equiv \exp z$ for notational convenience.

The envelope condition then yields that

$$\frac{\partial C}{\partial \tilde{z}_{nt}} \tilde{z}_{nt} = \lambda_{nt} y_{nt} \frac{\partial y_{nt}}{\partial \tilde{z}_{nt}} \frac{\tilde{z}_{nt}}{y_{nt}}$$

where λ_n is the Lagrange multiplier associated with the feasibility constraint for good n and the last term in the above equation is simply the elasticity of gross output to productivity, i.e., γ_n. We can rewrite this in terms of the change in welfare, which is proportional to $d\ln(C_t)$ because utility is separable in time.

$$\frac{\partial C_t}{\partial \tilde{z}_{nt}} \frac{\tilde{z}_{nt}}{C_t} = \frac{\nu_t}{C_t} \frac{\lambda_{nt} y_{nt}}{\nu_t} \gamma_n$$

Along the BGP, aggregate consumption is a constant fraction of GDP, ν, and by definition, $\eta_n = \frac{\lambda_{nt} y_{nt}}{\nu_t}$, i.e., the Domar weight.

$$\frac{d\ln C_t}{d\ln \tilde{z}_{nt}} = \frac{\nu_t}{C_t} \eta_{nt} \gamma_n.$$

□

Proof Proposition 4. Use the solution and the definition of ζ_i to solve for relative prices given investment rates.

$$\frac{p_i}{p_j} = \frac{c_j}{c_i} \frac{\zeta_i}{\zeta_j} = \frac{\eta_i}{\eta_j} \frac{y_j}{y_i}$$

These relative prices are useful to define the demand for intermediate inputs, investment and labor as a function of the vector of sectorial gross output. The demand for intermediate inputs follows $(1-\gamma_i)\frac{\eta_i}{\eta_n} y_n = m_{ni}$, while the demand for domestic investment goods is $\tilde{\beta}_i \frac{x_i}{k_i}(1-\phi_j)\omega_{ji}\alpha_i\gamma_i\frac{\eta_i}{\eta_j} y_j = \chi_{ji}$. The demand for imported investment satisfies

$$\tilde{\beta}_i \frac{x_i}{k_i} (\phi_j) \omega_{ji} \alpha_i \gamma_i \frac{\eta_i}{p^f} \nu = \chi^f_{ji}.$$

Total investment in sector i defines the level of the stock of capital as

$$x_i = \prod_j \left(\tilde{\beta}_i \left(\frac{x_i}{k_i} \alpha_i \gamma_i \frac{\eta_i}{\eta_j} y_j \right)^{1-\phi_j} \left(\frac{x_i}{k_i} \alpha_i \gamma_i \frac{\eta_i}{p^f} \nu \right)^{\phi_j} \right)^{\omega_{ji}},$$

, or equivalently, $k_i = \prod_j \left(\tilde{\beta}_i \left(\alpha_i \gamma_i \frac{\eta_i}{\eta_j} y_j \right)^{1-\phi_j} \left(\alpha_i \gamma_i \frac{\eta_i}{p^f} \nu \right)^{\phi_j} \right)^{\omega_{ji}}$.

Assume that the supply of labor is inelastic at 1, so the fraction of labor allocated to each sector follows Domar weights adjusted by the sectorial labor expenditure shares in gross output,

$$l_i^\star = \frac{(1-\alpha_i)\gamma_i p_i y_i}{\sum_i (1-\alpha_i)\gamma_i p_i y_i} = \frac{(1-\alpha_i)\gamma_i \eta_i}{\sum_i (1-\alpha_i)\gamma_i \eta_i}.$$

For the purpose of describing final demand, it would be useful to define $\tilde{l}_i = \frac{l_i^\star}{\gamma_i(1-\alpha_i)}$.

Final output in each sector is then

$$y_n = \left[\exp(z_n)(\prod_i \left(\tilde{\beta}_i(\frac{\eta_n}{\eta_i}y_i)^{1-\phi_i}(\frac{\eta_n}{p^f}\nu)^{\phi_i}\right)^{\omega_{in}})^{\alpha_n}(\tilde{l}_n)^{1-\alpha_n}\right]^{\gamma_n}\left[\prod_i \left(\frac{\eta_n}{\eta_i}y_i\right)^{\mu_{in}}\right]^{1-\gamma_n}$$

Taking logs and writing output in matrix form, we obtain

$$\ln(\mathbf{y}) = \Gamma \boldsymbol{z} + \boldsymbol{\iota} + \Gamma\alpha\boldsymbol{\phi}'\boldsymbol{\Omega}'\ln(\nu) + \Gamma\alpha(I-\boldsymbol{\phi})'\Omega'\ln(\mathbf{y}) + (I-\Gamma)M'\ln(\mathbf{y})$$

where each element of the vector $\boldsymbol{\iota}$ can be described as $\iota_n \equiv \gamma_n(1-\alpha_n)\ln(\tilde{l}_n) + \gamma_n\alpha_n\sum_i(1-\phi_i)\omega_{in}\ln(\frac{\eta_n}{\eta_i}) + \gamma_n\alpha_n\sum_i\phi_i\omega_{in}\ln(\frac{\eta_n}{p^f}) + \gamma_n\alpha_n\sum_i\omega_{in}\ln(\tilde{\beta}_i) + (1-\gamma_n)\sum_i\mu_{in}\ln(\frac{\eta_n}{\eta_i})$.

The solution for gross output is then

$$\ln(\mathbf{y}) = \Xi\Gamma\boldsymbol{z} + \Xi\boldsymbol{\iota} + \Xi\Gamma\alpha\boldsymbol{\phi}'\boldsymbol{\Omega}'\ln(\nu) \tag{12}$$

where the multiplier on sectorial productivity is $\Xi \equiv (I - \Gamma\alpha(I-\boldsymbol{\phi})'\Omega' - (I-\Gamma)M')^{-1}$. Let the price level of the economy be normalized to $p=1$; then, aggregate value added is $\nu = \frac{p_n y_n}{\eta_n}$ for any n. We can compute a geometric average of each of the terms using the expenditure shares of consumption and investment $\tilde{\zeta}_n \equiv \frac{p_n\hat{c}_n}{\nu} + \frac{p_n x_n^d}{\nu}$ as weights. Note that $p_n\hat{c}_n$ is the value of final uses from sector n that are allocated to aggregate consumption (these values can be split due to the CRS aggregator for final uses). Hence, weights sum to 1 since trade is balanced.

$$\ln(\nu) = \sum_n \tilde{\zeta}_n\ln(p_n) + \sum_n\tilde{\zeta}_n\ln(y_n) - \sum_n\tilde{\zeta}_n\ln(\eta_n).$$

Given a CRS aggregator of sectorial output, the price index for final goods satisfies $\ln(p) = \sum_n\tilde{\zeta}_n\ln(p_n)$. Because final output is the numeraire, the log of the price index equals zero, and therefore, the first term in the expression for value added drops out. The weighting of the terms in the sum also includes investment shares in value added. Investment shares are proportional to consumption shares in value added whenever sectorial value-added shares are proportional to consumption shares across sectors. This is by construction the assumption in canonical models of input–output linkages without capital, and we assume that feature here.[27]

[27]Alternatively, one can set up the economy so that investment in different capital types is produced through

We have characterized the solution to the last two terms in Equations 11 and 12.

$$\ln(\nu) = \tilde{\boldsymbol{\zeta}}'\Xi(\Gamma \boldsymbol{z} + \boldsymbol{\iota} + \Gamma\alpha\boldsymbol{\phi}'\boldsymbol{\Omega}'\ln(\nu)) - \sum_n \tilde{\zeta}_n \ln(\eta_n) \tag{13}$$

where we can define the elasticity of value to sectorial TFP as $\tilde{\eta} \equiv \tilde{\boldsymbol{\zeta}}'\Xi$. Unlike the Domar weight, these elasticities are not adjusted by the investment rate.

Because of the presence of tradable investment goods we obtain an additional amplification (as in Jones (2011) for tradable intermediate inputs). The reason is that as productivity increases within the economy, export capacity improves, and due to trade balance, this implies higher investment imports. The stronger the dependence on imported equipment and the intensity of capital use, the stronger this amplification channel is.

$$\ln(\nu) = \left(I - \tilde{\boldsymbol{\zeta}}'\Xi\Gamma\alpha\boldsymbol{\phi}'\boldsymbol{\Omega}'\right)^{-1}\left[\tilde{\boldsymbol{\zeta}}'\Xi(\Gamma\boldsymbol{z} + \boldsymbol{\iota}) - \sum_n \tilde{\zeta}_n \ln(\eta_n)\right] \tag{14}$$

Unpacking the vectors, $\tilde{\zeta}_n = \tilde{\eta}_n - \sum_j \gamma_j\alpha_j(1-\phi_j)\omega_{nj}\tilde{\eta}_j - \sum_j(1-\gamma_j)\mu_{nj}\tilde{\eta}_j$

$$\sum_n \tilde{\zeta}_n \ln(\mu_n) = \sum_n \tilde{\eta}_n \ln(\eta_n) - \sum_n\sum_j \gamma_n\alpha_n(1-\phi_n)\omega_{nj}\tilde{\eta}_j \ln(\mu_n) - \sum_n\sum_j(1-\gamma_n)\mu_{nj}\tilde{\eta}_j\ln(\mu_n)$$

Now consider the term $\tilde{\eta}\iota$

$$\begin{aligned}\sum_n \tilde{\eta}_n\iota_n &= \sum_n(\tilde{\eta}_n\gamma_n(1-\alpha_n)\ln(\tilde{l_n}) + \tilde{\eta}_n\gamma_n\alpha_n\sum_j(1-\phi_j)\omega_{jn}\ln(\frac{\eta_n}{\eta_j}) + \gamma_n\alpha_n\sum_j\phi_j\omega_{jn}\ln(\frac{\eta_n}{p^f})\\ &\quad +\tilde{\eta}_n(1-\gamma_n)\sum_j\mu_{jn}\ln(\frac{\eta_n}{\eta_j})) + \gamma_n\alpha_n\sum_i\omega_{in}\ln(\tilde{\beta}_i)\end{aligned}$$

which can be rewritten as

$$\begin{aligned}\sum_n \tilde{\eta}_n\iota_n &= \sum_n \tilde{\eta}_n\gamma_n(1-\alpha_n)\ln(\tilde{l_n}) + \sum_n \tilde{\eta}_n(\gamma_n\alpha_n + 1 - \gamma_n)\ln(\eta_n) + \gamma_n\alpha_n\sum_i\omega_{in}\ln(\tilde{\beta}_i)\\ &\quad -\sum_n\tilde{\eta}_n\gamma_n\alpha_n\sum_j\omega_{jn}\left((1-\phi_j)\ln(\eta_j) + \phi_j\ln(p^f)\right) - \sum_n\tilde{\eta}_n(1-\gamma_n)\sum_j\mu_{jn}\ln(\eta_j)\end{aligned}$$

Therefore, the difference in the last two terms in the expression for value added are

$$\sum_n\tilde{\eta}_n\iota_n - \sum_n\tilde{\zeta}_n\ln(\eta_n) = \sum_n\tilde{\eta}_n\gamma_n(1-\alpha_n)(\ln(\tilde{l_n}) - \ln(\eta_n)) - \sum_n\tilde{\eta}_n\gamma_n\alpha_n\sum_j\omega_{jn}\phi_j\ln(p^f)$$

the final good. This economy would also allow us to define the price of value added as a function of sectorial prices in a way that they drop out from the expression above while allowing for investment shares that need not be proportional to consumption shares. The undesirable feature of this economy is that sectors producing for final production and intermediate inputs are decoupled from those producing investment.

$$+\gamma_n \alpha_n \sum_i \omega_{in} \ln(\tilde{\beta}_i)$$

The second to last term can be written as a function of the terms of trade for imported equipment j, $\ln(\tau_j) = \ln(p) - \ln(p^f)$. Because the final good is the numeraire, p=1. Hence,

$$\begin{aligned}\sum_n \tilde{\eta}_n \iota_n - \sum_n \tilde{\tilde{\zeta}}_n \ln(\eta_n) \quad &= \quad \sum_n \tilde{\eta}_n \gamma_n (1-\alpha_n)(\ln(\tilde{l_n}) - \ln(\eta_n)) + \sum_n \tilde{\eta}_n \gamma_n \alpha_n \sum_j \omega_{jn} \phi_j \ln(\tau_j) \\ &+ \gamma_n \alpha_n \sum_i \omega_{in} \ln(\tilde{\beta}_i)\end{aligned}$$

which proves our result. $\square$

B Data Appendix

Table 4: Country Sample and Data Sources

	Country	GDP per capita (2005 PPP)	Use/IO Source	Employment Source	Investment Network Available Years
1	Ethiopia	679	MDV	ILOSTAT	1990–2019
2	Rwanda	1.246	MDV	ILOSTAT	1990–2019
3	Tanzania	1.507	MDV	ILOSTAT	1990–2019
4	Zambia	1.710	MDV	IPUMS	1990–2019
5	Kenya	1.972	MDV	ILOSTAT	1990–2019
6	Cambodia	2.048	OECD	ILOSTAT	2005–2015
7	Senegal	2.728	MDV	IPUMS	1990–2019
8	India	2.872	WIOD	IPUMS	1965–2000; 2000–2014
9	Vietnam	3.128	OECD	IPUMS	2005–2015
10	Ghana	3.219	MDV	ILOSTAT	1990–2019
11	Nigeria	3.481	MDV	IPUMS	1990–2019
12	Philippines	4.366	OECD	IPUMS	2005–2015
13	Indonesia	4.602	WIOD	IPUMS	2000–2014
14	Morocco	4.672	OECD	IPUMS	2005–2015
15	China	6.681	WIOD	IPUMS	1965–2000; 2000–2014
16	Peru	6.832	OECD	PIAAC	2005–2015
17	Colombia	8.367	OECD	ILOSTAT	2005–2015
18	Tunisia	9.353	OECD	ILOSTAT	2005–2015
19	Brazil	9.610	WIOD	IPUMS	1965–2000; 2000–2014
20	Thailand	10.293	OECD	IPUMS	2005–2015
21	South Africa	11.311	OECD	IPUMS	2005–2015
22	Costa Rica	11.580	OECD	IPUMS	2005–2015
23	Turkey	13.941	WIOD	PIAAC	2000–2014
24	Argentina	14.247	OECD	ILOSTAT	2005–2015
25	Mauritius	14.325	MDV	IPUMS	1990–2019
26	Chile	14.534	OECD	PIAAC	2005–2015
27	Mexico	15.230	WIOD	PIAAC	1965–2000; 2000–2014
28	Russia	15.450	WIOD	PIAAC	2000–2014
29	Poland	16.838	WIOD	PIAAC	2000–2014
30	Malaysia	17.412	OECD	IPUMS	2005–2015
31	Lithuania	17.646	WIOD	ILOSTAT	2000–2014
32	Slovakia	20.168	OECD	PIAAC	2000–2014
33	Hungary	20.819	WIOD	PIAAC	2000–2014
34	Czechia	26.624	WIOD	PIAAC	2000–2014
35	Portugal	27.149	WIOD	IPUMS	1965–2000; 2000–2014
36	Slovenia	28.821	OECD	PIAAC	2000–2014
37	Greece	30.138	WIOD	PIAAC	1965–2000; 2000–2014
38	South Korea	30.784	WIOD	PIAAC	1965–2000; 2000–2014
39	New Zealand	31.485	OECD	PIAAC	2005–2015
40	Israel	32.358	OECD	PIAAC	2005–2015
41	Spain	32.769	WIOD	PIAAC	1965–2000; 2000–2014
42	Cyprus	33.025	OECD	ILOSTAT	2005–2015
43	Italy	36.167	WIOD	PIAAC	1965–2000; 2000–2014
44	France	36.651	WIOD	PIAAC	1965–2000; 2000–2014
45	Japan	38.466	WIOD	PIAAC	1965–2000; 2000–2014
46	Germany	38.475	WIOD	PIAAC	1965–2000; 2000–2014
47	Belgium	39.220	WIOD	PIAAC	1965–2000; 2000–2014
48	United Kingdom	39.308	WIOD	PIAAC	1965–2000; 2000–2014
49	Denmark	40.344	WIOD	PIAAC	1965–2000; 2000–2014
50	Sweden	40.381	WIOD	PIAAC	1965–2000; 2000–2014
51	Austria	41.678	WIOD	ILOSTAT	1965–2000; 2000–2014
52	Australia	43.333	WIOD	ILOSTAT	1965–2000; 2000–2014
53	Netherlands	44.662	WIOD	PIAAC	1965–2000; 2000–2014
54	Ireland	47.211	WIOD	PIAAC	1965–2000; 2000–2014
55	Switzerland	49.859	WIOD	IPUMS	2000–2014
56	Norway	54.200	WIOD	PIAAC	2000–2014
57	United States	54.210	WIOD	PIAAC	1965–2000; 2000–2014
58	Singapore	63.949	OECD	PIAAC	2005–2015

Notes: Country-year coverage and main sources of data. "Use/IO Source" refers to VA shares and GFCF imported shares. GDP per capita in chained PPPs (2017 international dollars), 2005.

Table 5: Aggregate Sectors Definition

ISIC Rev.4 Industry Code	Industry Description	Aggregate Sector
A01	Crop and animal production, hunting and related service activities	Agriculture
A02	Forestry and logging	Agriculture
A03	Fishing and aquaculture	Agriculture
B	Mining and quarrying	Mining
C10–C12	Manufacture of food products, beverages and tobacco products	Non-Durables
C13–C15	Manufacture of textiles, wearing apparel and leather products	Non-Durables
C16	Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials	Durables
C17	Manufacture of paper and paper products	Non-Durables
C18	Printing and reproduction of recorded media	Non-Durables
C19	Manufacture of coke and refined petroleum products	Non-Durables
C20	Manufacture of chemicals and chemical products	Non-Durables
C21	Manufacture of basic pharmaceutical products and pharmaceutical preparations	Non-Durables
C22	Manufacture of rubber and plastic products	Non-Durables
C23	Manufacture of other non-metallic mineral products	Durables
C24	Manufacture of basic metals	Durables
C25	Manufacture of fabricated metal products, except machinery and equipment	Durables
C26	Manufacture of computer, electronic and optical products	Electronics
C27	Manufacture of electrical equipment	Electronics
C28	Manufacture of machinery and equipment n.e.c.	Machinery
C29	Manufacture of motor vehicles, trailers and semi-trailers	Transportation
C30	Manufacture of other transport equipment	Transportation
C31, C32	Manufacture of furniture; other manufacturing	Durables
C33	Repair and installation of machinery and equipment	Durables
D35	Electricity, gas, steam and air conditioning supply	Services
E36	Water collection, treatment and supply	Services
E37–E39	Sewerage; waste collection, treatment and disposal activities; materials recovery; remediation activities and other waste management services	Services
F	Construction	Construction
G45	Wholesale and retail trade and repair of motor vehicles and motorcycles	Services
G46	Wholesale trade, except of motor vehicles and motorcycles	Services
G47	Retail trade, except of motor vehicles and motorcycles	Services
H49	Land transport and transport via pipelines	Trpt Services
H50	Water transport	Trpt Services
H51	Air transport	Trpt Services
H52	Warehousing and support activities for transportation	Trpt Services
H53	Postal and courier activities	Trpt Services
I	Accommodation and food service activities	Services
J58	Publishing activities	ICT
J59, J60	Motion picture, video and television programme production, sound recording and music publishing activities; programming and broadcasting activities	ICT
J61	Telecommunications	ICT
J62, J63	Computer programming, consultancy and related activities; information service activities	ICT
K64	Financial service activities, except insurance and pension funding	Services
K65	Insurance, reinsurance and pension funding, except compulsory social security	Services
K66	Activities auxiliary to financial services and insurance activities	Services
L68	Real estate activities	Services
M69, M70	Legal and accounting activities; activities of head offices; management consultancy activities	ICT
M71	Architectural and engineering activities; technical testing and analysis	ICT
M72	Scientific research and development	ICT
M73	Advertising and market research	ICT
M74, M75	Other professional, scientific and technical activities; veterinary activities	ICT
N	Administrative and support service activities	ICT
O84	Public administration and defence; compulsory social security	Services
P85	Education	Services
Q	Human health and social work activities	Services
R, S	Other service activities	Services
T	Activities of households as employers; undifferentiated goods- and services-producing activities of households for own use	Services
U	Activities of extraterritorial organizations and bodies	Services

Notes: Crosswalk between ISIC Rev.4 classification and our 10-sector disaggregation. "Trpt Services" refers to Transportation Services.

Table 6: Comparison with vom Lehn and Winberry (2022), US 2012

(a) Outdegrees

Sector	This Paper	VLW
Agriculture	0.00	0.00
Construction	1.65	1.31
Durables	0.30	0.24
Electronics	0.90	0.64
ICT	3.02	3.57
Machinery	1.42	1.94
Nondurables	0.04	0.03
Services	1.16	1.06
Transportation	1.35	1.10
Transportation Services	0.16	0.10

(b) Homophily

Sector	This Paper	VLW
Agriculture	0.00	0.00
Construction	0.04	0.03
Durables	0.04	0.05
Electronics	0.12	0.07
ICT	0.43	0.61
Machinery	0.18	0.26
Nondurables	0.01	0.005
Services	0.11	0.12
Transportation	0.11	0.06
Transportation Services	0.03	0.01

Notes: Comparison between investment network estimates in year 2012, corresponding to the year in which we fix the occupational composition of the labor force. This table reports the row sum of the networks, *outdegrees*, as well as the weight of the diagonal in the network, *homophily*.

Table 7: Comparison with Gillmore et al. (2025), Chile 2015

	Outdegree		Homophily	
Sector	This Paper	Gillmore et al. (2025)	This Paper	Gillmore et al. (2025)
Agriculture	0.32	0.07	0.13	0.04
Construction	4.22	5.13	0.68	0.86
Durables	0.44	0.46	0.07	0.07
Electronics	0.06	0.11	0.01	0.05
ICT	2.73	0.15	0.33	0.03
Machinery	0.49	0.28	0.07	0.11
Nondurables	0.34	0.15	0.09	0.04
Services	1.08	4.47	0.06	0.36
Transportation	0.13	0.04	0.01	0.01
TrptServices	0.20	0.11	0.06	0.04

Notes: Comparison between our benchmark (domestic) investment network estimates and **?** VAT firm-to-firm transaction estimates. This table reports the row sum of the networks, *outdegrees*, as well as the weight of the diagonal in the network, *homophily*.

Table 8: Country Groups

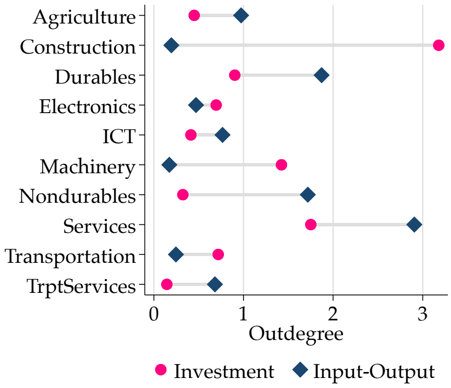
Low income	**Middle income**	**High income**
Ethiopia	Argentina	Australia
Ghana	Brazil	Austria
India	China	Belgium
Kenya	Colombia	Switzerland
Morocco	Costa Rica	Chile
Nigeria	Indonesia	Cyprus
Philippines	Mexico	Czech Republic
Rwanda	Mauritius	Germany
Senegal	Malaysia	Denmark
Tanzania	Peru	Spain
Zambia	Thailand	France
	Turkey	United Kingdom
	South Africa	Greece
		Hungary
		Ireland
		Israel
		Italy
		Japan
		South Korea
		Lithuania
		Netherlands
		Norway
		New Zealand
		Poland
		Portugal
		Russia
		Singapore
		Slovakia
		Slovenia
		Sweden
		United States

Notes: Countries are grouped into income categories per the World Bank classification. *Low income* comprises "Low income" and "Lower middle income"; *Middle income* corresponds to "Upper middle income"; *High income* corresponds to "High income." Average real GDP per capita (chained PPPs, 2017 international dollars) for 2005, from the Penn World Table (PWT): low 2587; middle 11110; high 35056.

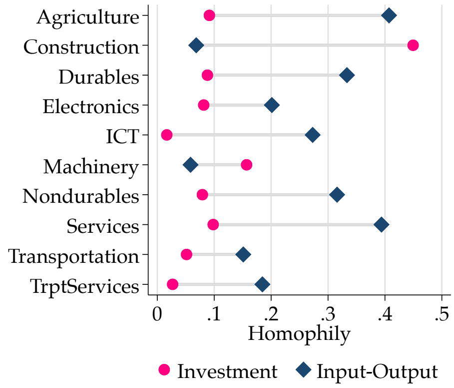
Figure 9: Investment Network vs. Input-Output Network

Low income

(a) Outdegrees

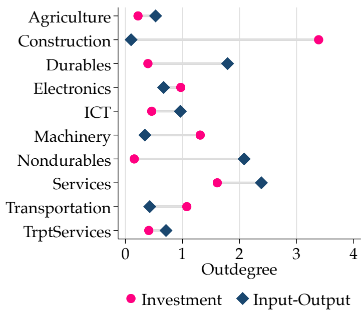


(b) Homophily

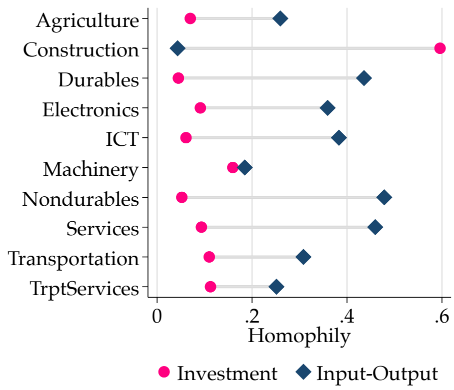


Middle income

(c) Outdegrees

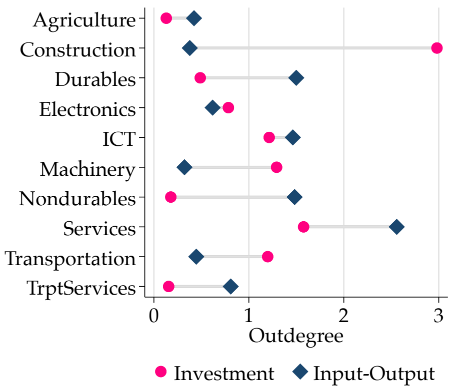


(d) Homophily

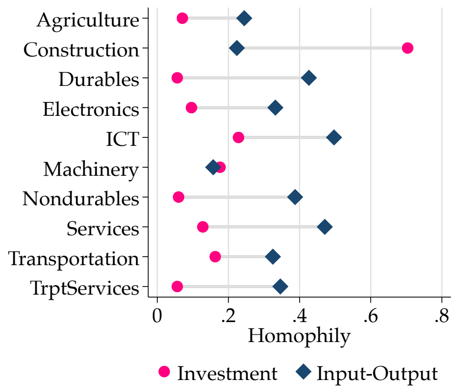


High income

(e) Outdegrees



(f) Homophily



Notes: Data for 2005, for Low, Middle and High income countries per the World Bank classification. Circles denote the investment network; diamonds denote the input–output network. Panel (a) reports sectorial outdegrees (row sums); panel (b) reports sectorial homophily (diagonal elements of each network).

Table 9: Input Output Outdegrees

Sector	Low income	Middle income	High income
Agriculture	0.97 (0.76 1.25)	0.53 (0.44 0.69)	0.42 (0.32 0.53)
Construction	0.20 (0.05 0.28)	0.10 (0.04 0.14)	0.38 (0.19 0.54)
Durables	1.87 (1.16 2.47)	1.79 (1.58 1.94)	1.50 (1.37 1.63)
Electronics	0.47 (0.04 0.69)	0.67 (0.51 1.01)	0.62 (0.43 0.73)
ICT	0.77 (0.44 0.88)	0.96 (0.69 1.13)	1.46 (1.17 1.66)
Machinery	0.17 (0.03 0.25)	0.34 (0.28 0.45)	0.32 (0.24 0.43)
Nondurables	1.72 (1.39 2.17)	2.08 (1.95 2.22)	1.48 (1.30 1.65)
Services	2.91 (2.35 3.57)	2.38 (2.20 2.59)	2.56 (2.28 2.81)
Transportation	0.25 (0.09 0.47)	0.43 (0.32 0.53)	0.45 (0.32 0.55)
TrptServices	0.68 (0.42 0.78)	0.71 (0.62 0.81)	0.81 (0.62 0.87)

Notes: Data for 2005, for Low, Middle and High income countries per the World Bank classification. Outdegrees are sectorial row sums in the investment network. Entries report means; values in parentheses are the 25th and 75th percentiles. Average GDP per capita (PPP): low 2587; middle 11110; high 35056.

Table 10: Investment Network Concentration Index

Sector	Low income	Middle income	High income
Agriculture	0.26 (0.19 0.35)	0.22 (0.17 0.25)	0.20 (0.15 0.22)
Construction	0.54 (0.35 0.80)	0.49 (0.28 0.70)	0.59 (0.40 0.78)
Durables	0.31 (0.18 0.44)	0.19 (0.17 0.19)	0.19 (0.16 0.20)
Electronics	0.36 (0.22 0.50)	0.24 (0.19 0.29)	0.20 (0.17 0.21)
ICT	0.43 (0.30 0.50)	0.36 (0.20 0.39)	0.21 (0.18 0.25)
Machinery	0.39 (0.21 0.60)	0.27 (0.20 0.29)	0.20 (0.17 0.21)
Nondurables	0.28 (0.17 0.42)	0.17 (0.16 0.18)	0.17 (0.14 0.18)
Services	0.36 (0.26 0.43)	0.36 (0.21 0.48)	0.26 (0.18 0.29)
Transportation	0.34 (0.23 0.48)	0.22 (0.18 0.25)	0.22 (0.17 0.23)
TrptServices	0.33 (0.26 0.38)	0.27 (0.18 0.30)	0.22 (0.16 0.24)

Notes: Data for 2005. Concentration index refers to the Herfindahl–Hirschman index computed as the squared sum of the elements of each column of the investment network. The lower the value of the index, the more diversified, with full-diversification achieved at 0.1. Entries report means; values in parentheses are the 25th and 75th percentiles. Average GDP per capita (PPP): low 2587; middle 11110; high 35056.

Table 11: Input-Output Concentration Index

Sector	Low income	Middle income	High income
Agriculture	0.34 (0.25 0.39)	0.30 (0.27 0.32)	0.27 (0.24 0.28)
Construction	0.38 (0.22 0.47)	0.28 (0.25 0.31)	0.23 (0.20 0.25)
Durables	0.35 (0.27 0.36)	0.28 (0.25 0.33)	0.28 (0.24 0.32)
Electronics	0.32 (0.23 0.35)	0.26 (0.21 0.32)	0.25 (0.20 0.28)
ICT	0.31 (0.25 0.36)	0.29 (0.26 0.31)	0.35 (0.31 0.38)
Machinery	0.30 (0.23 0.35)	0.23 (0.21 0.25)	0.21 (0.18 0.24)
Nondurables	0.31 (0.29 0.33)	0.32 (0.28 0.36)	0.28 (0.24 0.29)
Services	0.27 (0.22 0.32)	0.29 (0.27 0.33)	0.29 (0.26 0.31)
Transportation	0.28 (0.19 0.33)	0.23 (0.20 0.24)	0.23 (0.18 0.25)
TrptServices	0.31 (0.25 0.39)	0.26 (0.23 0.29)	0.26 (0.23 0.27)

Notes: Data for 2005. Concentration index refers to the Herfindahl–Hirschman index computed as the squared sum of the elements of each column of the input-output network. The lower the value of the index, the more diversified, with full-diversification achieved at 0.1. Entries report means; values in parentheses are the 25th and 75th percentiles. Average GDP per capita (PPP): low 2587; middle 11110; high 35056.

Table 12: Investment Network Homophily

Sector	Low income	Middle income	High income
Agriculture	0.09 (0.00 0.16)	0.07 (0.01 0.07)	0.07 (0.02 0.12)
Construction	0.45 (0.00 0.90)	0.60 (0.48 0.83)	0.70 (0.61 0.88)
Durables	0.09 (0.02 0.12)	0.04 (0.04 0.05)	0.06 (0.03 0.08)
Electronics	0.08 (0.01 0.14)	0.09 (0.06 0.11)	0.10 (0.06 0.12)
ICT	0.02 (0.00 0.03)	0.06 (0.04 0.10)	0.23 (0.15 0.30)
Machinery	0.16 (0.01 0.25)	0.16 (0.09 0.24)	0.18 (0.14 0.22)
Nondurables	0.08 (0.01 0.14)	0.05 (0.01 0.09)	0.06 (0.04 0.08)
Services	0.10 (0.03 0.15)	0.09 (0.07 0.10)	0.13 (0.09 0.16)
Transportation	0.05 (0.02 0.07)	0.11 (0.06 0.13)	0.16 (0.10 0.19)
TrptServices	0.03 (0.00 0.04)	0.11 (0.03 0.12)	0.06 (0.03 0.08)

Notes: Data for 2005, for Low, Middle and High income countries per the World Bank classification. Homophily consists on the diagonal elements of the network, i.e., how important are sectors are provider of investment inputs for themselves. Entries report means; values in parentheses are the 25th and 75th percentiles. Average GDP per capita (PPP): low 2587; middle 11110; high 35056.

Table 13: Input-Output Homophily

Sector	Low income	Middle income	High income
Agriculture	0.41 (0.27 0.54)	0.26 (0.18 0.32)	0.24 (0.16 0.33)
Construction	0.07 (0.00 0.13)	0.04 (0.01 0.05)	0.22 (0.06 0.35)
Durables	0.33 (0.13 0.49)	0.44 (0.41 0.50)	0.43 (0.37 0.47)
Electronics	0.20 (0.01 0.30)	0.36 (0.20 0.51)	0.33 (0.22 0.46)
ICT	0.27 (0.14 0.52)	0.38 (0.32 0.45)	0.50 (0.44 0.55)
Machinery	0.06 (0.01 0.10)	0.18 (0.12 0.22)	0.16 (0.09 0.21)
Nondurables	0.32 (0.23 0.44)	0.48 (0.41 0.54)	0.39 (0.35 0.44)
Services	0.39 (0.27 0.46)	0.46 (0.44 0.50)	0.47 (0.42 0.50)
Transportation	0.15 (0.01 0.25)	0.31 (0.25 0.40)	0.32 (0.21 0.40)
TrptServices	0.18 (0.05 0.35)	0.25 (0.18 0.31)	0.35 (0.25 0.42)

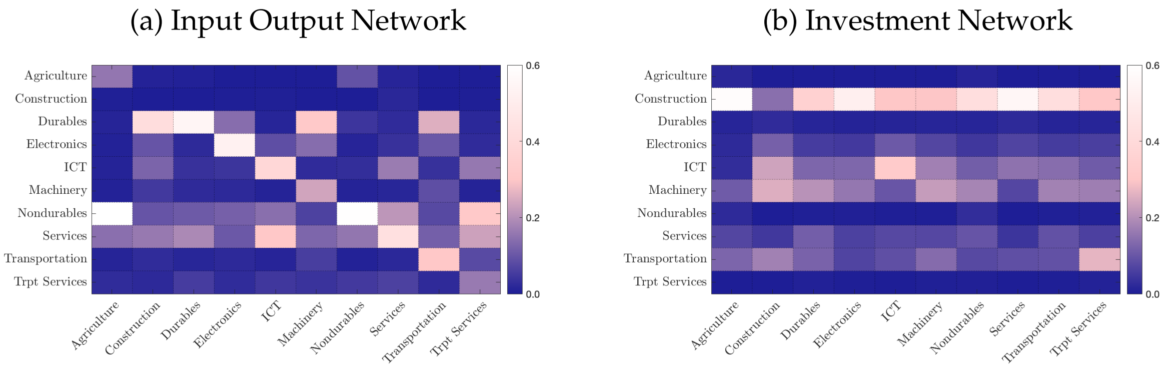
Notes: Data for 2005, for Low, Middle and High income countries per the World Bank classification. Homophily consists on the diagonal elements of the network, i.e., how important are sectors are provider of intermediate inputs for themselves. Entries report means; values in parentheses are the 25th and 75th percentiles. Average GDP per capita (PPP): low 2587; middle 11110; high 35056.

Table 14: Sectorial Influence

Sector	Low income	Middle income	High income
Agriculture	0.38 (0.28 0.51)	0.15 (0.08 0.20)	0.04 (0.02 0.06)
Construction	0.17 (0.07 0.26)	0.25 (0.21 0.33)	0.19 (0.13 0.21)
Durables	0.13 (0.05 0.18)	0.20 (0.13 0.21)	0.13 (0.10 0.16)
Electronics	0.05 (0.01 0.05)	0.10 (0.05 0.10)	0.06 (0.04 0.07)
ICT	0.14 (0.10 0.15)	0.23 (0.16 0.29)	0.31 (0.25 0.37)
Machinery	0.03 (0.01 0.04)	0.07 (0.05 0.08)	0.04 (0.03 0.06)
Nondurables	0.20 (0.10 0.31)	0.34 (0.23 0.44)	0.13 (0.09 0.15)
Services	0.67 (0.59 0.80)	0.69 (0.51 0.84)	0.75 (0.69 0.81)
Transportation	0.03 (0.01 0.05)	0.07 (0.05 0.08)	0.04 (0.03 0.06)
TrptServices	0.10 (0.07 0.13)	0.14 (0.09 0.15)	0.11 (0.08 0.12)

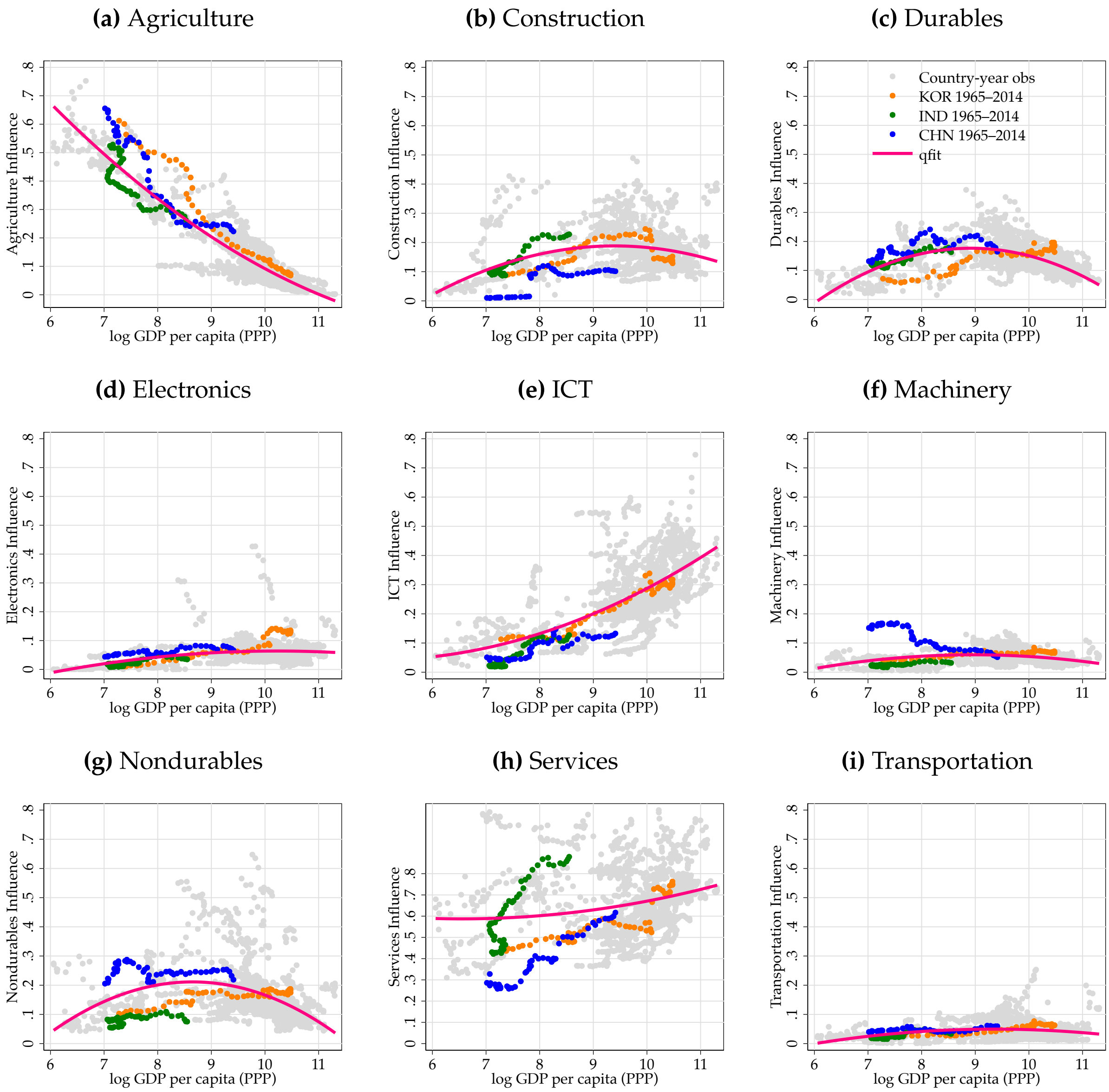
Notes: Data for 2005, for Low, Middle and High income countries per the World Bank classification. Sectorial influence is defined as $\Phi\tilde{\eta}\Gamma$ in Proposition 4, and measures the change in aggregate value added following a change in sectorial productivity. Entries report means; values in parentheses are the 25th and 75th percentiles. Average GDP per capita (PPP): low 2587; middle 11110; high 35056.

Figure 11: South Korea: Investment Network vs. Input–Output Network, 2014



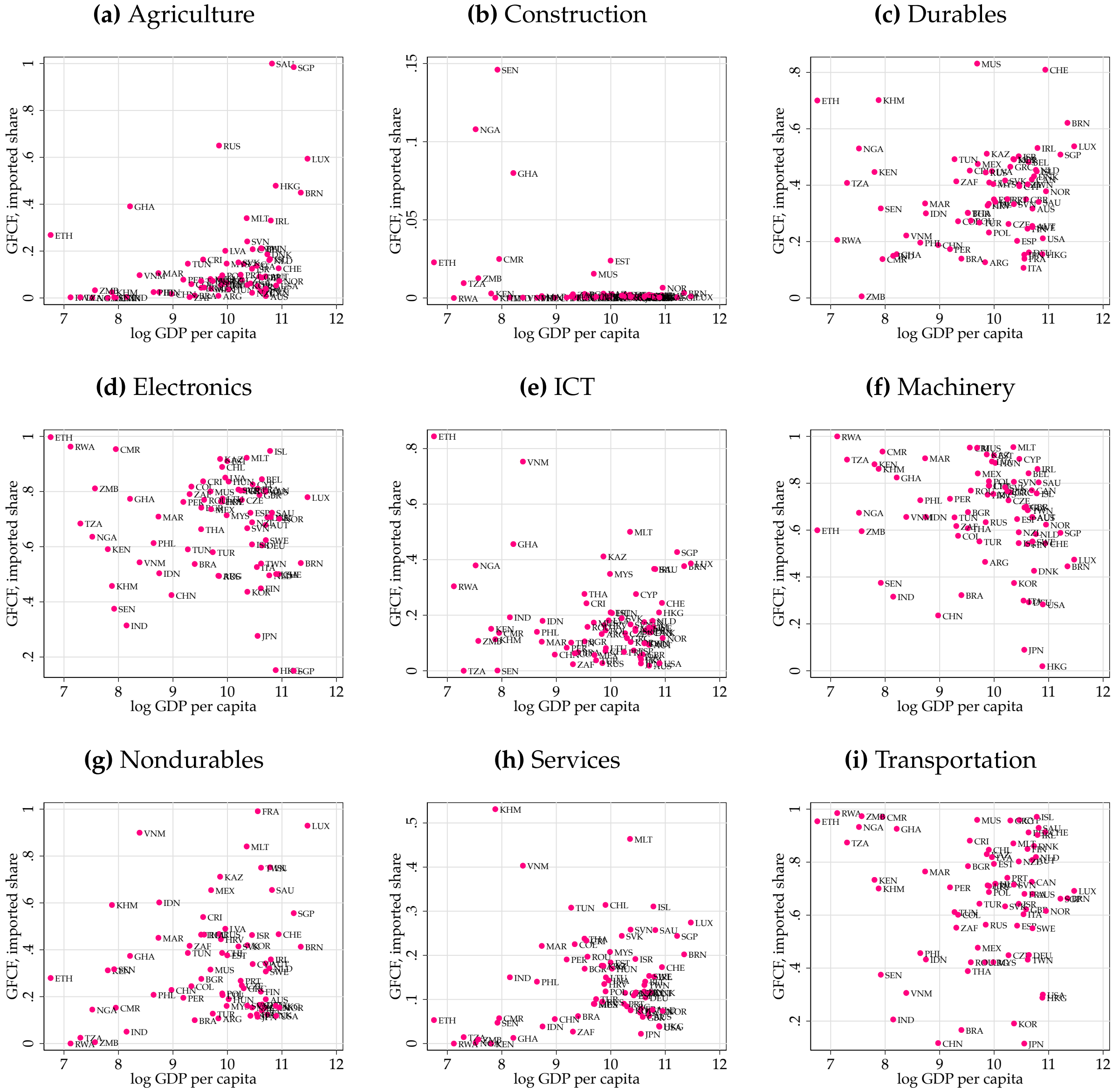
Notes: Estimates of the investment network and the input–output network in South Korea, 2014.

Figure 10: Sectorial Influence Along Development



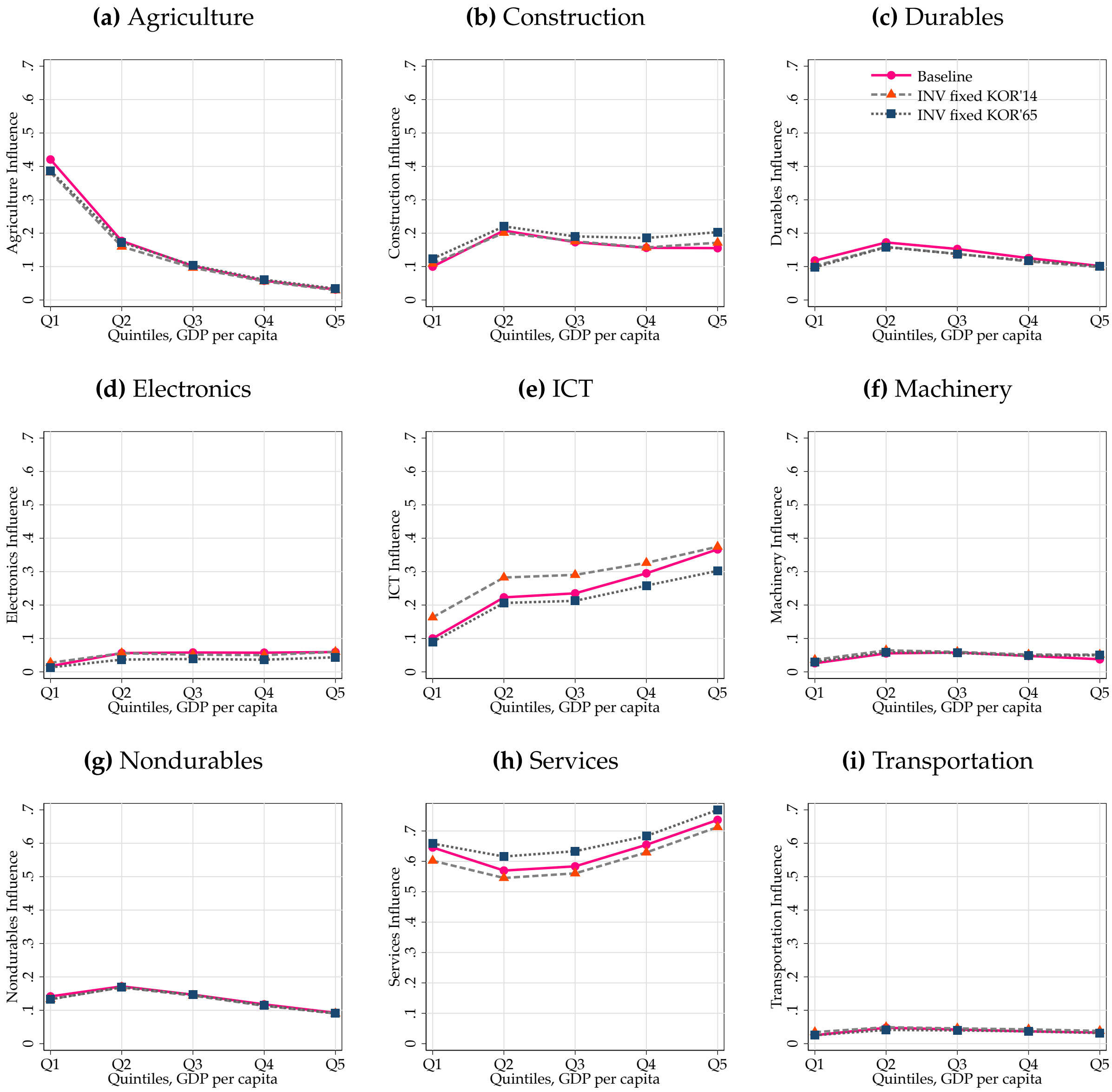
Notes: Data for all country-years in the sample. Sectorial influence is defined as $\Phi\tilde{\eta}\Gamma$ in Proposition 4, and measures the change in aggregate value added following a change in sectorial productivity. Dots represent country–year observations; South Korea (1965–2014), India (1965-2014) and China (1965-2014) are highlighted.

Figure 12: Sectorial Investment, Imported Share



Notes: Data for all country-years in the sample. For each sector, the share of total gross fixed capital formation (GFCF) sourced from abroad.

Figure 13: Counterfactual Sectorial Influence



Notes: Median sectorial influence by quintile of income per capita, using all country–year observations. Sectorial influence is defined as $\Phi\tilde{\eta}\Gamma$ in Proposition 4, and measures the change in aggregate value added following a change in sectorial productivity. *Baseline* (circle line): median influence using data for each country–year. *INV fixed KOR 65*: fixes sectorial the investment network to that of South Korea in 1965. *INV fixed KOR 14*: fixes the investment network to that of South Korea in 1965.