Sectoral Multipliers and Technology Adoption as Insight Into Growth

By *Nicholas Trachter* and *Lindsay Li*

Economic Brief
August 2024, No. 24-27

In a multisector model with technology adoption and rich network structures, what policy instruments best reduce distortions and promote economic development? This article discusses a framework showing that technology adoption has important effects on both the magnitude and relative effectiveness of sectoral industrial policies. After applying the framework to data on the Indian economy, adoption subsidies prove the most cost-effective instrument with high sectoral multipliers and relatively lower fiscal costs of implementation. Particularly promising sectors emerge that stand to foster the most growth from such subsidies.

Sectoral industrial policy refers to policy that aims to stimulate growth by targeting specific sectors within the economy. This approach recognizes that sectors are interconnected through input-output linkages, and related literature often explores the way shocks and distortions propagate through these sectoral linkages across the economy. Because of this propagation aspect, sectoral industrial policy instruments have an overall impact that surpasses their direct, initial effect. This amplification is interpreted as a multiplier.

My (Nicholas') working paper "Sectoral Development Multipliers" — co-authored with Francisco Buera of Washington University in St. Louis — formalizes a model that introduces technology adoption within this kind of multisector structure. We study the interaction of technology choice with various policy instruments, as well as the implications of this interaction both on growth and on the wedge between optimal and realized levels of modern technology adoption. As established in previous work on distorted economies,[1] distortions may impede economic development in less-developed countries due to low levels of modern technology adoption.

In our framework, establishments in a multisector economy either employ a traditional technology or pay for "adoption goods" that allow them to employ a modern, more productive technology. Adoption goods capture such factors as more efficient capital that might be necessary to harness modern technology. Importantly, establishments operate within an input-output network, where outputs from one sector can serve as intermediate inputs for another, creating a complex system of interdependencies. It is through these types of networks that shocks to one sector generate ripple effects.

Sectoral Development Instruments and Feedback Loops

Typically, policy tools designed to encourage sectoral development take the form of sector-level subsidies. Different types of subsidies — such as revenue subsidies, intermediate input subsidies, labor subsidies and technology adoption subsidies — support establishments in different ways. For example, technology adoption subsidies reduce the cost of adopting modern technology, thus allowing for increased adoption.

We define a sectoral development multiplier for a particular sector as the elasticity of aggregate consumption to the relevant subsidy, relative to the fiscal cost required to implement such a policy. That is, the multiplier comprises the change in aggregate consumption after a subsidy in one specific sector. In this definition, the inclusion of fiscal costs recognizes the budget constraints policymakers must face when implementing policy. A multiplier above 1 denotes that consumption will rise by more than the fiscal cost of financing the subsidy, and a multiplier below 1 would indicate a relatively less cost-effective policy.

How might endogenous technology adoption affect the mechanisms of industrial policies? Absent technology adoption, a policy like a revenue subsidy would reduce the marginal cost of production, which would propagate through input-output structures as falling output costs contribute to falling intermediate input prices, and so on. An object known as the Leontief inverse mathematically characterizes the effects that emerge through these infinite rounds of interactions in a multisector economy.[2]

Introducing technology adoption extends the Leontief inverse in what we term the double-Leontief inverse. Essentially, this captures the existence of multiple feedback loops through which instruments like adoption subsidies can spur further technology adoption: One feedback loop sees adoption in one sector reducing the marginal cost of production in that sector, which is then transmitted through all sectors as in the logic above. This increases the profits that establishments stand to gain by adopting modern technology, thus increasing adoption levels. A second feedback loop involves the heightened productivity stemming from technology adoption leading to lower sector prices. Because of lower prices, the price of adoption for other establishments is reduced, spurring further adoption, and so on.

Quantitative Application to the Indian Economy

To make quantitative statements about the relative effectiveness of different subsidies as policy instruments, we apply our model to data on the Indian economy. Data on the size distribution of establishments by sector are obtained from the Sixth Indian Economic Census (from 2013-14), and data from the World Input-Output Database and on the investment network from the 2022 paper "The Investment Network, Sectoral Comovement and the Changing U.S. Business Cycle"[3] are used to calibrate sectoral linkages.

Regarding estimation of the parameters governing technology distribution, we present an identification strategy based on heterogeneity in employment-size distributions across sectors. If there is no variation in technology use type in a sector, the employment-size distribution will be unimodal, meaning that the shape of the distribution has one distinct peak.

Alternatively, the existence of modern technology adoption in a sector generates bimodality (two distinct peaks). A bimodal distribution suggests that both small and large establishments are highly relevant in the sector, with relatively fewer medium-sized firms. Intuitively, modern technology adoption may make this possible by allowing larger firms to achieve significant economies of scale while allowing smaller firms to leverage productive technology to remain competitive despite their size.

After structurally estimating the parameters of the model, large heterogeneity is evident over several measures. For one, the share of modern establishments across sectors sees considerable variation: Figure 1 shows that they account for 60 percent of value-added share in mining, while only 0.4 percent in wood manufacturing. Consistent with this, the relative cost of adoption in mining is not extreme, whereas the relative cost of adoption in wood manufacturing is much higher.

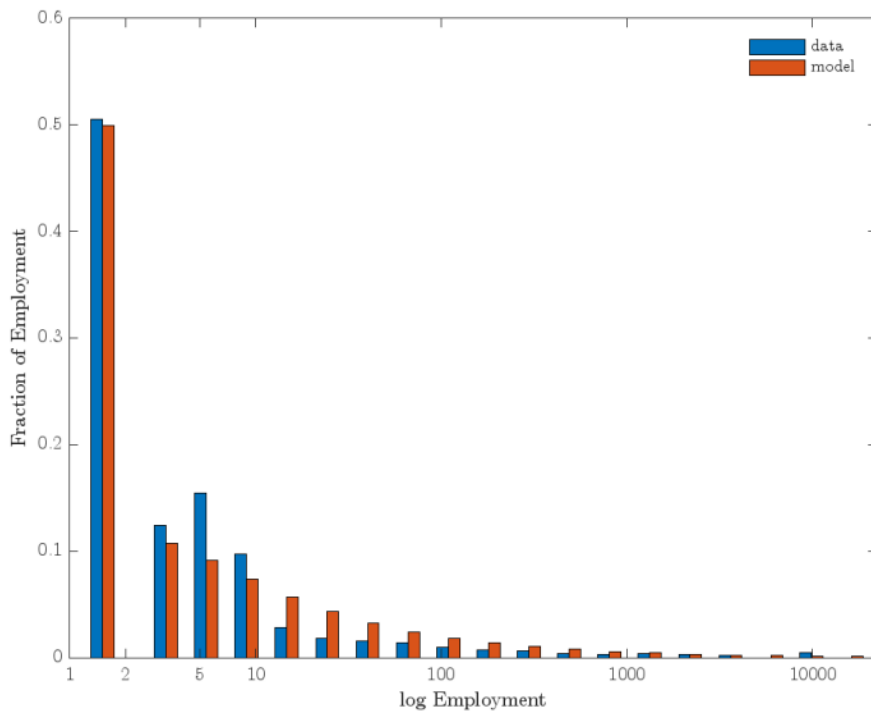**Figure 1a: Examples of Employment Share Distributions**
Mining
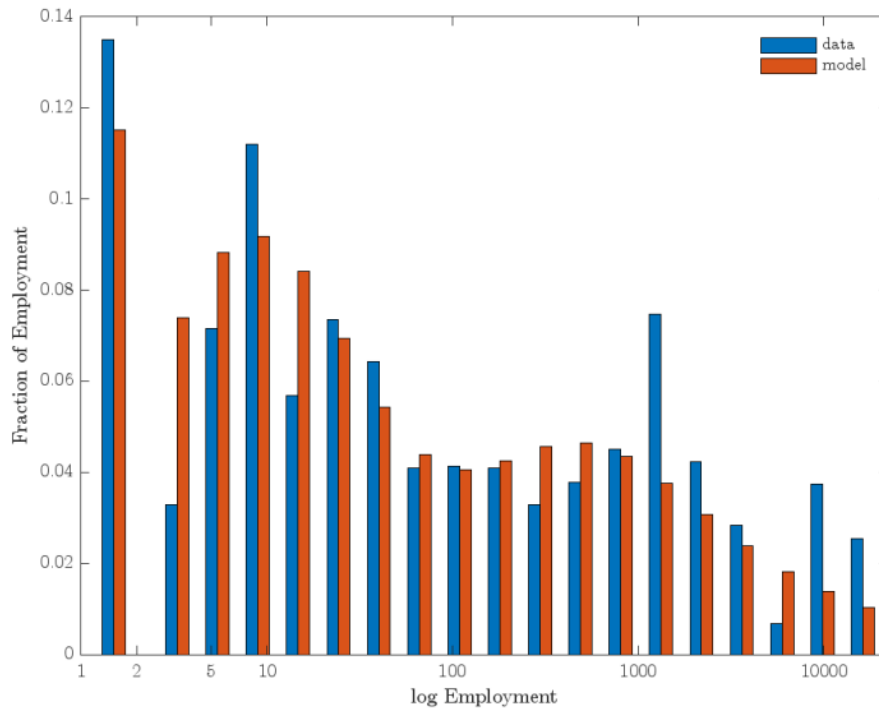
Source: The 2024 working paper "Sectoral Development Multipliers" by Francisco Buera and Nicholas Trachter.

Enlarge

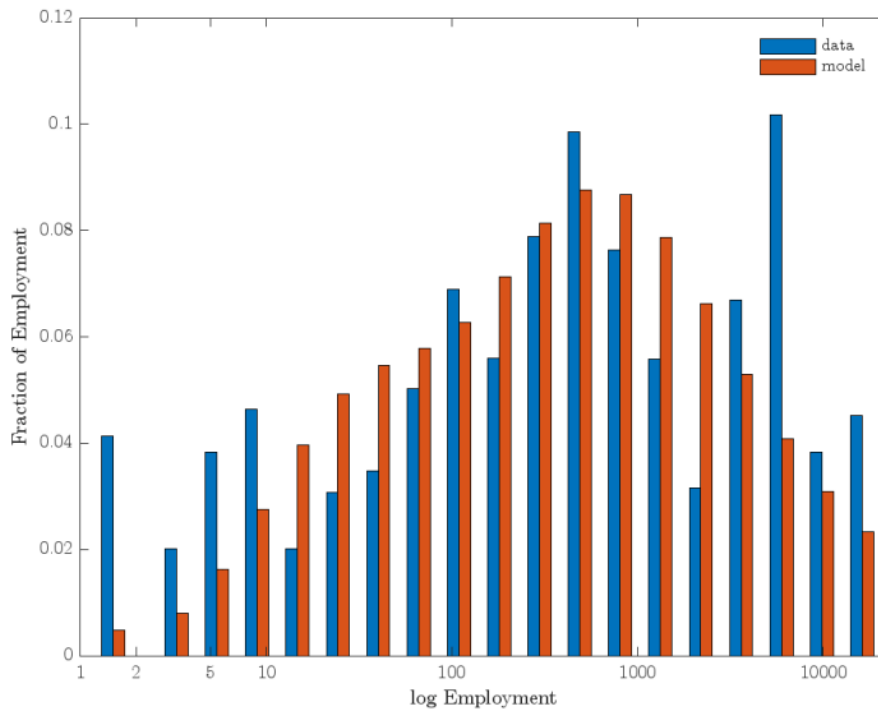**Figure 1b: Examples of Employment Share Distributions**
M-Wood

Source: The 2024 working paper "Sectoral Development Multipliers" by Francisco Buera and Nicholas Trachter.

Enlarge

Figure 1c: Examples of Employment Share Distributions
M-Motor Vehicles

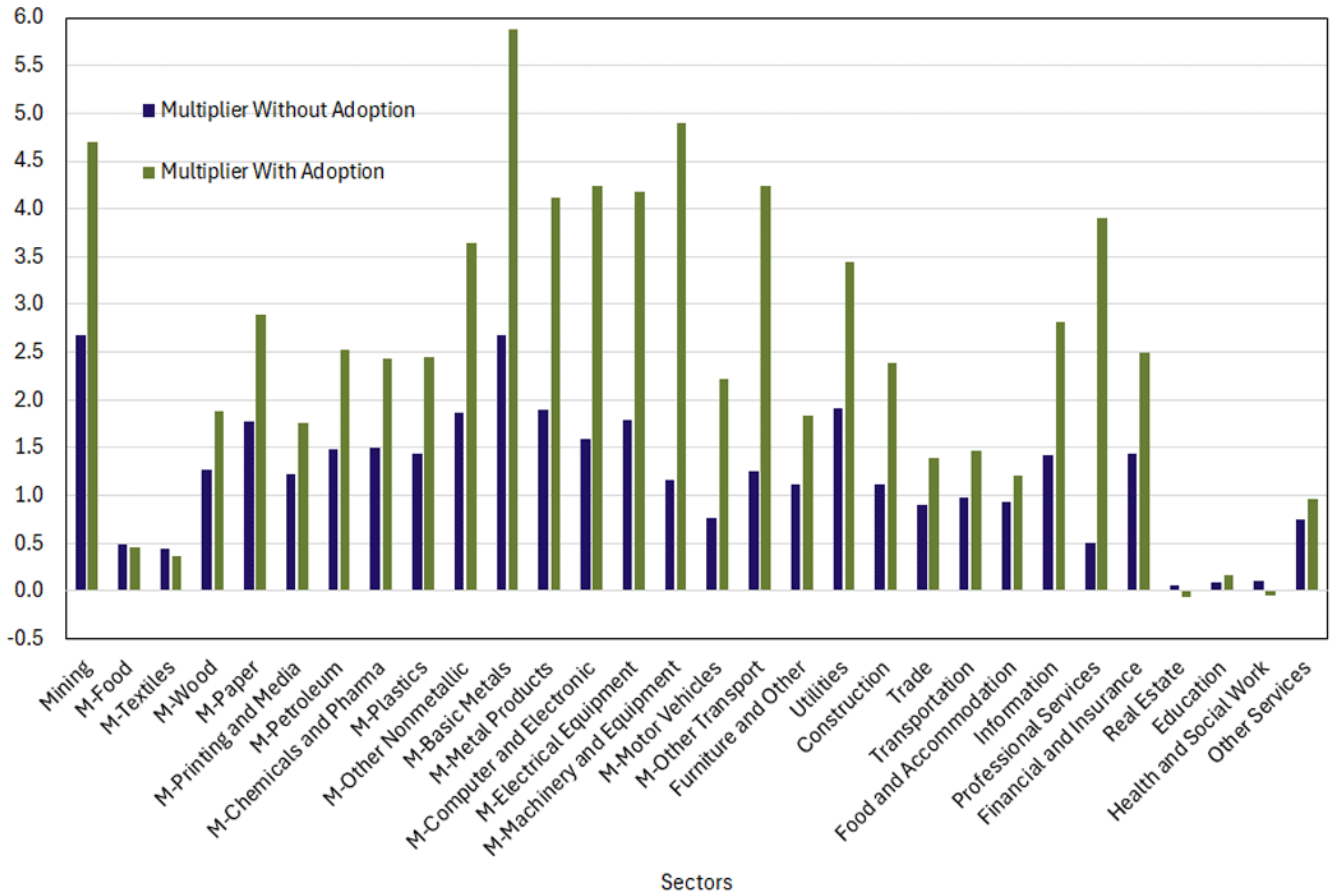Source: The 2024 working paper "Sectoral Development Multipliers" by Francisco Buera and Nicholas Trachter.

[Enlarge]

For another, some sectors seem to be cost effective for implementing revenue subsidies — that is, the multiplier is greater than 1 — while others would be cost ineffective, and still others are such that it would be detrimental to subsidize them at all (that is, having a multiplier less than zero).

The Role of Adoption and the Most Effective Policy Instrument

The difference in revenue multipliers between an economy with and without adoption manifests strongly in some key sectors, while barely affecting others: Figure 2a illustrates the multipliers in purple and green for these two respective instances.

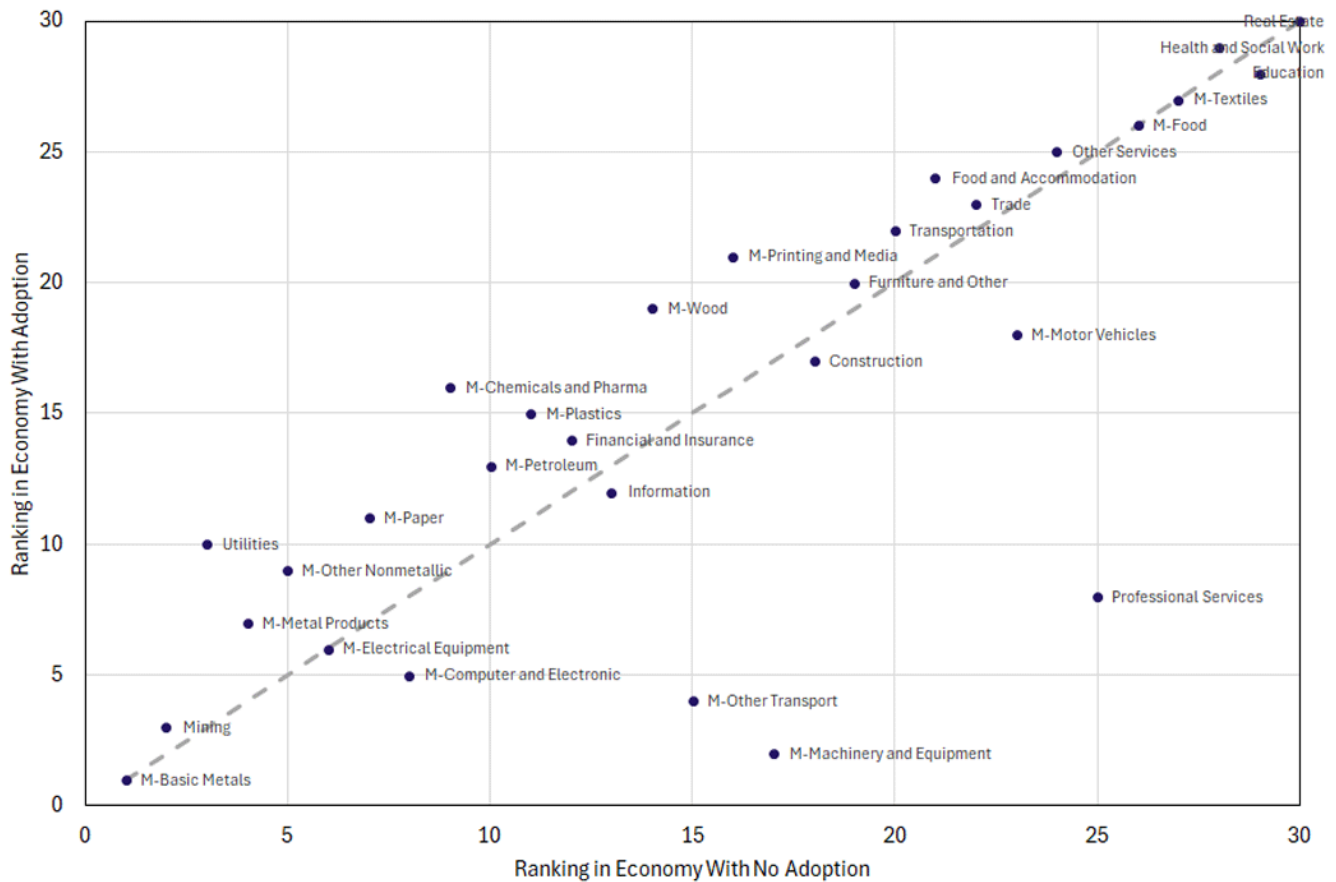**Figure 2a: Multipliers With and Without Adoption and Entry**

Source: The 2024 working paper "Sectoral Development Multipliers" by Francisco Buera and Nicholas Trachter.

Enlarge

Not only does the introduction of technology adoption heterogeneously amplify sectoral multipliers, but it also substantially changes the ranking of key sectors in terms of their cost effectiveness for revenue subsidies, as seen in Figure 2b.
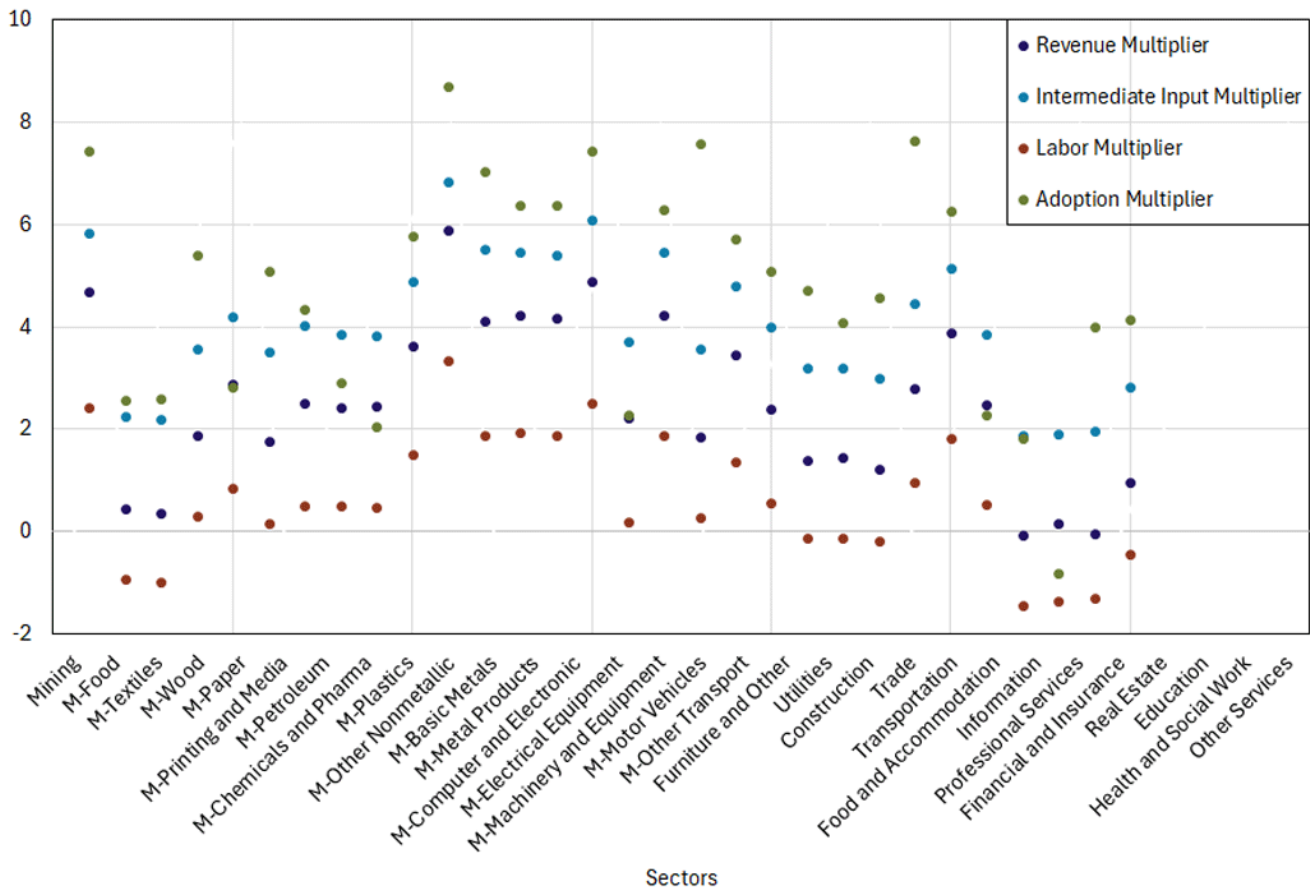
Figure 2b: Ranking

Source: The 2024 working paper "Sectoral Development Multipliers" by Francisco Buera and Nicholas Trachter.

Enlarge

The most promising five sectors in an economy without adoption are basic metals manufacturing, mining, utilities, metal products manufacturing, and other nonmetallic manufacturing. With adoption, they are basic metals manufacturing, machinery and equipment manufacturing, mining, computer and electronic manufacturing, and electrical equipment manufacturing. For policymakers deciding on the financing of these industrial policy tools, then, considering the adoption margin is crucial.

We now turn to assessing alternative policy instruments. Revenue and technology adoption subsidies — as well as labor and intermediate input subsidies — are ranked in terms of the magnitude of their multipliers across the 30 sectors of our data in Figure 3.

Figure 3: Multipliers Under Alternative Policy Instruments

Source: The 2024 working paper "Sectoral Development Multipliers" by Francisco Buera and Nicholas Trachter.

Enlarge

Subsidies differ in both the way they promote development and their fiscal cost of implementation. Due to a broad aim of increasing revenue across establishments, for example, revenue subsidies incur a larger fiscal cost than technology adoption subsidies, where the cost applies only to the share of establishments operating with traditional technology. Figure 3 shows that sectors with high revenue multipliers tend to be disproportionately smaller to offset this higher fiscal cost.

But despite these distinctions, the rankings are widely consistent across the board: Labor subsidies are the least-effective policy tool, revenue subsidies are better than labor subsidies but worse than intermediate input subsidies, and adoption subsidies seem to be the most cost-effective way to promote development.

Nicholas Trachter is a senior economist and research advisor and Lindsay Li is a research associate in the Research Department at the Federal Reserve Bank of Richmond.

1 *See my 2021 working paper "Big Push in Distorted Economies," co-authored with Francisco Buera, Hugo Hopenhayn and Yongseok Shin.*

2 *Here, the Leontief inverse is defined as (I−vΩ)-1=I+vΩ+v2Ω2+v3Ω3+... where v is the intermediate input elasticity and Ω refers to the production network.*

3 *Authored by Christian vom Lehn and Thomas Winberry.*

To cite this Economic Brief, please use the following format: Trachter, Nicholas; and Li, Lindsay. (August 2024) "Sectoral Multipliers and Technology Adoption as Insight Into Growth." *Federal Reserve Bank of Richmond Economic Brief*, No. 24-27.

Topics

Economic Growth   Production and Investment

Subscribe to Economic Brief

Receive a notification when Economic Brief is posted online.

By submitting this form you agree to the **Bank's Terms & Conditions and Privacy Notice.**

Email Address

Subscribe

📞 **Contact Us**

RC Balaban

(804) 697-8144