Intangible Capital, Multinational Production, and Productivity Growth*

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Abstract

Over the past three decades, the global economy has experienced secular trends: the rise of intangible capital, the expansion of multinational enterprises (MNEs), and the growing prevalence of international profit shifting. Using firm-level data, we document that these trends are strongly positively related and increasingly concentrated among high-productivity firms. To interpret these patterns, we develop a quantitative general equilibrium model in which firms invest in intangible capital, expand across borders, and reallocate profits across jurisdictions. A central feature of the model is that intangible capital is nonrival and can be deployed across multiple production locations. This generates scalable complementarity: multinational expansion raises the return to intangible investment by increasing scale, while greater intangible intensity strengthens incentives to expand globally. Quantitative exercises show that this mechanism produces superlinear responses in firm scale and profit shifting and contributes importantly to aggregate productivity growth through reallocations toward large, intangible-intensive multinational firms.

Keywords: Economic growth; intangible capital; multinational production; total factor productivity; firm heterogeneity; globalization.

JEL Codes: E23, F23, O33, O41, H25, D24

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1 Introduction

Over the past four decades, two key trends have dramatically reshaped the global economy: the rise of intangible capital and the expansion of multinational production. We argue that these trends are tightly linked through the nonrival nature of intangible capital and that their interaction has first-order implications for aggregate productivity growth. Unlike tangible capital, intellectual property, software, and other intangible assets can be deployed simultaneously across multiple production locations. This scalability implies that multinational firms have stronger incentives to invest in intangible capital than purely domestic firms, while firms with higher intangible intensity have greater incentives to expand their production footprint across borders. As a result, reductions in barriers to multinational production raise intangible intensity, while intangible-biased technological change or declines in the cost of producing intangible capital increase multinational activity. Through these channels, the joint rise of intangibles and multinational production generates economy-wide efficiency gains that appear as measured total factor productivity (TFP), rather than as standard factor deepening. We develop a quantitative model to discipline the importance of these forces and to measure their contribution to the observed rise in intangible intensity, multinational production, and aggregate productivity.

These trends have first-order implications for aggregate productivity growth. Because intangible capital is nonrival and can be deployed simultaneously across production locations, increases in intangible intensity translate into economy-wide efficiency gains that appear as measured total factor productivity (TFP). We show that the joint rise of intangibles and multinational production—amplified by their complementarity—accounts for a substantial share of post-1995 TFP growth, operating primarily through reallocations toward high-productivity, intangible-intensive multinationals rather than uniform technical progress. This provides a structural interpretation of the sources and distribution of recent productivity growth.

In addition to these two trends, we consider a third, closely related development: the rise of international profit shifting by multinational firms. Empirical evidence indicates that intangible capital plays a central role in profit shifting, as it is highly mobile and difficult to value, making it particularly amenable to transfer pricing. As shown by Dyrda, Hong, and Steinberg (2024a), profit shifting raises multinationals' incentives to invest in intangible capital by lowering effective tax rates on intangible income. At the same time, higher intangible intensity expands the scope for profit shifting, reinforcing firms' incentives to reallocate profits across jurisdictions. We extend our baseline framework to incorporate profit shifting as an endogenous margin and use the model to decompose the joint evolution of intangible investment, multinational production, and profit shifting into changes in production technologies, globalization frictions, and the costs of shifting profits.

Our first contribution is to document these interconnected trends using linked firm-level data from Compustat and U.S. Securities and Exchange Commission (SEC) disclosures. Intangible intensity—measured as the ratio of intangible assets (including capitalized R&D) to total assets—more than doubled among U.S. public firms between 1995 and 2023, rising from 22% to 42%. This increase occurred broadly across industries and is driven primarily by within-industry changes rather than sectoral reallocation. Over the same period, multinational activity expanded sharply: the share of firms operating foreign subsidiaries rose from 16% to 38%, and the average foreign sales share of multinational enterprises (MNEs) increased from 10% to 27%. Profit shifting, proxied by tax-haven subsidiary ownership, grew in parallel—peaking at 74% of MNEs in 2017 before declining following the Tax Cuts and Jobs Act (TCJA).

Cross-sectional evidence reveals that these trends are closely linked at the firm level. Multinational firms exhibit substantially higher intangible intensity than purely domestic firms, with an average gap of 11.1 percentage points that widens after 2005. Firms operating in a larger number of countries or engaging in profit shifting display even higher intangible intensity. These relationships are strongly structured by firm productivity: more productive firms are both more intangible-intensive and more likely to operate as multinationals, and the positive relationship between productivity and intangible intensity is steepest among firms with multinational activity. Together, these patterns indicate that the rise of intangible capital and multinational production is concentrated among high-productivity firms that rely more heavily on scalable, nonrival inputs.

To examine how these relationships evolve over time, we employ an event-study framework that traces firms before and after multinational entry or the initiation of profit-shifting activity. Firms that become multinationals experience a sustained increase in intangible intensity by 6 percentage points following entry, while firms initiating profit shifting exhibit a rise by 3 percantage points. These dynamic responses are consistent with a mechanism in which multinational expansion raises the return to intangible investment by increasing the scale over which intangibles can be deployed. Taken together with the cross-sectional evidence, the event-study patterns highlight the joint role of productivity heterogeneity, intangible investment, and multinational expansion in shaping firms' organizational choices over time.

While these empirical patterns are informative, they are not sufficient to identify the forces driving the joint evolution of intangible intensity, multinational production, and profit shifting and their macroeconomic implications. First, both the cross-sectional relationships and the dynamic responses around multinational entry reflect endogenous firm decisions: firms choose when to expand and invest based on expected returns, making it difficult to isolate causal effects using reduced-form variation alone. Second, firm-level empirical designs necessarily abstract from general equilibrium effects. Changes in intangible investment or multinational activity at the firm level may have aggregate price, scale, and reallocation effects that are absorbed by time fixed effects or common trends, creating a missing-intercept problem when interpreting aggregate implications. Third, reduced- form evidence does not provide the economic structure required to conduct counterfactual analysis or to decompose observed trends into underlying technological, globalization, and tax forces. These limitations motivate a quantitative general equilibrium framework that explicitly models firms' endogenous choices, accounts for equilibrium feedbacks, and allows us to trace the structural mechanisms linking intangibles, multinational expansion, and productivity.

Motivated by these empirical patterns, we develop a structural framework that links the rise of intangible capital, multinational expansion, and profit shifting within a unified economic environment. This framework, our second contribution, models firms' decisions to invest in intangibles, expand across borders, and reallocate profits as jointly determined outcomes of productivity heterogeneity, scalable technologies, and globalization frictions. By embedding these choices in a multi-region general equilibrium setting, the model captures equilibrium feedbacks, selection into multinational activity, and the interaction between firm organization and aggregate outcomes. A central feature of the framework is the nonrival nature of intangible capital: intangibles are developed at the firm's headquarters but can be deployed simultaneously across multiple production locations, shaping both the incentives to expand internationally and the aggregate consequences of globalization.

We formalize the nonrival nature of intangible capital as a technological feature that allows a firm to deploy the same stock of intangible assets across multiple production locations simultaneously. Intangible capital is developed at the firm's headquarters and enters production in each subsidiary alongside locally hired rival inputs, implying that the return to intangible investment rises with the firm's multinational scope. Building on our prior work (Dyrda et al., 2024a), we incorporate profit shifting through transfer pricing of intangible assets, allowing multinational firms to reallocate ownership of intangible capital—at a cost—to low-tax jurisdictions.

Within this framework, two mechanisms link intangible investment, multinational expansion, and profit shifting. First, reductions in the cost of producing intangible capital and declines in barriers to multinational expansion act as scalable complements: each force independently raises intangible intensity and the propensity to operate abroad, but their joint effect is superlinear. Second, profit shifting emerges endogenously from the interaction of tax differentials, enforcement costs, and intangible scalability, further amplifying firms' incentives to invest and expand. Together, these mechanisms generate mutually reinforcing dynamics in intangible intensity, multinational production, and profit shifting.

Our third contribution is a quantitative analysis that disciplines the model and connects its firm-level mechanisms to aggregate trends. While full counterfactual decompositions are ongoing, we present preliminary results that illustrate the model's core mechanisms and quantify key complementarities. This analysis is designed to serve two purposes: to organize the data around a coherent structural framework, and to quantify the relative importance of technological change, globalization, and tax incentives in shaping firms' organizational choices. The quantitative strategy is deliberately parsimonious, focusing on the key margins emphasized by the theory.

We proceed in three steps. First, we infer time paths for the model's key primitives over the period 1995–2023 so that the framework rationalizes the observed joint rise in intangible intensity and multinational activity. In particular, we back out changes in the cost of intangible investment and in globalization frictions that are consistent with the evolution of these two aggregate trends. This exercise is best interpreted as a structural accounting, in which the inferred wedges summarize the forces required for the model to replicate the data. Importantly, this approach does not mechanically pin down complementarities. The strength of the interaction between intangible investment and multinational expansion is not targeted or imposed, but instead emerges endogenously from firms' optimal responses to the inferred wedges, the nonrival nature of intangible capital, and productivity heterogeneity. Once the wedges are disciplined by the aggregate trends, the model generates additional implications—for firm-level behavior, selection into multinational activity, and aggregate productivity—that are not directly targeted and therefore provide discipline on the underlying mechanisms.

Second, we use the model for external validation by asking whether it reproduces key cross-sectional and dynamic patterns documented in the data that are not targeted in the inference of aggregate wedges. In particular, we examine whether the model generates the strong positive relationship between intangible intensity, multinational status, and productivity, as well as the evolution of intangible investment around multinational entry and the initiation of profit-shifting activity. This exercise evaluates whether the model's structural mechanisms— nonrival intangible capital, endogenous multinational expansion, and productivity-driven selection—are capable of replicating the magnitude and structure of the empirical interdependence across firms without being imposed by construction.

Third, we use the model to conduct counterfactual experiments that isolate and decompose the roles of technological change, globalization, and tax incentives in shaping firm behavior. Using the inferred paths of intangible investment costs and globalization frictions, we compare counterfactual scenarios in which individual forces are held fixed at their initial levels to scenarios in which multiple forces evolve simultaneously. Tax incentives enter these exercises as part of the policy environment and are varied directly in counterfactuals, rather than inferred from aggregate trends. These experiments allow us to quantify how much of the rise in intangible intensity, multinational activity, and profit shifting is attributable to each force on its own, and how much arises from their interaction. In particular, the counterfactuals make it possible to assess the extent to which complementarities between intangible investment and multinational expansion amplify firm-level responses beyond what would be implied by partial-equilibrium effects.

Using the model's counterfactual structure, we decompose the component of aggregate productivity growth generated by these forces into contributions from cheaper intangibles, globalization, and their interaction, and trace how these gains are distributed across firms and production locations. A key implication is that productivity growth generated by scalable intangibles is highly uneven: it is disproportionately driven by multinational firms—particularly through foreign-owned production—and concentrated among the most productive firms. In this sense, the paper provides a structural interpretation of how globalization and the rise of intangibles jointly shape not only firm organization, but also the sources and allocation of aggregate productivity growth.

Related Literature. Our paper builds on the idea that nonrival intangible assets generate powerful scale effects. McGrattan and Prescott (2009, 2010) formalize technology capital as a nonrival input deployable across locations in open economies, while Jones and Tonetti (2020), Perla, Tonetti, and Waugh (2021), and Benhabib, Perla, and Tonetti (2021) emphasize how scalable technologies and their diffusion shape reallocation and growth. We contribute to this strand of the literature by embedding these nonrivalry forces in a quantitative model of heterogeneous multinational firms where the global footprint is an endogenous choice, and by quantifying how changes in frictions to operating abroad translate into the joint distribution of firm scale, intangible intensity, and aggregate outcomes in general equilibrium.

Relatedly, recent work links rising concentration and firm scale to the growing importance of intangible capital and to changes in the costs of operating at large scale. Crouzet, Eberly, Eisfeldt, and Papanikolaou (2022) document that intangible-intensive firms are systematically larger, more scalable, and account for a rising share of aggregate activity, while Aghion, Bergeaud, Boppart, Klenow, and Li (2023) and Klenow and Li (2025) emphasize how shifts in entry and expansion costs generate endogenous concentration and declining dynamism. Our framework complements these contributions by providing an open-economy, quantitative mechanism through which scalable intangible assets interact with firms' extensive-margin decisions to expand across borders, shaping the equilibrium distribution of firm scale and aggregate outcomes.

A related literature shows that international tax policies affect firms' real decisions, not only the location of reported profits. Bilicka, Devereux, and Güçeri (2024) document that policies curbing profit shifting raise firms' cost of capital and can reduce real investment, even when some firms continue to shift profits. In related work, Dyrda et al. (2024a) develop a positive theory of profit shifting with nonrival intangible capital, highlighting how tax-induced changes in shifting incentives affect real investment and production decisions, while Dyrda, Hong, and Steinberg (2024b) study the optimal taxation of multinational enterprises in a global economy and derive normative implications for international tax design. Suárez Serrato (2018) emphasizes that eliminating tax havens can generate unintended real effects as firms adjust their economic activity. Our contribution is to show the presence of scalable complementarity between profit shifting incentives and firms' global expansion decisions, and to illustrate how this interaction has first-order implications for productivity dynamics and long-run macroeconomic trends.

The remainder of the paper is organized as follows. Section 2 presents empirical evidence documenting the joint evolution of intangible intensity, multinational production, and profit shifting. Section 3 develops the theoretical framework and derives its main qualitative implications. Section 4 introduces the quantitative model and describes its equilibrium. Section 5 validates the model and presents the main quantitative results. Section 6 studies the implications of the framework for aggregate productivity. Section 7 concludes.

2 Empirical Analysis

This section documents empirical evidence on the interconnection between intangible capital, multinational production, and profit shifting. We proceed in four stages. First, we describe our data sources and the construction of key variables. Second, we document secular trends in intangible intensity, multinational production, and profit shifting over the period 1995–2023 and examine cross-sectional relationships between these phenomena using panel regressions. Third, we employ an event-study design to analyze the dynamic effects of multinational entry and profit-shifting initiation on intangible intensity. Finally, we document the relationship between firm productivity and intangible intensity, providing evidence of selection into multinational status.

2.1 Data

Our primary dataset is the Compustat North America database, which covers publicly listed U.S. and Canadian firms, from 1995 to 2023. We utilize the Annual Fundamentals dataset to extract consolidated, firm-level balance sheet and income statement information, including total revenue, cost of goods sold, research and development (R&D) expenditure, selling, general and administrative (SG&A) expense, as well as tangible and intangible assets. We only use the domestic version of the dataset, which has been standardized across firms and years for comparability. We exclude firm-year observations with missing industry codes and those with non-positive or missing values of total revenue.

Measuring intangible capital. Our theoretical framework centers on the nonrivalry of intangible capital: unlike tangible inputs, intangibles can be deployed simultaneously across multiple production locations without diminishing their productivity at any single site. This property is what generates the complementarity between intangible investment and multinational expansion: a firm that develops a patent, algorithm, or product design at headquarters can deploy it across all foreign subsidiaries at zero marginal cost. This theoretical focus disciplines our measurement choice. We construct intangible capital as the sum of balance-sheet intangibles and internally-generated knowledge capital from capitalized R&D expenditures, following Peters and Taylor (2017). This measure captures the canonical nonrival inputs: patents, proprietary software, product designs, chemical formulas, and other forms of codified knowledge that can be scaled globally. We deliberately exclude organizational capital constructed from SG&A expenses, despite its use in related literature (Eisfeldt and Papanikolaou, 2013). While organizational capital includes some nonrival components, such as codifiable management practices or brand equity, it also encompasses substantial location-specific, rival investments: local employee training, market-specific advertising, regional supplier relationships, and management attention subject to span-of-control constraints. Moreover, the profit-shifting mechanisms we emphasize (transfer pricing of intellectual property, cross-border deployment of R&D outputs) operate primarily through knowledge capital rather than organizational capital.

Our primary outcome variable is intangible intensity, defined as the ratio of intangible capital to total assets, where total assets equals the sum of intangible capital and tangible capital (property, plant, and equipment):

$$s^z_{jt} \equiv \frac{\text{Intangible Capital}_{jt}}{\text{Intangible Capital}_{jt} + \text{Tangible Capital}_{jt}}. \tag{1}$$

This measure captures the firm's reliance on scalable, nonrival inputs relative to location-specific factors.

Measuring multinational activity. To measure the extent of multinational production, we use a linked database combining Compustat data with firm-level disclosures to the U.S. Securities and Exchange Commission (SEC), accessed through Wharton Research Data Services (WRDS). By the SEC rules, public firms in the U.S. are required to disclose the country of incorporation and ownership structure for subsidiaries in which they hold at least a 10% ownership stake. We use this information to measure multinational activity along both extensive and intensive margins. On the extensive margin, we classify a firm as a multinational enterprise (MNE) in year t if it reports at least one foreign subsidiary in its Exhibit 21 disclosure for that fiscal year. On the intensive margin, we construct two measures: (i) the number of distinct foreign countries in which the firm operates subsidiaries, and (ii) the share of foreign segment revenue in total consolidated revenue, obtained from geographic segment disclosures.

Measuring profit shifting. We measure profit shifting along both extensive and intensive margins. On the extensive margin, we identify profit-shifting firms as those with foreign subsidiaries in any of the tax-haven countries identified by Tørsløv, Wier, and Zucman (2022). On the intensive margin, we use firm-year estimates of the share of profits shifted from Delis, Delis, Laeven, and Ongena (2024), which provides granular measures of profit-shifting intensity since 2009.

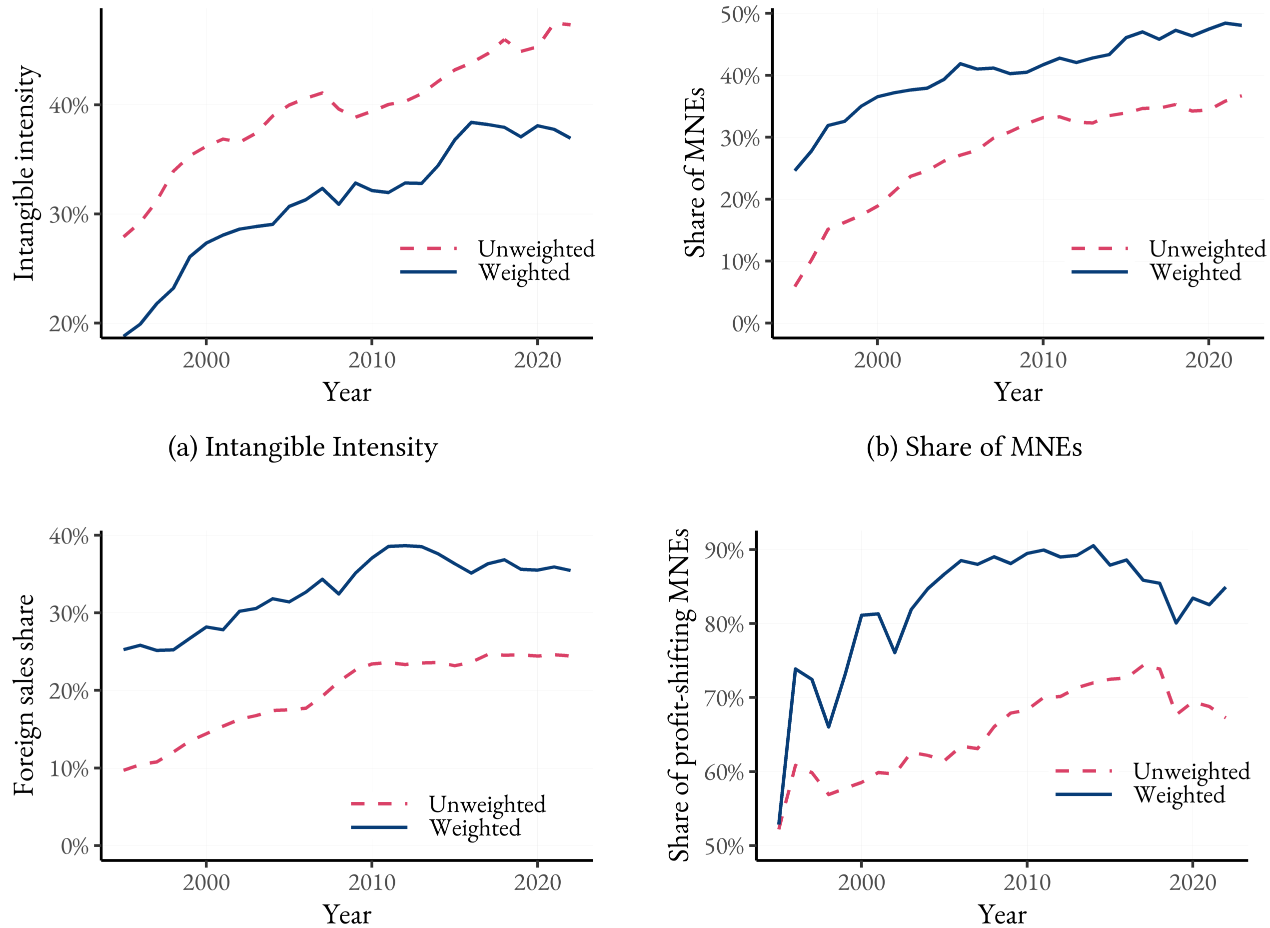
2.2 Secular Trends

We document four sets of secular trends over our sample period: the rise in intangible intensity, the expansion of multinational production, the growth of profit shifting, and the decline in the costs of intangible investment and foreign expansion. Figure 1 summarizes the first three trends using Compustat data.

2.2.1 The Rise in Intangible Intensity

Figure 1, Panel (a) displays the evolution of intangible intensity from 1995 to 2023. Average intangible intensity, computed as the unweighted mean across firms, increased from 26% in 1995 to 47% in 2023, nearly a doubling over the sample period. The revenue-weighted average exhibits a similar trajectory, rising from 16% to 38%. This secular increase in intangible intensity is consistent with extensive prior documentation in the literature (Corrado, Hulten, and Sichel, 2009; Crouzet et al., 2022).

Figure 1: Secular Trends of Intangible Intensity, MNEs, and Profit Shifting: 1995 – 2023



(a) Intangible Intensity

(b) Share of MNEs

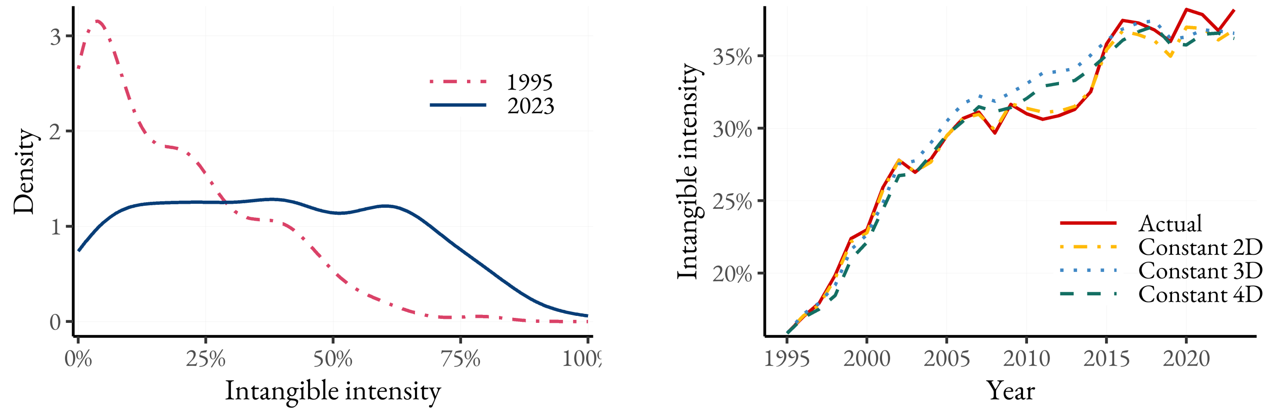
(c) Foreign sales share of MNEs

(d) Share of Profit-Shifting Firms

Notes: This figure displays the time series of key variables from 1995 to 2023 using Compustat North America data. Panel (a) shows intangible intensity, defined as the ratio of intangible assets to total assets. Intangible assets include balance-sheet intangible assets (externally acquired) and internally generated intangible capital constructed by capitalizing R&D expenditures using the perpetual inventory method following Peters and Taylor (2017), with industry-specific depreciation rates ranging from 15% to 40%. Total assets are defined as the sum of tangible (property, plant, and equipment) and intangible assets. Panel (b) shows the share of firms classified as multinational enterprises (MNEs), defined as firms reporting at least one foreign subsidiary in Exhibit 21 of SEC 10-K filings. Panel (c) displays the foreign sales share among MNEs, calculated as the ratio of foreign segment revenue to total consolidated revenue. Panel (d) shows the share of MNEs with at least one subsidiary located in a tax-haven jurisdiction, as identified by Tørsløv et al. (2022). In all panels, dashed lines represent unweighted averages across firms, while solid lines represent revenue-weighted averages. The sample excludes firm-year observations with missing industry codes, or non-positive total revenue.

A natural concern is whether the aggregate trend reflects within-industry increases in intangible intensity or compositional shifts toward high-intensity industries. We address this concern in two ways. First, Figure 2, Panel (a) plots the kernel density of intangible intensity aggregated to four-digit NAICS industries using firm revenue weights, separately for 1995 and 2023. The rightward shift of the entire distribution indicates broad-based increases across the intensity spectrum, rather than reallocation toward a subset of high-intensity sectors.

Figure 2: Intangible Intensity Across Industries Over Time



(a) Intangible Intensity Density in 1995 and 2023 (b) Intangible Intensity with Fixed Industry Shares

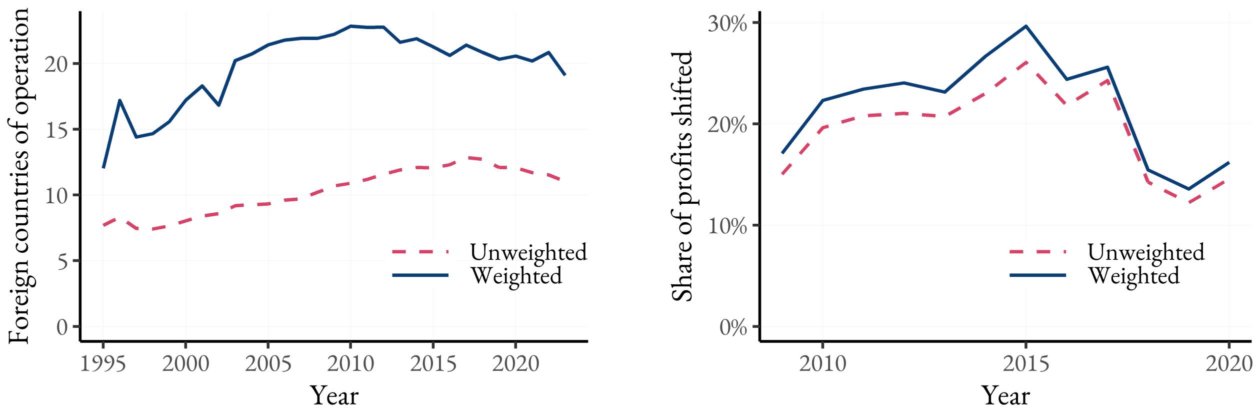
Notes: This figure examines whether the secular increase in intangible intensity reflects within-industry changes or compositional shifts across industries. Panel (a) presents kernel density estimates of intangible intensity aggregated to 4-digit NAICS industries using firm revenue weights, separately for 1995 (dashed line) and 2023 (solid line). The rightward shift indicates a broad-based increase in intangible intensity across the distribution rather than a reallocation toward high-intensity industries. Panel (b) displays counterfactual intangible intensity series constructed by holding industry revenue shares fixed at their 1995 levels while allowing within-industry intangible intensities to evolve. The "Constant 2D," "Constant 3D," and "Constant 4D" series fix industry composition at the 2-digit, 3-digit, and 4-digit NAICS level, respectively. The close tracking of counterfactual series with the actual series (solid red line) confirms that the aggregate trend is driven primarily by within-industry increases. For more granular industry definitions than 2 digits, we restrict attention to NAICS industries present throughout the 1995–2023 sample period.

Second, Panel (b) displays counterfactual intangible intensity series constructed by holding industry revenue shares fixed at their 1995 levels while allowing within-industry intangible intensities to evolve. The counterfactual series track the actual series closely regardless of whether we fix composition at the two-digit, three-digit, or four-digit NAICS level. This decomposition confirms that the aggregate trend is driven overwhelmingly by within-industry increases rather than sectoral reallocation.

2.2.2 The Expansion of Multinational Production

Figure 1, Panel (b) documents significant growth in multinational activity over the sample period. The unweighted share of firms classified as MNEs increased from 7% in 1995 to approximately 30% by 2020 before declining slightly thereafter. The expansion of multinational production is evident not only at the extensive margin but also along the intensive margin. Figure 3, Panel (a) shows that the average number of foreign countries in which MNEs operate subsidiaries increased from approximately 5 in 1995 to around 10 by 2020, with revenue-weighted averages showing steeper growth. Panel (c) of Figure 1 further demonstrates that the share of foreign sales in total MNE revenue has risen steadily, from 10% (unweighted) in 1995 to 22% by 2023. These patterns indicate deepening global integration beyond simply entering new markets.

Figure 3: Intensive Margin of MNE Expansion and Profit Shifting



(a) Average Number of Subsidiary Countries

(b) Share of Profits Shifted

Notes: This figure documents trends in the intensive margin of multinational activity and profit shifting from 1995 to 2023. Panel (a) displays the average number of foreign countries in which MNEs operate subsidiaries, as reported in Exhibit 21 of SEC 10-K filings. Panel (b) shows the average share of profits shifted to low-tax jurisdictions, using firm-year estimates from Delis et al. (2024). The Delis et al. methodology estimates profit shifting as the difference between reported profits and counterfactual profits implied by firms' real economic activity, exploiting variation in subsidiary locations and tax rates. These estimates are available beginning in 2009. The sharp decline in shifted profits after 2017 coincides with the implementation of the Tax Cuts and Jobs Act (TCJA), which introduced provisions such as the Global Intangible Low-Taxed Income (GILTI) tax and the Foreign-Derived Intangible Income (FDII) deduction designed to reduce profit-shifting incentives. Dashed lines represent unweighted averages, and solid lines represent revenue-weighted averages.

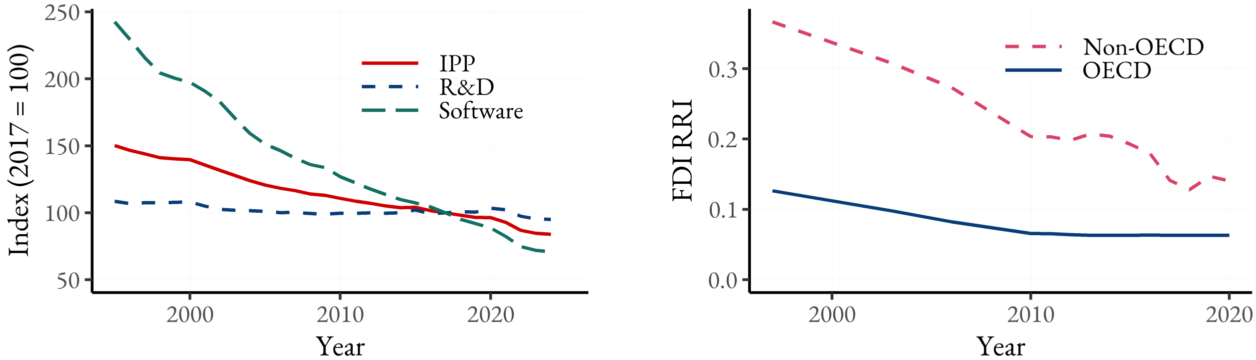
2.2.3 The Growth of Profit Shifting

Figure 1, Panel (d) displays the evolution of profit-shifting activity, measured as the share of MNEs with at least one subsidiary in a tax-haven jurisdiction. This share increased from 55% in 1995 to a peak of 74% in 2017, with revenue-weighted averages consistently higher, reflecting that larger firms are more likely to engage in tax optimization strategies. The sharp decline following 2017 coincides with the implementation of the Tax Cuts and Jobs Act (TCJA), which introduced provisions specifically designed to curtail profit shifting, including the Global Intangible Low-Taxed Income (GILTI) tax.[1]

The intensive margin of profit shifting tells a consistent story. Figure 3, Panel (b) displays the average share of profits shifted to low-tax jurisdictions using firm-year estimates from Delis et al. (2024). The unweighted average rose from approximately 14% in 2009 to nearly 30% by 2017, before declining sharply following the TCJA. The co-movement of aggregate trends in intangible intensity and profit shifting aligns with theoretical predictions linking intangible capital to transfer pricing opportunities (Dyrda et al., 2024a).

[1]See Dyrda, Hong, Sajid, and Steinberg (2025) for a detailed analysis of the TCJA's impact on profit shifting.

Figure 4: Declining Costs of Intangible Investment and FDI Barriers: 1995-2023



(a) Intangible Investment Costs

(b) FDI Regulatory Restrictiveness

Notes: This figure documents the decline in the costs of intangible investment and foreign direct investment over the sample period. Panel (a) presents the Bureau of Economic Analysis (BEA) Price Index for Private Fixed Investment in Intellectual Property Products (IPP), deflated by the Consumer Price Index (CPI) and normalized to 100 in 2017. Three series are shown: the aggregate IPP index (solid red), the R&D component (dashed blue), and the software component (dashed green). The software price index exhibits the steepest decline, falling from approximately 240 in 1995 to 70 in 2023, reflecting rapid technological progress in information technology. Panel (b) displays the OECD FDI Regulatory Restrictiveness Index, which measures statutory restrictions on foreign direct investment including foreign equity limitations, screening and approval requirements, restrictions on key foreign personnel, and operational restrictions. The index ranges from 0 (fully open) to 1 (fully closed). Separate series are shown for OECD member countries (solid blue) and non-OECD countries (dashed red). Both groups experienced substantial liberalization, with the OECD average falling from 0.13 to 0.06 and the non-OECD average declining from 0.33 to 0.18.

2.2.4 Declining Costs of Intangibles and FDI Barriers

The secular trends documented above occurred alongside substantial declines in the costs of intangible investment and foreign expansion. Figure 4 presents evidence on both margins.

Panel (a) presents the BEA Price Index for Private Fixed Investment in Intellectual Property Products (IPP), deflated by CPI and normalized to 100 in 2017. The overall IPP price index declined from approximately 150 in 1995 to 85 in 2023, representing a roughly 40% reduction in the real cost of intangible investment over this period. The decline is particularly pronounced for software, which fell from approximately 240 in 1995 to around 70 in 2023, a nearly 70% reduction.

Panel (b) presents the OECD FDI Regulatory Restrictiveness Index, which measures statutory restrictions on foreign direct investment across countries. Both OECD and non-OECD countries have experienced substantial reductions in FDI barriers since 1997. The average FDI restrictiveness index for OECD countries fell from approximately 0.13 to 0.06, while non-OECD countries saw declines from approximately 0.33 to 0.18. These reductions reflect widespread liberalization of foreign investment regimes, including the removal of equity restrictions, screening requirements, and operational restrictions on foreign-owned firms.

Table 1: Intangible Intensity, Multinational Production, and Profit Shifting

Dependent Var	Intangible Intensity					
	(1)	(2)	(3)	(4)	(5)	(6)
MNE indicator	0.09***	0.12***	0.06***			
	(0.01)	(0.01)	(0.00)			
× post−2005	0.05***	0.05***	0.05***			
	(0.01)	(0.01)	(0.01)			
TA-region indicator				0.03***	0.04***	0.03***
				(0.01)	(0.01)	(0.01)
× post−2005				0.03***	0.04***	0.02**
				(0.01)	(0.01)	(0.01)
Industry FE	N	N	Y	N	N	Y
Control for log revenue	N	Y	Y	N	Y	Y
Observations	27,318	27,318	27,318	11,925	11,925	11,925

Notes: This table reports OLS estimates of the relationship between intangible intensity and indicators for multinational status and profit-shifting activity. The dependent variable in all columns is intangible intensity, defined as the ratio of intangible assets (including capitalized R&D) to total assets. “MNE indicator” equals one if the firm reports at least one foreign subsidiary in Exhibit 21 of its SEC 10-K filing. “TA-region indicator” equals one if the firm has at least one subsidiary in a tax-haven jurisdiction identified by Tørsløv et al. (2022). “Post-2005” is an indicator for observations from 2006 onward. Columns (1)–(3) examine the full sample; columns (4)–(6) restrict to MNEs only (to examine within-MNE variation in tax-haven presence). All specifications include year fixed effects. Columns (2), (3), (5), and (6) include log total revenue as a control for firm size. Columns (3) and (6) additionally include 4-digit NAICS industry fixed effects to absorb systematic cross-industry variation in intangible intensity arising from differences in production technology or accounting conventions. Standard errors, reported in parentheses, are clustered at the year level to account for aggregate shocks affecting all firms within a year. Significance levels: $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$.

The concurrent decline in both intangible costs and FDI frictions, alongside the rise in intangible intensity, multinational production, and profit-shifting, raises a natural question: how much of the observed trends in firm behavior can be attributed to these cost reductions? Moreover, how do these cost reductions interact? Our quantitative model is designed to answer these questions.

2.3 Cross-Sectional Analysis

2.3.1 Empirical Specification

We now examine the cross-sectional relationships between intangible intensity, multinational production, and profit shifting. We estimate the following regression:

$$s^z_{jt} = \alpha + \beta_1 \mathbf{1}\{\text{Post-2005}_{jt}\} + \beta_2 \mathbf{1}\{X_{jt}\} + \beta_3 \mathbf{1}\{\text{Post-2005}_{jt}\} \times \mathbf{1}\{X_{jt}\} + Z_{jt}\delta + \varepsilon_{jt}$$

where $\mathbf{1}\{X_{jt}\}$ is an indicator for whether firm j in year t is an MNE or has a subsidiary in a tax-avoidance region, and $\mathbf{1}\{\text{Post-2005}_{jt}\}$ is a post-2005 time indicator. Z_{jt} is a vector of controls.

In our fullest specifications, we include: (i) year fixed effects to account for the secular increase in intangible intensity over our analysis period, (ii) industry fixed effects to account for systematic variation in intangible intensity across industries (e.g., differences in production technology, or systematic over/underreporting of intangibles on firm balance sheets from accounting conventions), and (iii) log firm revenue to proxy for time-varying firm characteristics, such as idiosyncratic productivity.

Table 1 reports results. Columns (1)–(3) examine the relationship between intangible intensity and MNE status in the full sample. Column (1) includes only year fixed effects, yielding a coefficient of 0.09: MNEs have 9 percentage points higher intangible intensity than domestic firms. Adding a control for log revenue (column 2) *increases* the coefficient to 0.12, indicating that the unconditional correlation understates the conditional relationship: within revenue categories, MNEs are even more intangible-intensive.

Our preferred specification in column (3) adds industry fixed effects, yielding a baseline coefficient of 0.06 for the pre-2005 period. The interaction with the post-2005 indicator is positive and statistically significant (0.05), indicating that the intangible intensity gap between MNEs and domestic firms nearly doubled after 2005. This temporal pattern is consistent with the hypothesis that declining barriers to globalization and intangible investment have disproportionately benefited intangible-intensive firms.

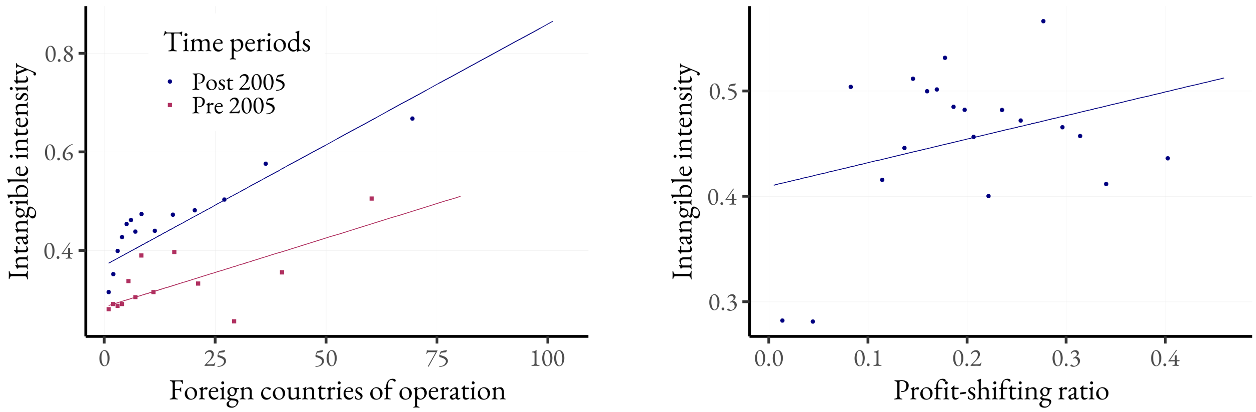
Columns (4)–(6) restrict attention to MNEs and examine variation in tax-haven presence. In our preferred specification (column 6), MNEs with tax-haven subsidiaries have 3 percentage points higher intangible intensity than MNEs without such presence during the pre-2005 period, with the gap widening by an additional 2 percentage points thereafter.

2.3.2 Intensive-Margin Relationships

The positive associations documented above extend to intensive-margin measures. Figure 5, Panel (a) presents a binned scatter plot of intangible intensity against the number of foreign countries in which a firm operates, separately for pre- and post-2005 periods. The positive slope indicates that firms with broader geographic reach exhibit higher intangible intensity, with the relationship steepening over time.

Panel (b) plots intangible intensity against the firm-level profit-shifting ratio from Delis et al. (2024). The positive correlation indicates that firms engaging in more aggressive profit shifting exhibit substantially higher intangible intensity, consistent with the theoretical prediction that intangible assets, due to their mobility and difficulty of valuation, facilitate profit reallocation across

Figure 5: Intangible Intensity versus Intensive Margin of Profit Shifting and MNE expansion



(a) Intangibles and MNE Expansion

(b) Intangibles and Profit Shifting

Notes: This figure presents binned scatter plots of intangible intensity against intensive-margin measures of multinational expansion and profit shifting. Each point represents the mean intangible intensity within a bin defined by the y-axis variable, with 20 equal-sized bins. Panel (a) plots intangible intensity against the number of foreign countries in which the firm operates subsidiaries. Red squares denote observations from 1995–2005; blue circles denote observations from 2006–2023. The fitted lines (OLS) illustrate the positive cross-sectional relationship, which steepens in the later period. Panel (b) plots intangible intensity against the firm-year profit-shifting ratio estimated by Delis et al. (2024), available from 2009 onward. The profit-shifting ratio measures the share of total profits reallocated to low-tax jurisdictions through transfer pricing and related mechanisms. The positive slope indicates that firms engaging in more aggressive profit shifting exhibit higher intangible intensity, consistent with the theoretical prediction that intangible assets, due to their mobility and difficulty of valuation, facilitate profit reallocation across jurisdictions.

jurisdictions.

We note that the estimated cross-sectional relationship may be driven by many unobserved firm characteristics, such as productivity and tradability of the product. They are also subject to reverse causality, namely, high intangible intensity firms are more likely to open more foreign subsidiaries and engage in profit shifting. Therefore, we view these results as suggestive evidence and will later apply the quantitative model to shed light on the mechanisms.

2.4 Dynamic Effects of MNE Entry and Profit Shifting

To examine the temporal relationship between multinational status and intangible intensity, we employ an event-study design that exploits variation in the timing of firms' transitions to MNE status or initiation of profit-shifting activity.

We employ the interaction-weighted (IW) estimator, as introduced in Sun and Abraham (2021), to estimate the dynamic treatment effects of MNE status or profit-shifting on intangible intensity for a balanced panel of firms spanning 1995 to 2023. Specifically, we focus on the impact of a firm first attaining MNE status or initially engaging in profit-shifting. In the context of staggered treatment adoption, the IW estimator offers significant advantages. It mitigates contamination from treatment effects in other periods and accounts for treatment effect heterogeneity, an issue when applying the standard two-way fixed-effects (TWFE) event-study approach. To address variations in the duration that firms remain MNEs or engage in profit-shifting, we estimate treatment effects separately for cohorts of firms based on their initiation year of treatment. Specifically, we run the following regression

$$s_{jt}^{z} = \gamma_j + \delta_t + \sum_{e \notin C} \sum_{\tau \neq -1} \beta_{e,\tau} \cdot \mathbb{1}_{\{E_j = e\}} \cdot \mathbb{1}_{\{t - E_i = \tau\}} + \varepsilon_{jt}, \tag{2}$$

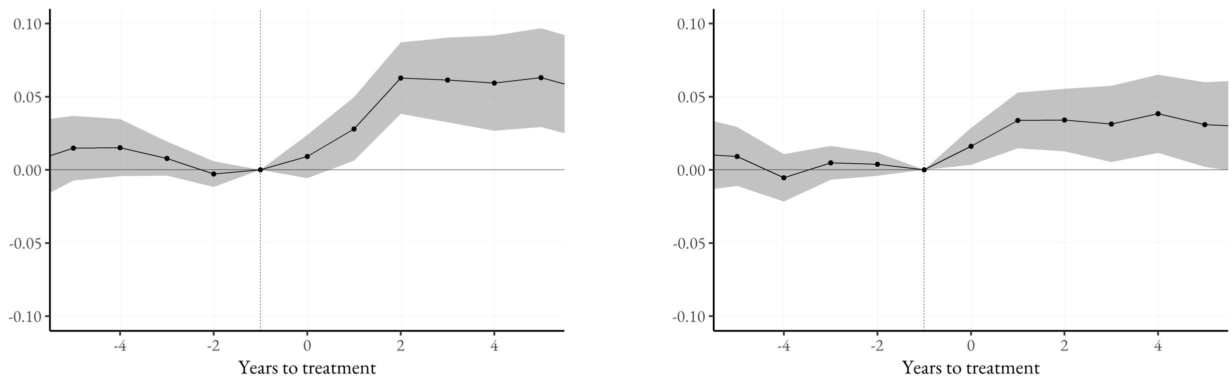
where E_j is the year when firm j becomes an MNE or begins profit shifting, and $\beta_{e,\tau}$ is the cohort-specific average treatment effect on the treated (CATT) τ periods from initial treatment for the cohort of firms first treated in year e. We use firms that never become multinational enterprises (MNEs) or engage in profit-shifting as the control group C . We include all relative time indicators τ, excluding only the indicator for the period before treatment ($\tau = -1$) to address multicollinearity. The dynamic treatment effect estimate for each relative time period is given by the average of $\hat{\beta}_{e,\tau}$, weighted by the proportion of each cohort e in the relative time period τ. Treatment is absorbing: once a firm becomes an MNE or initiates profit shifting, it remains treated in subsequent periods.

The IW estimator identifies CATT under two key assumptions. First, *parallel trends*: in the absence of treatment, treated and control firms would have experienced parallel evolution of intangible intensity. We assess this assumption by examining pre-treatment coefficients ($\tau < 0$); under parallel trends, these should be statistically indistinguishable from zero. Second, *no anticipation*: firms do not adjust their intangible intensity in anticipation of future treatment. This assumption may be violated if firms increase R&D investment prior to planned international expansion, in which case pre-treatment coefficients would be positive. We examine this possibility in our results.

A maintained assumption is that treatment timing is exogenous conditional on firm and year fixed effects. This is unlikely to hold exactly: firms endogenously choose when to expand internationally based on productivity shocks, market opportunities, and strategic considerations. We therefore interpret our estimates as descriptive of the *average experience* of firms before and after treatment, rather than as causal effects of treatment per se.

Figure 6 shows that both becoming an MNE and initiating profit-shifting activities are associated with sustained increases in intangible intensity. MNE expansion increases intangible intensity by approximately 6 percentage points after 2-4 years, with the effect emerging around one year

Figure 6: Event Study: Dynamic Effects of MNE Entry and Profit-Shifting Initiation



(a) MNE (b) Profit Shifting

Notes: This figure displays dynamic treatment effect estimates from event-study regressions examining how intangible intensity evolves around firms' transitions to multinational status (Panel a) or initiation of profit-shifting activity (Panel b). The plotted coefficients are cohort-share-weighted averages of the $\hat{\beta}_{e,\tau}$ estimates from Equation (2). The omitted category is $\tau = -1$ (one year before treatment). Shaded bands represent 95% confidence intervals based on standard errors clustered at both the firm and year level. The flat pre-trends (coefficients near zero for $\tau < 0$) support the parallel trends assumption. Panel (a) shows that MNE entry increases intangible intensity by approximately 6 percentage points within 2–4 years. Panel (b) shows that profit-shifting initiation increases intangible intensity by approximately 3 percentage points over a similar horizon.

after treatment and stabilizing thereafter. Similarly, MNEs engaging in profit shifting increase intangible intensity by approximately 3 percentage points after 2-4 years. The lagged responses in intangible intensity suggest the presence of adjustment costs in intangible investment.

The event-study results provide evidence of a treatment effect: conditional on a firm's prior trajectory, intangible intensity increases following multinational entry. This pattern is consistent with the nonrivalry mechanism emphasized by our model: once a firm incurs the fixed costs of foreign expansion, the marginal return to intangible investment rises because intangibles can be deployed across a larger production base.

However, the event-study estimates cannot distinguish this treatment effect from time-varying selection. If firms expand internationally precisely when they anticipate high returns to intangible investment (due to product opportunities, technological breakthroughs, or competitive pressures), the observed increases in intangible intensity may reflect these underlying shocks rather than a causal effect of MNE status per se.

Combined with the cross-sectional evidence from Section 2.3, the event studies suggest that both *selection* (i.e., high-productivity, high-intangible firms choose to become MNEs) and *treatment* (i.e., MNE entry raises intangible intensity) contribute to the observed correlation. Disentangling these channels requires the structural model developed in Section 3.

2.5 Productivity, Intangible Intensity, and Selection into Multinational Status

To further investigate the selection mechanism, we examine the relationship between firm-level productivity and intangible intensity. We estimate firm-level total factor productivity (TFP) using the Ackerberg, Caves, and Frazer (2015) estimator. Specifically, we assume a (log) Cobb-Douglas production technology:

$$y_{it} = \alpha + w_{it}\beta + k_{it}\gamma + \omega_{it} + \varepsilon_{it}$$

where y_{it} is log output (value-added); w_{it} is a vector of log free variables (employment headcount); k_{it} is a vector of state variables (tangible and intangible capital); ω_{it} is productivity; and ε_{it} is an idiosyncratic error term.[2] Following Levinsohn and Petrin (2003), we use materials (proxied by cost of goods sold) as the control variable to address the simultaneity of productivity and input choices.

Figure 7 displays the relationship between firm TFP and intangible intensity, with bubble size proportional to the share of MNEs in each TFP vigintile. Appendix B provides corresponding regression evidence, confirming that these relationships are statistically robust to controls for industry composition and firm size. Three patterns emerge.

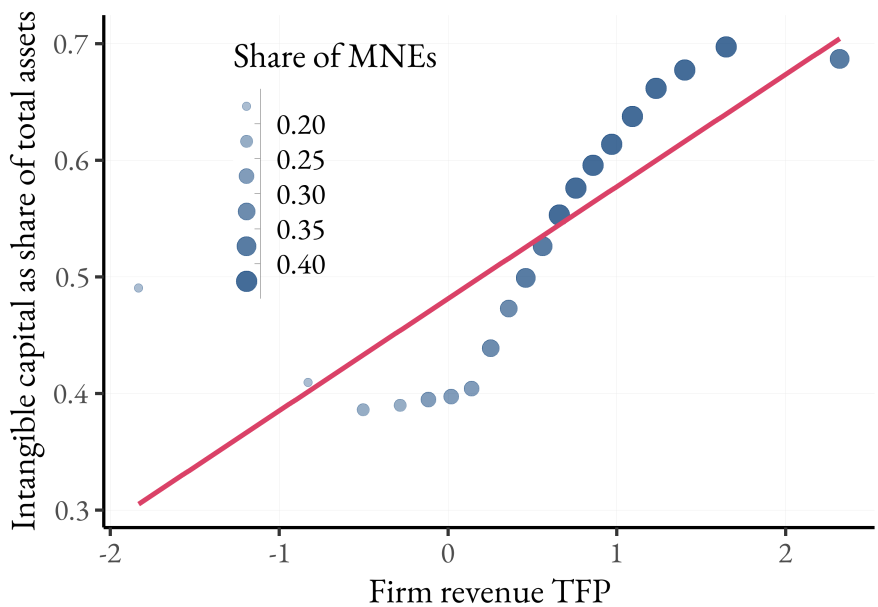
First, intangible intensity increases monotonically with productivity. Firms in the highest TFP vigintile exhibit intangible intensity approximately 20 percentage points above firms in the lowest vigintile. This positive gradient is consistent with models in which intangible capital is complementary to firm productivity, either because productive firms have higher marginal products of intangible investment, or because intangible investment itself raises measured productivity.

Second, MNE status increases sharply with productivity. The share of MNEs rises from approximately 20% in the lowest TFP bins to over 40% in the highest bins, consistent with the well-documented pattern that only the most productive firms find it profitable to bear the fixed costs of foreign expansion (Melitz, 2003; Helpman, Melitz, and Yeaple, 2004).

Third, the slope of the TFP-intangible intensity relationship appears steeper at higher produc-

[2] We use employment headcount rather than the wage bill as our labor input measure because Compustat's staff expense variable (XLR) has poor coverage, with missing values exceeding 70% of firm-year observations. This choice implicitly treats labor as homogeneous, so our revenue TFP estimates absorb cross-firm differences in workforce quality that would otherwise be captured by wage variation. If MNEs systematically employ higher-skilled workers than domestic firms, our estimates may overstate their productivity advantage. However, our focus on relative rankings rather than absolute magnitudes, combined with industry-year fixed effects that absorb systematic variation in workforce composition, mitigates this concern.

Figure 7: Selection into Multinational Status: Productivity and Intangible Intensity



Notes: This figure examines the relationship between firm-level productivity and intangible intensity, and how this relationship varies with multinational status. The x-axis displays firm revenue total factor productivity (TFP), estimated using the Ackerberg et al. (2015) control function approach. We assume a Cobb-Douglas production function in employment (free variable) and tangible plus intangible capital (state variables), using cost of goods sold as the proxy variable following Levinsohn and Petrin (2003). Firm-year TFP estimates are residualized by industry-year fixed effects and normalized to have mean zero. The y-axis displays intangible capital as a share of total assets. Each bubble represents a bin of firm-year observations grouped by TFP vigintiles. Bubble size is proportional to the share of MNEs within each bin, ranging from approximately 20% in the lowest TFP bins to over 40% in the highest bins. The fitted line (OLS) illustrates the strong positive relationship between productivity and intangible intensity.

tivity levels. This pattern is consistent with our theoretical result (Proposition 3) that cost reductions have larger effects for high-productivity firms: if intangible costs have fallen over time, the induced increase in intangible intensity should be concentrated among the most productive firms.

The productivity-based selection patterns documented in Figure 7 have important implications for interpreting the earlier cross-sectional and event-study results. The positive correlation between MNE status and intangible intensity (Table 1) reflects, at least in part, selection on productivity: firms that choose to become MNEs are more productive *and* more intangible-intensive, even absent any causal relationship between multinational status and intangible investment.

Our empirical analysis establishes five principal findings. First, intangible intensity, multinational production, and profit shifting have all increased substantially since 1995, with particularly rapid growth in the 2000s. Second, these trends occurred alongside declining costs of intangible investment and FDI barriers. Third, MNEs and profit-shifting firms exhibit significantly higher intangible intensity than their domestic counterparts, with gaps that have widened over time. Fourth, firms transitioning to MNE status or initiating profit-shifting activity experience subsequent increases in intangible intensity. Fifth, high-productivity firms are disproportionately intangible-intensive and more likely to operate internationally, suggesting an important role for selection.

These patterns are consistent with the theoretical mechanisms we formalize in Section 3, but they do not permit sharp causal inference. The correlational nature of the evidence, combined with the clear presence of selection effects, motivates the structural approach we develop next.

3 Theory of Multinational Production, Intangible Investment and Profit Shifting

We develop a theory to study firms' decisions regarding multinational production, intangible investment, and profit shifting. We use the framework to show how declining costs of multinational expansion, intangible investment and profit shifting affect firms' outcomes of interest, and how the effects of these costs reductions endogenously complement each other. At the heart of the theory is the interplay between the non-rivalry of intangible capital and multinational expansion: when intangible investment costs fall, firms have stronger incentives to scale globally; when expansion frictions fall, the returns to investing in intangibles rise. In addition, profit shifting enables firms to decrease global effective tax rate, which further encourages firms to invest and expand. The model is deliberately parsimonious, delivering transparent comparative statics and a clean mapping to empirical moments. See Appendix A for detailed derivations and proofs for the theoretical results.

3.1 Environment

Suppose a world that consists of a set of identical, atomic, productive and high-tax countries, $\mathbb{J} = [0, \bar{J}]$, and a tax haven country, TH. In each productive country, there exists a set of firms that differ in productivity $a \in \mathbb{A}$. We index each firm by its productivity, as all firms with the same productivity make identical decisions. For simplicity, we assume there is no international trade. To serve other countries, firms can set up foreign subsidiaries, subject to a multinational expansion cost that is a function of the number of foreign countries the firm serves, $C^J(J)$. Firms invest in its intangible capital z at a marginal cost, MC, which is a non-rival input so can be used in all of its subsidiaries. Each subsidiary produces a final good using the local rival input l and the non-rival input z. All firms take the input prices of the rival factor w and the intangible capital MC and output price p as given. Finally, firms can shift a share λ of its global operating profits π^G to the tax haven, subject to a profit shifting cost that is a function of the shifted profits paid at its headquarter. The corporate income tax rate of the productive countries is τ, greater than the corporate income tax rate of the tax haven, τ^{TH}.

The profit maximization problem of a firm with productivity a is specified as follows.

$$\pi(a) = \max_{l,z,\lambda,J} \left\{ \left(1-\tau^e(\lambda, s^z)\right) \pi^G(a,l,z,J) - (1-\tau)\left(MC \cdot z + C^\lambda\left(\lambda, \pi^G\right) + C^J(J)\right) \right\} \tag{3}$$

where

$$\pi^G(a,l,z,J) = J \times \pi(a,l,z)$$
$$\pi(a,l,z) = p \times aF(z,l) - wl$$
$$\tau^e(\lambda, s^z) = (1-\lambda s^z)\tau + \lambda s^z \tau^{TH}$$

where $\tau^e(\lambda, s^z)$ is the firm-level effective tax rate, which is a weighted average of τ and τ^{TH} with the weights determined by profit shifting share λ and the intangible intensity defined as $s^z \equiv \frac{MC \cdot z}{Jwl + MC \cdot z}$, and $\pi(a,l,z)$ is the profits earned in each market. Following our prior work (Dyrda et al., 2024a), we assume that the firms transfer a fraction λ of the income derived by the intangible capital, $s^z \pi^G$, to the tax haven. Hence, a larger s^z increases the effect of λ on τ^e. The cost of intangible investment, MCz, profit shifting $C^\lambda\left(\lambda, \pi^G\right)$, and the cost of expansion $C^J(J)$ are all tax-deductible expenditures paid at the headquarter. We make the following assumptions on the production technology and the cost functions.

Assumption 1. *We make the following parametric form assumptions on the production and cost functions:*

1. *The production technology features constant elasticity-of-substitution between the two factors, that is*

$$F(z,l) = \left[\mu z^{\frac{\sigma-1}{\sigma}} + (1-\mu) l^{\frac{\sigma-1}{\sigma}}\right]^{\frac{\sigma\alpha}{\sigma-1}}$$

   where is the returns-to-scale, σ is the elasticity of substitution between z and l, and μ is the input weight of z in the CES production function. We assume $\alpha < 1, \sigma > 1$ and the weight on the rival input, $1-\mu$, is sufficiently large.

2. *The expansion cost is iso-elastic in the number of foreign countries, that is*

$$C^J(J) = \bar{C}^J J^\gamma$$

   where $\bar{C}^J > 0$ governs the level of the cost function, and $\gamma > 1$ is the cost elasticity with respect to the number of foreign subsidiaries. We assume the marginal cost of multinational expansion increases faster than the global profits as the firm operate in more countries, i.e. $\gamma > \frac{\partial \ln \pi^G(a,l,z,J)}{\partial \ln J}, \forall J > 0$.

3. *The profit shifting cost function is assumed to be an increasing and convex function in λ and linear in π^G*

$$C^{\lambda}\left(\lambda, \pi^G\right) = \bar{C}^{\lambda} \cdot (\lambda - (1-\lambda)\log(1-\lambda)) \cdot \pi^G.$$

where $\bar{C}^{\lambda}$>0 governs the level of the cost function.

First, assuming DRS technology ($\alpha < 1$) is standard in an environment of perfect competition and heterogeneous firms. Assuming $\sigma > 1$ implies that the firm substitute towards the relatively cheaper production input. This gross substitutability assumption is supported by the empirical literature that estimates the elasticity of substitution between intangible capital and rival factors such as labor and tangible capital (Jerbashian, 2024). The assumption on μ requires the rival factor to account for a non-trivial input share, and it is needed for the complementarity results we will establish later. Second, we assume that the cost of expansion is convex in the number of foreign subsidiaries, which reflects information frictions and span-of-control costs of managing a greater number of establishments (Oberfield, Rossi-Hansberg, Sarte, and Trachter, 2024). The assumption on γ ensures that any firm cannot expand indefinitely to earn greater profits. Third, the functional form assumption of the profit-shifting cost follows our previous work in Dyrda et al. (2024a).

For notational convenience, we introduce the following definitions:

Definition 1. *We define the elasticity terms as follows:*

1. *The elasticity of an endogenous variable y with respect to a variable β is defined as $\varepsilon_{y,\beta} = \frac{\partial \ln y}{\partial \ln \beta}$.*

2. *The combined elasticity of an endogenous variable y with respect to variables β_1 and β_2 is defined as*

$$\varepsilon_{y,(\beta_1,\beta_2)} = \varepsilon_{y,\beta_1} + \varepsilon_{y,\beta_2} + \frac{\partial^2 \ln y}{\partial \ln \beta_1 \partial \ln \beta_2}.$$

With the functional form assumptions and the definition, we can derive the endogenous variables of interest from the first-order conditions of the firm as follows.

$$s^z = \left[\left(\tilde{\tau}\left(\lambda, s^z\right)\frac{1-\mu}{\mu}\right)^{\sigma}\left(\frac{w}{MC}\right)^{1-\sigma} J^{1-\sigma} + 1\right]^{-1} \tag{4}$$

$$J = \left(\frac{1}{\gamma\tilde{\tau}\left(\lambda, s^z\right)\bar{C}^J}\pi\left(a, l, z\right)\right)^{\frac{1}{\gamma-1}} \tag{5}$$

$$\lambda = 1 - \exp\left(\frac{\left(\tau - \tau_{TH}\right)s^z}{\left(1-\tau\right)\bar{C}^{\lambda}}\right) \tag{6}$$

where $\tilde{\tau}(\lambda, s^z) \equiv \frac{1-\tau}{1-\tau^e(\lambda, s^z)}$ and it decreases with λ and s^z. The expressions shed light on the intrinsic interactions between the three phenomena we study. First, multinational expansion incentivizes intangible capital deepening at the firm level when $\sigma > 1$. Second, more intangible investment enhances per-market profit π, encouraging a greater extent of expansion. Third, more intangible investment increases the return of profit shifting. Finally, profit shifting reduces firms' effective tax rate, prompting greater investment and expansion.

3.2 Theoretical Results

Comparative statics on cost reduction

We first establish a set of comparative statics on how reductions in intangible cost MC, expansion cost $\bar{C}^J$, and profit shifting cost $\bar{C}^\lambda$ affect intangible intensity s^z, multinational expansion J, and profit shifting λ in the following proposition.

Proposition 1. *When intangible cost MC, expansion cost $\bar{C}^J$ or profit shifting cost $\bar{C}^\lambda$ falls, the following statements hold under the assumptions:*

1. *all firms increase in intangible intensity, i.e. $\epsilon_{s^z,\beta} < 0$, $\beta \in \{MC, \bar{C}^J, \bar{C}^\lambda\}$;*
2. *all firms expand in more foreign countries, i.e. $\varepsilon_{J,\beta} < 0$, $\beta \in \{MC, \bar{C}^J, \bar{C}^\lambda\}$;*
3. *all firms shift a greater share of profits to the tax haven, i.e. $\varepsilon_{\lambda,\beta} < 0$, $\beta \in \{MC, \bar{C}^J, \bar{C}^\lambda\}$.*

The following lemma illustrates the role multinational expansion in mediating the impact on intangible investment.

Lemma 2. *We have $\frac{\partial s^z}{\partial \beta} = \frac{\partial s^z}{\partial \beta}|_J + \frac{\partial s^z}{\partial J}\frac{\partial J}{\partial \beta}$, $\beta \in \{MC, \bar{C}^J, \bar{C}^\lambda\}$. Endogenous multinational expansion amplifies the effect of cost reductions on the intangible intensity of a firm, i.e. $\frac{\partial s^z}{\partial J}\frac{\partial J}{\partial \beta} < 0$.*

The effect of expansion J on intangible intensity s^z can be clearly seen in equation (4). Intuitively, cost reductions from any source can affect intangible intensity s^z through its effect on expansion J. As intangible capital is non-rival, the increase in J raise the firm-level investment return on z. When the production inputs are gross substitutes, $\sigma > 1$, firms optimally substitute towards the non-rival intangibles as its marginal return increases, pushing up the intangible intensity. This investment effect, in turn, increases the profits the firm can earn in each country, further fueling greater expansion and higher intangible intensity.

Complementarity

Next, we formalize the complementary effects of reductions in MC, $\bar{C}^J$ and $\bar{C}^\lambda$ on s^z, J, λ.

Proposition 2. *The following statements are true under the assumptions for* $y = \{s^z, J, \lambda\}$*:*

1. *The effects of reductions in* $\bar{C}^J$ *and* MC *are complementary: their joint reduction generates super-linear increases in* s^z*,* J *and* λ*, i.e.*

$$\left|\varepsilon_{y,\left(\bar{C}^J,MC\right)}\right| > \left|\varepsilon_{y,\bar{C}^J}\right| + \left|\varepsilon_{y,MC}\right|.$$

2. *The effects of reductions in* $\bar{C}^J$ *and* $\bar{C}^\lambda$ *are complementary: their joint reduction generates super-linear increases in* s^z*,* J *and* λ*, i.e.*

$$\left|\varepsilon_{y,\left(\bar{C}^J,\bar{C}^\lambda\right)}\right| > \left|\varepsilon_{y,\bar{C}^J}\right| + \left|\varepsilon_{y,\bar{C}^\lambda}.\right|$$

3. *The effects of reductions in* MC *and* $\bar{C}^\lambda$ *are complementary: their joint reduction generates super-linear increases in* s^z*,* J *and* λ*, i.e.*

$$\left|\varepsilon_{y,\left(MC,\bar{C}^\lambda\right)}\right| > \left|\varepsilon_{y,MC}\right| + \left|\varepsilon_{y,\bar{C}^\lambda}\right|.$$

The inequality results are expressed with absolute values as the elasticities are all negative: reductions in the costs cause increases in s^z, J and λ. The first part of the proposition states the complementary effect of expansion cost $\bar{C}^J$ and intangible investment cost MC. Such complementarity stems from the interdependence of multinational expansion and intangible investment. For the expansion margin, the effect of lowering expansion costs operates through the induced change in per-market profits π. When intangible investment is cheaper, firms raise their intangible capital to a greater extent as they enter additional markets, which boosts π and amplifies the expansion response. For the intangible intensity margin, the effect of lowing investment cost, in turn, operates through the induced expansion in J. When expansion is cheaper, firms open more foreign subsidiaries as they increase intangible investment, which further boosts the returns of intangible investment and induces greater increases in intangible intensity. This positive effect on s^z further raise the returns of profit shifting, thereby increasing the profit shifting share λ.

Firm Heterogeneity

The last set of theoretical results concerns the role of firm heterogeneity. We begin by showing comparative statics of firm productivity a on s^z, J and λ.

Proposition 3. *The following statements are true under the assumptions:*

1. *Intangible intensity increases with firm productivity, i.e.* $\epsilon_{s^z,a} > 0$.
2. *The global scope of production increases with firm productivity, i.e.* $\epsilon_{J,a} > 0$.
3. *The profit shifting share increases with firm productivity, i.e.* $\epsilon_{\lambda,a} > 0$

The proposition states that more productive firms choose higher intangible intensity, a larger global footprint, and shifts a greater share of profits. This selection effect comes from the monotonicity of firm profits in productivity: holding fixed production inputs, more productive firms earn greater profits in an market. As a result, high-productivity firms are able to expand in more markets in face of the convex expansion costs, which raises their intangible intensity as we have shown in Proposition 1. Greater intangible intensity further increases the profit shifting share λ. These theoretical predictions align with our empirical findings: in Appendix B, we document that higher-productivity firms exhibit greater intangible intensity (Table 6), broader multinational scope (Table 5), and more aggressive profit shifting (Table 7), with these relationships robust to controlling for industry and firm size.

Finally, we show that the effects of the cost reductions are greater for high-productivity firms.

Proposition 4. *The following statements are true under the assumptions for* $y = \{s^z, J, \lambda\}$*:*

1. *A decrease in* MC *increases* J, s^z, *and* λ *by more for high-productivity firms, i.e.*

$$\left|\varepsilon_{y,(a,MC)}\right| > \left|\varepsilon_{y,a}\right| + \left|\varepsilon_{y,MC}\right|.$$

2. *A decrease in* $\bar{C}^J$ *increases* J, s^z, *and* λ *by more for high-productivity firms, i.e.*

$$\left|\varepsilon_{y,\left(a,\bar{C}^J\right)}\right| > \left|\varepsilon_{y,a}\right| + \left|\varepsilon_{y,\bar{C}^J}\right|.$$

3. *A decrease in* $\bar{C}^\lambda$ *increases* J, s^z, *and* λ *by more for high-productivity firms, i.e.*

$$\left|\varepsilon_{y,\left(a,\bar{C}^\lambda\right)}\right| > \left|\varepsilon_{y,a}\right| + \left|\varepsilon_{y,\bar{C}^\lambda}\right|.$$

The proposition implies that cost reductions have larger effects for high-productivity firms. The intuition is the same as above: the impact of a cost decline hinges on the firm's capacity to expand, which rises with productivity. Higher productivity effectively lowers firm-specific expansion costs (or raises per-market returns), so firm-level efficiency complements economy-wide cost reductions, giving rise to high-productivity firms' stronger global expansion, greater intangible intensities, and larger profit shifting shares.

We conclude this section with the following remark concerns how profit shifting affects the measurement of GDP in a country.

Remark 3. *As discussed in Guvenen, Mataloni Jr, Rassier, and Ruhl (2021), an implication of profit shifting is that it artificially decreases the calculated value-added in the US. Consider the micro-foundation of transfer pricing of intangible capital in Dyrda, Hong, and Steinberg (2022), the transfer of the ownership of z leads to a λ share of the value-added generated by z being accrued to the tax haven. Formally, using the income approach, the contribution of the value-added by a firm of productivity a to its headquarter country i is:*

$$va_{ii}(a) = \underbrace{[(1-\lambda)\vartheta_{ii}(z_i(a))z_i(a) + w_{ii}(a)l_{ii}(a) + \pi_{ii}(a)]}_{\text{Headquarter value-added}} + \underbrace{\sum_{j\in J, j\neq i} (1-\lambda)\vartheta_{ij}(z_i(a))z_i(a)}_{\text{Intangible Income from abroad}} . \tag{7}$$

Holding all else constant, $va_{ii}(a)$ decreases with λ. The contribution of the value-added by a subsidiary of a foreign country j's MNE to country i is:

$$va_{ji}(a) = \underbrace{w_{ji}(a)l_{ji}(a) + \pi_{ji}(a)}_{\text{Foreign Subsidiary value-added in } i} , \tag{8}$$

which is unaffected by profit shifting.

We do not specify the source of the shifted profit (either from intangible or labor income) in the model setup of this paper. In this environment, the contribution of the value-added by a firm of productivity a to its headquarter country i is:

$$va_{ii}(a) = \underbrace{\left[(1-\lambda)\pi_{ii}(a) + w_{ii}l_{ii}(a) + \frac{1}{J}MC\cdot z\right]}_{\text{Headquarter value-added}} + \underbrace{\sum_{j\in J, j\neq i} \frac{1}{J}MC\cdot z}_{\text{Contribution to Subsidiary value-added}} . \tag{9}$$

The contribution of the value-added by a subsidiary of a foreign country j's MNE to country i is:

$$va_{ji}(a) = \underbrace{w_{ji}(a)l_{ji}(a) + (1-\lambda)\pi_{ji}(a)}_{\text{Foreign Subsidiary value-added in } i}, \tag{10}$$

which is affected by profit shifting.

4 Quantitative Theory

This section develops a dynamic, multi-country general equilibrium model designed to quantify the joint evolution of intangible investment, multinational expansion, and profit shifting. The model embeds the core mechanisms highlighted in the analytical theory—nonrival intangible capital, endogenous multinational scope, and tax-motivated income reallocation—into a tractable quantitative framework with heterogeneous firms and forward-looking investment decisions. The objective is twofold: first, to discipline the strength of the key complementarities using firm-level data, and second, to conduct counterfactual experiments that decompose the observed trends into technological change, globalization, and tax policy.

4.1 Households.

Each region i has a representative household with preferences over sequences of consumption, $\{C_{it}\}_{t=0}^{\infty}$, and labor supply, $\{L_{it}\}_{t=0}^{\infty}$, given by

$$\sum_{t=0}^{\infty} \beta^t \left[\log\left(\frac{C_{it}}{N_i}\right) + \psi_i \log\left(1 - \frac{L_{it}}{N_i}\right)\right]. \tag{11}$$

Households choose consumption, labor supply, tangible investment, $\{X_{it}\}_{t=0}^{\infty}$, and internationally-traded bonds, $\{B_{it+1}\}_{t=0}^{\infty}$ to maximize utility subject to a sequence of budget constraints,

$$P_{it}[C_{it} + K_{it+1} - (1-\delta)K_{it}] + P_{bt}B_{it+1} = (1-\tau_{i\ell t})\,W_{it}L_{it} + R_{it}K_{it} + B_{it} + D_{it} + T_{it}, \tag{12}$$

taking the wage, W_{it}, the labor income tax rate, $\tau_{i\ell t}$, the rental rate, R_{it}, the bond price, P_{bt}, dividends, D_{it}, and lump-sum transfers T_{it} as given.

4.2 Firms

Firms are the central decision-making units in the model. They are heterogeneous in productivity and dynamically choose intangible investment, multinational expansion, and profit-shifting intensity in response to prices, taxes, and policy frictions. Each firm is headquartered in a single country but may operate production units in multiple foreign locations, allowing intangible capital developed at headquarters to be deployed globally. We describe the firm problem in stages, beginning with production technology and intangible accumulation, followed by multinational expansion, profit shifting, and the firm's static and dynamic optimization problems.

Production technology. Firms are headquartered in a home country i and may operate production units in a set of foreign countries j. A firm with productivity a and intangible capital stock z produces output in country j according to

$$f_{ij}(a, z, k_j, \ell_j) = a \cdot \mathbf{1}\{i \neq j\}(1-\eta)\left[\mu z^{\frac{\sigma-1}{\sigma}} + (1-\mu)\left(k_j^{\alpha}\ell_j^{1-\alpha}\right)^{\frac{\sigma-1}{\sigma}}\right]^{\theta}, \tag{13}$$

where k_j and ℓ_j denote tangible capital and labor hired locally in country j. Intangible capital z is a nonrival input that can be deployed simultaneously across all production locations of the firm, while tangible capital and labor are rival and location-specific. The parameter α governs the labor share within the rival input bundle, μ controls the importance of intangibles in production, and $\sigma > 1$ is the elasticity of substitution between intangible capital and the composite rival input. The parameter $\eta \in (0, 1)$ captures variable barriers to foreign production, which reduce effective productivity in foreign affiliates relative to the headquarters location. Finally, $\theta < 1$ governs returns to scale at the plant level, ensuring decreasing returns to production at each location.

Intangible capital accumulation. Intangible capital is accumulated at the firm level and is *nonrival across production locations.* At the beginning of each period, a firm enters with an existing stock of intangible capital z and chooses new intangible investment x, denominated in units of the home country's final good. Intangible capital evolves according to

$$z' = (1-\delta)z + x,$$

where $\delta \in (0, 1)$ is the depreciation rate of intangible capital. Investment in intangibles is subject to a constant marginal cost MC and a convex adjustment cost, so that total investment expenditures equal

$$(1-\tau)\left[MC \cdot x + \frac{\phi}{2}x^2\right],$$

where $\phi > 0$ governs the degree of adjustment frictions. Adjustment costs smooth the dynamics of intangible accumulation and generate gradual responses of intangible intensity to shocks, consistent with the delayed investment responses observed in the data. Because intangible capital is nonrival, a higher stock of z raises productivity simultaneously across all domestic and foreign production units, implying that the return to intangible investment is increasing in the firm's multinational scope.

Multinational expansion. Firms may operate production units in multiple foreign countries in addition to their headquarters location. Let $n \in \{0, 1, \ldots, \bar{J} - 1\}$ denote the number of foreign affiliates a firm operates at the beginning of a period. After observing current productivity and intangible capital, the firm draws an idiosyncratic fixed cost of expanding to an additional foreign country. The cost of expanding from n to $n + 1$ affiliates is given by

$$\bar{C}_J = \bar{C}_J^0 - \varepsilon, \qquad \varepsilon \sim \text{Gumbel}(0, \sigma_{C_J}),$$

where $\bar{C}_J^0$ governs the average level of expansion costs and σ_{C_J} controls their dispersion. After observing the draw, the firm chooses whether to remain at n affiliates or expand to $n+1$ by paying the fixed cost. Expansion is irreversible within the period and subject to the upper bound $\bar{J}$ on the number of foreign locations.

Multinational expansion increases the scale over which the firm can deploy its intangible capital. Because intangible capital is nonrival, a higher number of affiliates raises the return to intangible investment by allowing the same stock of z to be used simultaneously across more production units. This mechanism generates endogenous selection into multinational status: firms with higher productivity or higher intangible capital are more likely to find expansion profitable. The stochastic cost structure ensures smooth aggregate responses of multinational activity to changes in technology, globalization frictions, and policy parameters.

Profit shifting. Multinational firms may reallocate taxable income across jurisdictions through profit shifting. We model profit shifting as the reallocation of income generated by intangible capital from high-tax production locations to a low-tax jurisdiction (a tax haven). Let $\lambda \in [0, 1]$ denote the share of global intangible-related income that is shifted. Profit shifting reduces the firm's effective tax rate by reallocating income from the statutory rate τ in productive countries to the tax-haven rate $\tau^{\text{TH}} < \tau$.

Consistent with Dyrda et al. (2024a), the effectiveness of profit shifting depends on the firm's intangible intensity. Intangible capital generates income that is difficult to value and geographically mobile, making it particularly amenable to transfer pricing. Accordingly, the firm's effective tax rate is given by

$$\tau_e(\lambda, s_z) = (1 - \lambda s_z)\tau + \lambda s_z \tau^{\text{TH}}, \tag{14}$$

where s_z denotes intangible intensity, defined as the share of global income attributable to intangible capital. A higher intangible intensity increases the marginal benefit of profit shifting by enlarging the tax base that can be relocated to the tax haven.

Profit shifting is costly. Firms incur a convex cost proportional to global profits,

$$C_\lambda(\lambda, \pi_G) = \frac{1}{2}\,\bar{C}_\lambda\,\lambda^2\,\pi_G,$$

where $\bar{C}_\lambda > 0$ governs the level of enforcement, legal, and organizational costs associated with shifting income. These costs capture resources devoted to tax planning, legal compliance, and the risk of detection. Through its effect on the effective tax rate, profit shifting increases the after-tax return to intangible investment and multinational expansion, while greater intangible investment simultaneously raises the return to profit shifting, generating an additional complementarity channel in the model.

Static profit maximization. Given productivity a, intangible capital z, and the number of foreign affiliates n, the firm chooses local production inputs and profit-shifting intensity to maximize global after-tax profits. Let country i denote the headquarters location and $j = 1, \ldots, n$ index foreign affiliates. In each location, the firm rents tangible capital and hires labor at competitive prices. Static global profits are given by

$$\begin{aligned} \pi(a, z, n) \;&=\; (1 - \tau_e(\lambda, s_z))\left[P_i f_{ii}(a, z, k_i, \ell_i) - W_i\ell_i - \delta k_i + \sum_{j=1}^{n}\big(P_j f_{ij}(a, z, k_j, \ell_j) - W_j\ell_j - \delta k_j\big)\right] \\ &-\; (1 - \tau)\,C_\lambda(\lambda, \pi_G), \end{aligned} \tag{15}$$

where P_j and W_j denote the price of the final good and the wage in country j, and δ is the depreciation rate of tangible capital. Tangible capital expenditures are only partially deductible through depreciation allowances, while profit-shifting costs are fully deductible at the statutory rate τ.

Within the period, the firm takes (a, z, n) as given and chooses $\{k_j, \ell_j\}_{j=0}^{n}$ and λ to maximize profits. Optimal input choices equalize marginal revenue products to factor prices in each location. Profit shifting trades off the tax savings from lowering the effective tax rate against the convex shifting cost. Static profits $\pi(a, z, n)$ summarize the payoff-relevant state for the firm and enter the dynamic problem governing intangible investment and multinational expansion decisions.

Dynamic program. Let the firm's state at the beginning of a period be (a, z, n), where a is productivity, z is the stock of nonrival intangible capital, and $n \in \{0, 1, \ldots, \bar{J} - 1\}$ is the number of foreign affiliates. Given the within-period static problem, the firm earns optimized after-tax profits $\pi(a, z, n)$. The firm then chooses intangible investment x (and, equivalently, next period's stock $z' = (1 - \delta)z + x$), and faces an expansion opportunity governed by the stochastic fixed cost described above. Let $V(a, z, n)$ denote the value function and define the post-investment continuation value

$$W(a, z', n) \equiv \rho_a V(a, z', n) + (1 - \rho_a) \int V(a', z', n) \, dG(a'), \tag{16}$$

where the firm survives to the next period with probability ψ and, conditional on survival, keeps its current productivity with probability ρ_a and otherwise draws a' from distribution G.

Under the i.i.d. Gumbel structure for the expansion cost draw, the discrete choice between remaining at n affiliates and expanding to $n + 1$ affiliates admits a closed-form expression for the expected continuation value. Let

$$\tilde{W}(a, z', n) = \sigma_{C_J} \log\left[\exp\left(\frac{W(a, z', n)}{\sigma_{C_J}}\right) + \mathbf{1}\{n < \bar{J} - 1\} \exp\left(\frac{W(a, z', n + 1) - \bar{C}_J}{\sigma_{C_J}}\right)\right], \tag{17}$$

which represents the expected value, conditional on (a, z'), of optimally choosing whether to expand the firm's multinational footprint in the current period.

Using this representation, the firm's value function can be written compactly as

$$V(a, z, n) = \max_{x, \lambda} \left\{ \pi(a, z, n) - (1 - \tau) \left[MC \cdot x + \tfrac{\phi}{2} x^2\right] + \beta\psi \, \tilde{W}(a, z', n) \right\}. \tag{18}$$

Intuitively, the firm chooses intangible investment (and profit shifting) to maximize current payoffs plus the expected continuation value, where the option value of expanding from n to $n+1$ affiliates is smoothed by the extreme-value dispersion parameter σ_{C_J}. The resulting probability of expansion is

$$p(a, z', n) = \psi \, \mathbf{1}\{n < \bar{J} - 1\} \frac{\exp\left(\frac{W(a, z', n+1) - \bar{C}_J}{\sigma_{C_J}}\right)}{\exp\left(\frac{W(a, z', n)}{\sigma_{C_J}}\right) + \mathbf{1}\{n < \bar{J} - 1\} \exp\left(\frac{W(a, z', n+1) - \bar{C}_J}{\sigma_{C_J}}\right)}, \tag{19}$$

which is increasing in the net gain from operating one additional affiliate. This dynamic structure delivers gradual intangible adjustment through ϕ and smooth extensive-margin responses through the Gumbel-logit expansion technology.

4.3 Aggregation and Equilibrium

We close the model by aggregating firm-level decisions and defining a stationary recursive equilibrium. Aggregate outcomes are obtained by integrating firms' optimal policies over the stationary distribution of firm states, accounting for multinational production and cross-border factor usage. We then characterize the law of motion for the firm distribution and define equilibrium conditions governing prices, allocations, and market clearing across countries.

Aggregation. Let $\Psi_i(a, z, n)$ denote the stationary joint distribution of firms headquartered in country i over productivity a, intangible capital z, and the number of foreign affiliates n. Given firms' optimal static and dynamic policies, aggregate quantities in each country are obtained by integrating firm-level decisions over this distribution.

Labor market clearing in country i requires that total labor supplied equals labor demand from both domestic firms headquartered in i and foreign affiliates operating in i:

$$\bar{L}_i = \int \ell_{ii}(a, z, n)\, d\Psi_i(a, z, n) + \sum_{j \neq i} \int \ell_{ji}(a, z, n)\, d\Psi_j(a, z, n),$$

where $\ell_{ji}(a, z, n)$ denotes labor hired in country i by a firm headquartered in country j.

Similarly, capital market clearing requires

$$K_i = \int k_{ii}(a, z, n)\, d\Psi_i(a, z, n) + \sum_{j \neq i} \int k_{ji}(a, z, n)\, d\Psi_j(a, z, n),$$

where $k_{ji}(a, z, n)$ denotes tangible capital rented in country i by firms headquartered abroad.

Aggregate output in country i is given by

$$Y_i = \int f_{ii}(a, z, k_i, \ell_i)\, d\Psi_i(a, z, n) + \sum_{j \neq i} \int f_{ji}(a, z, k_i, \ell_i)\, d\Psi_j(a, z, n).$$

The final good in each country is used for consumption, tangible investment, intangible investment, adjustment costs, and multinational expansion costs. Resource feasibility implies

$$Y_i = C_i + K_i' - (1-\delta)K_i + \int \left[\frac{x_i(a,z,n)}{MC} + \frac{\phi}{2} x_i(a,z,n)^2 + p_i(a,z,n)\bar{C}_J \right] d\Psi_i(a,z,n),$$

where $x_i(a,z,n)$ denotes intangible investment and $p_i(a,z,n)$ the probability of multinational expansion. Government tax revenues are rebated lump-sum to households.

Laws of motion. The evolution of the firm distribution is governed by firms' optimal policies for intangible investment and multinational expansion, together with exogenous productivity shocks and firm exit. Let (a,z,n) denote the firm's state at the beginning of a period. After choosing intangible investment x, the firm's intangible capital evolves deterministically according to

$$z' = (1-\delta)z + x(a,z,n).$$

Productivity follows a Markov process. Conditional on survival, a firm retains its current productivity with probability ρ_a and draws a new productivity level a' from distribution $G(a')$ with probability $1-\rho_a$. Firms exit exogenously at the end of the period with probability $1-\psi$.

Multinational expansion occurs after intangible investment and before the next period's state is realized. A firm operating n foreign affiliates expands to $n+1$ affiliates with probability $p(a,z',n)$ implied by the logit expansion rule, provided $n < \bar{J}-1$. Otherwise, the firm remains at n. Expansion is irreversible within the period and subject to the upper bound $\bar{J}$.

Let $\Psi_i(a,z,n)$ denote the distribution of firms headquartered in country i. The law of motion for this distribution is given by

$$\Psi_i'(A,Z,n) = \psi \int \left[(1-p(a,z',n))\,\mathbb{P}(a' \in A)\,\mathbf{1}\{z' \in Z\}\right] d\Psi_i(a,z,n),$$

for $n = 0,\ldots,\bar{J}-1$, and

$$\Psi_i'(A,Z,n+1) = \psi \int \left[p(a,z',n)\,\mathbb{P}(a' \in A)\,\mathbf{1}\{z' \in Z\}\right] d\Psi_i(a,z,n),$$

for $n = 0,\ldots,\bar{J}-2$, where $\mathbb{P}(a' \in A) = \rho_a \mathbf{1}\{a \in A\} + (1-\rho_a)G(A)$. Exiting firms are replaced by entrants with $z=0$, $n=0$, and productivity drawn from $G(a)$, ensuring a stationary mass of firms.

Equilibrium. A stationary recursive equilibrium consists of: (i) firm policy functions for intangible investment $x(a, z, n)$, profit shifting $\lambda(a, z, n)$, and multinational expansion probabilities $p(a, z', n)$; (ii) value functions $V(a, z, n)$ and continuation values $W(a, z, n)$; (iii) stationary firm distributions $\{\Psi_i(a, z, n)\}_i$; and (iv) prices $\{W_i, R_i, P_i\}_i$ and aggregate quantities $\{C_i, K_i, Y_i\}_i$, such that:

1. Given prices, taxes, and policies, firm policy functions solve the static profit maximization problem and the dynamic program.
2. Firm distributions $\{\Psi_i\}$ are stationary and satisfy the laws of motion induced by firm policies, productivity shocks, entry, and exit.
3. Labor and capital markets clear in every country i.
4. Goods markets clear and resource constraints hold in every country.
5. Government budget constraints are satisfied, with corporate tax revenues rebated lump-sum to households.

The equilibrium is symmetric across countries and time-invariant.

5 Preliminary Quantitative Results

This section presents preliminary quantitative results from the dynamic general equilibrium model developed in Section 4. The objective is not to provide a full quantitative decomposition of historical trends, but rather to illustrate the model's core mechanisms and discipline their magnitude. We proceed in three steps. First, we inspect firm-level policy functions and the implied selection patterns to clarify how productivity and intangible capital jointly govern multinational expansion. Second, we study comparative statics with respect to key technological and policy parameters—intangible investment costs, expansion costs, and barriers to foreign direct investment—to understand how different shocks operate through intensive and extensive margins. Third, we quantify the complementarity between intangible investment and multinational expansion using a set of transparent counterfactual experiments. Together, these results demonstrate how nonrival intangible capital shapes firm behavior and generates amplification effects that are central to the model's quantitative implications.

5.1 Inspecting the Mechanism

Multinational Expansion. Figure 8 provides an economic interpretation of the firm's expansion decision at the extensive margin. Foreign expansion entails a fixed cost, but allows the firm to deploy its intangible capital across multiple markets. Intangible capital therefore plays a central role because it is largely non-rival across locations: once developed, it can be leveraged abroad without proportional increases in production costs. As a result, firms with higher intangible capital face a higher marginal benefit from expansion, which explains the steep increase in expansion probabilities along the z dimension.

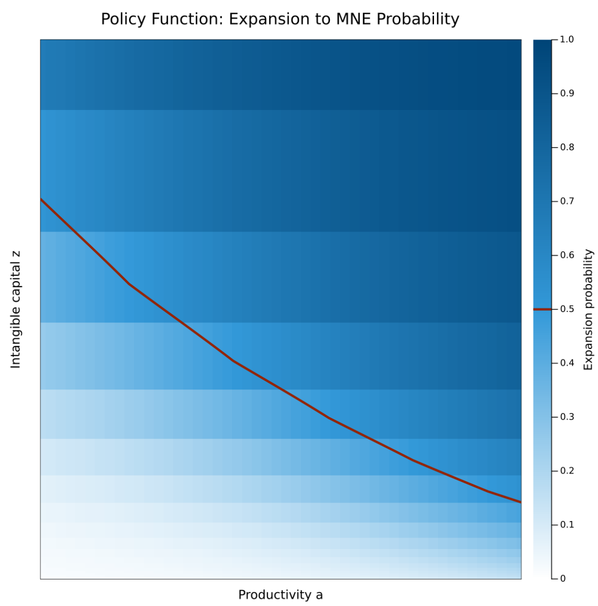
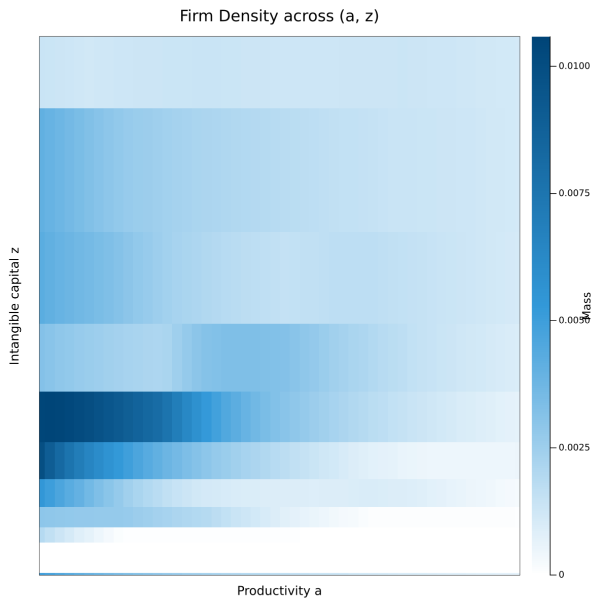


Figure 8: Policy function: expansion (to MNE) probability at $n = 0$.

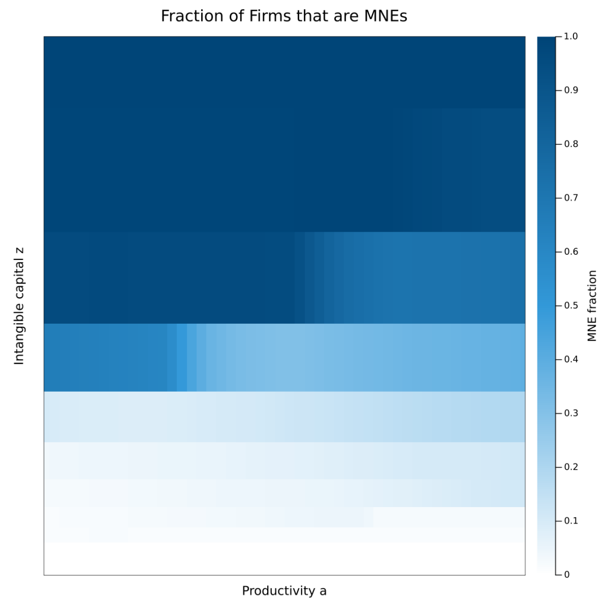
Productivity affects the expansion decision through scale. More productive firms operate at a larger scale in the domestic market, which increases revenues and allows fixed expansion costs to be amortized over a larger output base. This mechanism raises the expansion probability in productivity, though more gradually than for intangible capital. The downward-sloping contour captures the substitutability between these two margins: high productivity can partially compensate for lower intangible capital, and vice versa, in making foreign expansion profitable.

Taken together, the figure highlights that multinational selection is not driven by productivity alone. Instead, expansion reflects a joint interaction between scale (productivity) and scalability (intangible capital), with intangibles governing how effectively firms can translate size into profitable foreign presence.

Selection. Figure 9 illustrates how the expansion policy in Figure 8 maps into selection and composition in the stationary distribution. Panel (a) shows the joint density of firms over productivity a and intangible capital z. Firm mass is concentrated at relatively low levels of intangible capital, with productivity dispersion within each z bin. This reflects the fact that intangible accumulation is costly and that only a subset of firms finds it optimal to operate with high intangible intensity.



(a) Firm density over (a, z).



(b) Fraction of firms that are MNEs over (a, z).

Figure 9: Selection and composition in the stationary distribution.

Panel (b) reports, for each point in the (a, z) space, the fraction of firms that operate as multinationals. Multinational activity is negligible at low levels of intangible capital, regardless of productivity, but rises sharply with z. Conditional on sufficiently high intangible capital, even moderately productive firms exhibit a high probability of foreign expansion, while productivity alone is insufficient to generate multinational status in the absence of intangibles.

Taken together, the two panels highlight the nature of selection at the extensive margin. Although most firms are small and intangible-poor, multinational firms are disproportionately drawn from the upper tail of the intangible distribution. Productivity affects selection primarily by shifting firms along the scale dimension, but intangible capital determines whether scale can be effectively leveraged across markets. As a result, multinational firms are not simply the most productive firms in the economy; they are firms that combine sufficient productivity with scalable intangible assets, leading to a sharp sorting pattern in the stationary equilibrium.

The selection patterns in Figure 9 are consistent with several well-documented empirical facts about multinational firms. Empirically, multinational firms are larger, more productive, and substantially more intangible-intensive than purely domestic firms, but productivity alone does not fully explain multinational status. The model reproduces this feature by generating selection that is sharp in intangible capital but gradual in productivity. In particular, the absence of a strict productivity cutoff mirrors the empirical observation that many highly productive firms remain domestic, while some moderately productive firms operate internationally. In the model, this occurs because foreign expansion is primarily driven by the presence of scalable intangible assets, which determine whether scale advantages can be profitably extended across borders. As a result, multinational firms emerge as a selected subset of firms that combine sufficient productivity with high intangible intensity, rather than simply occupying the extreme upper tail of the productivity distribution.

5.2 Comparative Statics: Intangible Investment, Expansion Costs, and FDI Barriers

Figure 10 reports the response of the economy to a reduction in the marginal cost of intangible investment. Lower investment costs lead firms to accumulate larger stocks of intangible capital, strengthening the complementarity between intangibles and foreign expansion. As a result, expansion becomes more attractive at the extensive margin, increasing the share of multinational firms. The rise in intangible capital also raises aggregate intangible intensity, reflecting higher investment both among incumbent multinationals and among firms that newly select into multinational status.

Figure 11 shows the effects of a reduction in fixed expansion costs. Lower expansion costs primarily operate through the extensive margin, drawing marginal and less productive firms into multinational status. This increases the overall share of multinationals and raises aggregate intangible intensity. However, because newly entering multinationals are less intangible-intensive than incumbent ones, the average intangible intensity among multinational firms declines. The figure highlights that changes in expansion costs affect composition as much as firm-level investment behavior.

Figure 12 considers a reduction in barriers to foreign direct investment. The mechanism closely mirrors that of lower expansion costs: reduced barriers make foreign operations viable for a broader set of firms, increasing the multinational share and aggregate intangible intensity. At the same time, selection effects imply that newly expanding firms are, on average, less intangible-intensive than incumbent multinationals, leading to a decline in average intangible intensity within

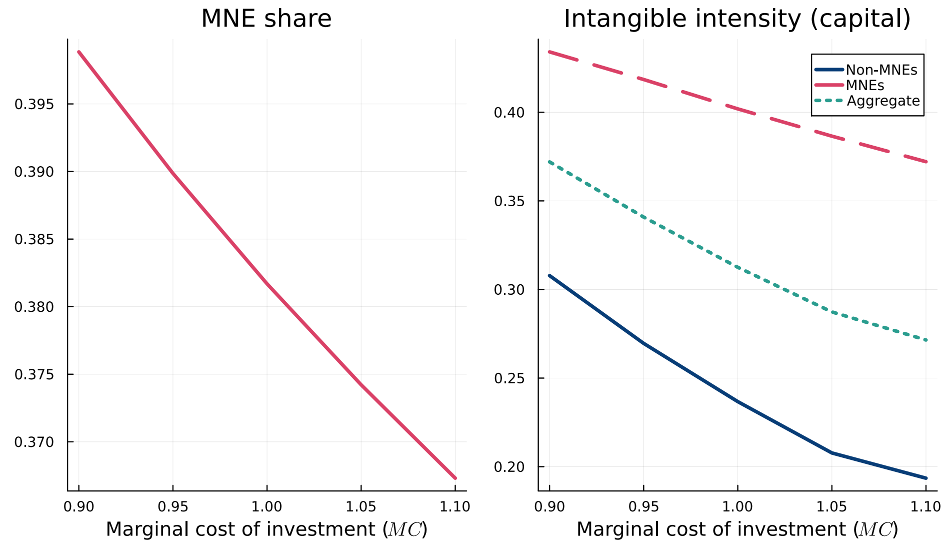


Figure 10: Decrease in the marginal cost of intangible investment.

the multinational group.

Taken together, these comparative statics illustrate that different policy or technological changes affect multinational activity through distinct margins. Reductions in the cost of intangible investment primarily operate through the intensive margin by strengthening the complementarity between intangibles and foreign expansion, while reductions in expansion costs or FDI barriers mainly affect the extensive margin by altering selection into multinational status. Despite these differences, all three experiments increase multinational activity and aggregate intangible intensity, underscoring the central role of intangibles in shaping firms' global organization.

5.3 Quantifying Complementarity Between Intangible Investment and Expansion

To quantify the interaction between intangible investment incentives and foreign expansion, we conduct a set of counterfactual experiments that vary the marginal cost of intangible investment and the fixed cost of expansion. Table 2 reports percentage changes in key outcomes relative to a baseline with high investment costs and high expansion costs. The table is organized as a 2×2 design, where columns correspond to the cost of intangible investment and rows correspond to the cost of expansion.

We define complementarity as the extent to which the joint effect of lowering both costs exceeds the sum of their individual effects. Formally, for an outcome variable Y, the complementarity

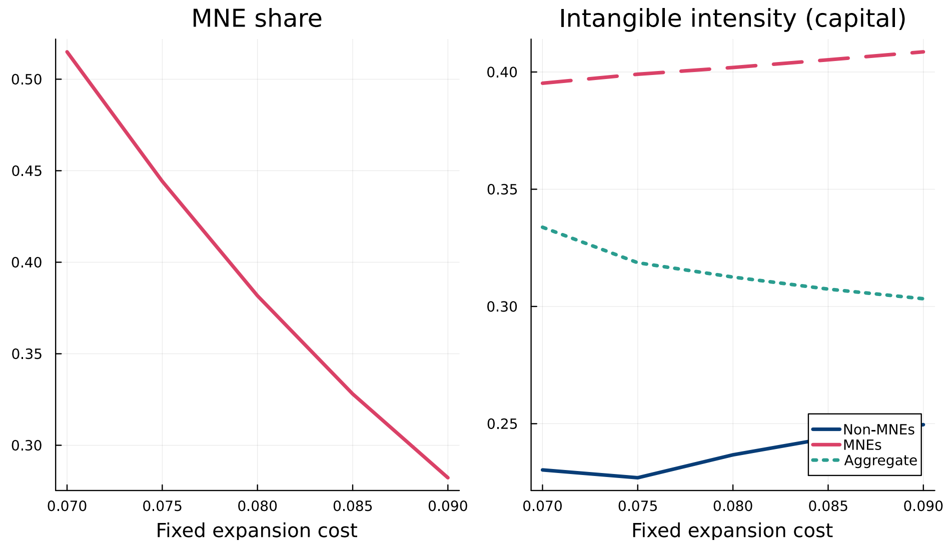


Figure 11: Decrease in fixed expansion costs.

Table 2: Complementarity Between Intangible Investment and Multinational Expansion Costs

	High Investment Cost	Low Investment Cost
	% changes from High–High	
Panel (A): MNE share		
High Expansion Cost	–	+3.0
Low Expansion Cost	+36.7	+43.1
Complementarity (p.p.):		3.4
Panel (B): Intangible Intensity		
High Expansion Cost	–	+12.3
Low Expansion Cost	+1.9	+20.1
Complementarity (p.p.):		6.0

Notes: The table reports percentage changes in outcomes relative to the high–investment–cost and high–expansion–cost benchmark. Complementarity is measured as the excess effect of jointly lowering both costs relative to the sum of their individual effects.

measure is computed as

$$\begin{aligned}\Delta^{\text{comp}} Y \quad \equiv \quad & \left(Y_{\text{Low } MC, \text{ Low } \bar{C}^J} - Y_{\text{High } MC, \text{ High } \bar{C}^J}\right) - \left(Y_{\text{Low } MC, \text{ High } \bar{C}^J} - Y_{\text{High } MC, \text{ High } \bar{C}^J}\right) \\ - \quad & \left(Y_{\text{High } MC, \text{ Low } \bar{C}^J} - Y_{\text{High } MC, \text{ High } \bar{C}^J}\right), \end{aligned} \tag{20}$$

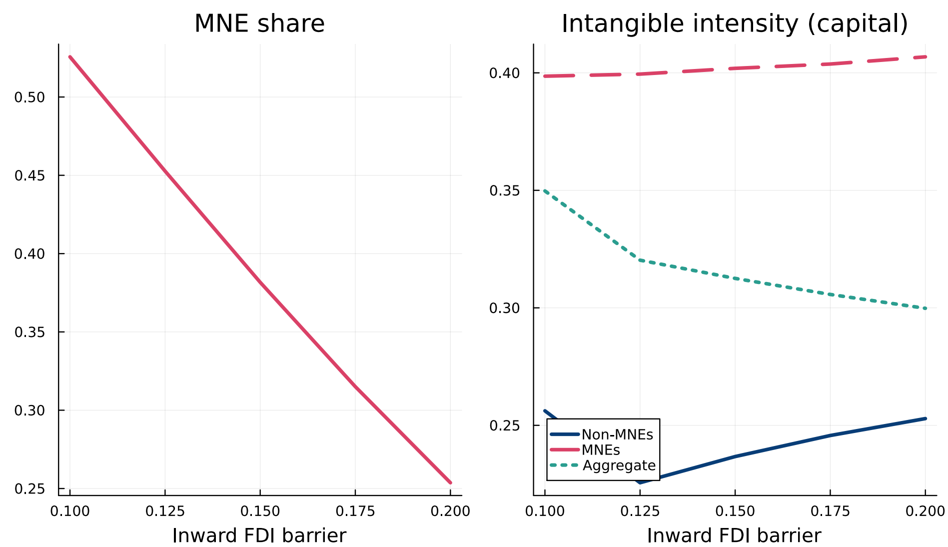


Figure 12: Decrease in foreign direct investment barriers.

and is reported in percentage points (p.p.). A positive value indicates that lowering one cost amplifies the marginal effect of lowering the other.

Panel (A) reports results for the share of multinational firms. Reducing the marginal cost of intangible investment increases the MNE share modestly when expansion costs remain high, but has a much larger effect when expansion costs are low. Conversely, lowering expansion costs has a limited impact when intangible investment is expensive, but a substantial effect when investment costs are low. The positive complementarity implies that intangible investment and expansion reinforce each other: lower investment costs raise the stock of scalable intangibles, which increases the return to expansion, while lower expansion costs raise the payoff to accumulating intangibles ex ante.

Panel (B) reports analogous results for aggregate intangible intensity. The complementarity is even stronger along this margin. When expansion costs are high, cheaper intangible investment raises intensity only modestly. When expansion costs are low, however, the same reduction in investment costs leads to a much larger increase in intangible intensity. This reflects the fact that foreign expansion increases the effective scale at which intangibles can be deployed, strengthening incentives to invest in intangible capital. As a result, policies or shocks that jointly reduce investment and expansion frictions generate disproportionately large effects on both multinational activity and aggregate intangible accumulation.

Overall, the table shows that intangible investment and foreign expansion are quantitatively complementary decisions in equilibrium. Changes that affect one margin alter the incentives on the other, implying that partial-equilibrium evaluations of investment subsidies or trade cost reductions may substantially understate their aggregate and extensive-margin effects.

The magnitude of the complementarities reported in Table 2 can be directly understood through the policy-function and selection mechanisms illustrated in Figures 8 and 9. In the expansion policy function, lowering the marginal cost of intangible investment shifts firms upward in the z dimension, increasing expansion probabilities at every level of productivity. When expansion costs are high, this shift has a limited effect on the extensive margin, as many firms remain below the expansion threshold. This explains the relatively small increase in the MNE share when investment costs fall but expansion costs remain high.

When expansion costs are low, however, the same upward shift in z moves a large mass of firms across the expansion region of the policy function. As a result, the reduction in investment costs generates a disproportionately large increase in multinational activity, consistent with the large difference between the $+36.7$ and $+43.1$ entries in Panel (A). The positive complementarity reflects the fact that changes in intangible investment costs rotate the expansion policy frontier in a region where firm density is high.

A similar logic applies to intangible intensity in Panel (B). Lower expansion costs increase the expected return to intangible accumulation by expanding the set of firms for which intangibles can be profitably deployed across multiple markets. In the policy function, this operates by steepening the responsiveness of expansion probabilities to z, which in turn strengthens incentives to invest in intangibles ex ante. As a consequence, reductions in investment costs translate into much larger increases in aggregate intangible intensity when expansion costs are low, accounting for the stronger complementarity observed along the intensive margin.

Overall, the quantitative complementarities arise from a non-linear mapping between firm states and expansion decisions: shifts in intangible investment or expansion costs move firms across regions of the policy function where selection is most sensitive. This interaction amplifies the joint effect of policy changes relative to their isolated impacts.

6 Implications for Aggregate Productivity Growth

The quantitative analysis in Section 5 shows that declining intangible investment costs and lower barriers to multinational expansion interact strongly, generating large increases in intangible intensity and multinational activity. While Section 5 focuses on firm-level behavior and aggregate composition effects, the same mechanisms have direct implications for aggregate productivity growth. Because intangible capital is nonrival and scalable across production locations, changes that raise intangible intensity and multinational scope translate into economy-wide efficiency gains that appear as measured total factor productivity (TFP). In this section, we use the model to clarify how rising intangible intensity—and its interaction with globalization—maps into aggregate TFP growth and how these gains are distributed across firms and production locations.

A large growth-accounting literature attributes a substantial share of post-1995 productivity growth to intangible capital accumulation. Using a broad measure of intangibles, Corrado et al. (2009) estimate that intangible investment accounts for roughly one-third of U.S. labor productivity growth since the mid-1990s. However, this literature is largely silent on *why* intangible investment accelerated and on how its contribution to productivity depends on globalization, firm heterogeneity, and reallocation. Our framework provides a structural mapping from changes in intangible costs and trade frictions to aggregate productivity outcomes, allowing us to decompose model-implied TFP growth into within-firm efficiency gains and endogenous reallocations toward high-productivity, intangible-intensive firms.

6.1 Intangible Capital as a Driver of Productivity Growth

TFP in the model and in the data. In our framework, total factor productivity (TFP) is not a primitive but an endogenous outcome of firms' choices of intangible capital and multinational scope. We define model-implied aggregate TFP as the Solow residual from the equilibrium allocation,

$$\text{TFP}^{\text{model}} \equiv \frac{Y}{K^{\alpha}L^{1-\alpha}},$$

where Y is aggregate output and K and L are aggregate tangible capital and labor. Intangible capital does not enter as a separate factor input. Instead, higher intangible intensity raises measured TFP by increasing output for given quantities of rival inputs, reflecting the nonrival and scalable nature of intangible assets.

This definition aligns closely with empirical TFP measurement. In the data, many forms of intangible capital—especially internally generated R&D, software, and intellectual property—are imperfectly capitalized or treated as intermediate expenditures. As a result, increases in intangible intensity typically appear as higher measured TFP rather than factor deepening. The model therefore speaks directly to movements in measured aggregate TFP, rather than to exogenous technological progress in a narrow sense.

Two mechanisms are central. First, lower intangible investment costs induce firms to substitute toward scalable, nonrival technologies, raising output conditional on measured, rival inputs. Second, declining expansion costs and trade barriers reallocate activity toward high-productivity, intangible-intensive multinational firms. Together, these forces generate increases in aggregate TFP that are amplified by complementarity between intangible accumulation and multinational expansion. Accordingly, the quantitative exercises in this section are best interpreted as explaining how much of observed TFP growth can arise endogenously from these interacting forces, rather than as a literal growth-accounting decomposition.

Decomposition exercises. To quantify the contribution of declining intangible investment costs and globalization to *model-implied* aggregate TFP growth, we run a set of counterfactuals that vary the key time-varying primitives in the model. Throughout, we hold fixed all other parameters and exogenous processes (including baseline productivity growth and preference/technology parameters), so that differences in TFP across counterfactuals can be attributed solely to the mechanisms emphasized in the paper.

1. **Intangible-cost-only counterfactual.** We allow the marginal cost of intangible investment (MC) to follow its observed post-1995 decline, while holding globalization frictions (fixed expansion costs and FDI barriers) at their initial levels. This isolates the contribution of cheaper intangible investment to model-implied TFP growth.

2. **Globalization-only counterfactual.** We allow globalization frictions (fixed expansion costs and FDI barriers) to decline as observed, while holding MC fixed at its initial level. This isolates the contribution of globalization to model-implied TFP growth through selection, reallocation, and scale.

3. **Joint counterfactual.** We allow both MC and globalization frictions to decline simultaneously. This delivers the total model-implied TFP change generated by the two forces operating jointly.

4. **No-complementarity benchmark.** We recompute the joint counterfactual under a modified environment in which the interaction between intangible accumulation and multinational scope is shut down (i.e., the return to intangible capital is restricted to be independent of the firm's multinational footprint). Comparing this benchmark to the joint counterfactual isolates the amplification due to scalable complementarity.

For each counterfactual, we compute aggregate TFP as the Solow residual implied by the equilibrium allocation and aggregate input use. The decomposition reported in Table 3 expresses the contributions of MC, globalization, and their interaction as shares of the total model-implied TFP change generated by these forces.

Table 3: Decomposition of Aggregate TFP Growth

	Aggregate	Non-MNEs	MNEs		
			Total	Domestic	Foreign
Panel A: Sources of TFP Growth					
Lower intangible investment costs (MC)	XX	XX	XX	XX	XX
Globalization (expansion costs / FDI barriers)	YY	YY	YY	YY	YY
Complementarity ($MC\times$ globalization)	ZZ	ZZ	ZZ	ZZ	ZZ
Total model-implied TFP change	100	100	100	100	100
Panel B: Contribution by Firm Type and Location					
Non-multinational firms	XX	XX	–	–	–
MNEs: domestic production	YY	–	YY	YY	–
MNEs: foreign production	ZZ	–	ZZ	–	ZZ
Panel C: Concentration of TFP Gains					
Top productivity decile	XX	XX	XX	XX	XX
Bottom 90% of firms	YY	YY	YY	YY	YY

Notes: The table reports the planned decomposition of cumulative model-implied aggregate TFP growth over the post-1995 period. TFP is measured as the Solow residual implied by the model. The decomposition conditions on all other sources of productivity growth being held fixed; accordingly, entries sum to 100 by construction and represent the share of TFP changes explained by the mechanisms studied in the paper, not total observed TFP growth in the data. Panel A decomposes TFP growth into contributions from declining intangible investment costs, globalization, and their interaction. Panel B allocates model-implied TFP growth across firm types and production locations, distinguishing between non-multinational firms, domestic production by multinational firms, and production in the U.S. by foreign-headquartered multinational firms. Panel C reports the concentration of TFP gains across the firm productivity distribution. All entries are expressed in percentage points.

Interpreting the contribution of intangibles. Table 3 summarizes the planned decomposition of *model-implied* aggregate TFP growth. Panel A decomposes TFP growth into contributions from declining intangible investment costs, globalization, and their interaction. Panel B allocates the resulting TFP gains across firm types and production locations, distinguishing between non-multinational firms, domestic production by U.S.-headquartered multinationals, and production in the U.S. by foreign-headquartered multinational firms (inward MNE activity). Panel C highlights the concentration of productivity gains across the firm productivity distribution.

This decomposition is designed to isolate the economic margins through which scalable complementarity operates. While lower intangible investment costs raise productivity broadly, their interaction with globalization disproportionately increases TFP through multinational activity—particularly through the deployment of intangible capital by foreign-headquartered firms operating in the U.S. By separating domestic and foreign MNE production, the table makes explicit whether aggregate productivity gains primarily reflect within-firm efficiency improvements or the reallocation and scaling of intangible-intensive production across borders.

6.2 Decomposition of TFP Growth: Technical vs. Allocative Efficiency

To further disentangle the mechanisms driving aggregate productivity growth, we decompose the model-implied TFP changes into contributions from shifting firm-level production frontiers (technical efficiency) and the reallocation of market share toward more productive firms (allocative efficiency). Following Olley and Pakes (1996), we express aggregate TFP in period t, denoted by Φ_t, as the share-weighted average of firm-level measured productivity:

$$\Phi_t = \sum_i s_{it}\varphi_{it} \tag{21}$$

where s_{it} is the output market share of firm i and φ_{it} is the firm's measured total factor productivity (the Solow residual implied by its state vector (a, z, n)). We decompose aggregate TFP into an unweighted average component and a covariance component:

$$\Phi_t = \underbrace{\bar{\varphi}_t}_{\text{Unweighted Average}} + \underbrace{\sum_i (s_{it} - \bar{s}_t)(\varphi_{it} - \bar{\varphi}_t)}_{\text{Allocative Efficiency (Covariance)}} \tag{22}$$

where $\bar{\varphi}_t$ and $\bar{s}_t$ represent the unweighted means of productivity and market share, respectively. This decomposition maps the forces of our structural model—technological change and globalization—to distinct components of aggregate growth:

- **Technical Efficiency ($\bar{\varphi}_t$):** Shifts in this term capture the direct effect of declining intangible investment costs (MC). As costs fall, firms across the entire distribution accumulate more intangible capital z, raising their individual production capabilities given rival inputs. This generates a broad-based increase in the unweighted average productivity.
- **Allocative Efficiency (Covariance):** Shifts in this term capture the selection and reallocation mechanisms induced by globalization. As expansion costs ($\overline{C}^J$) and FDI barriers decline, high-(a, z) firms are disproportionately likely to expand their multinational footprint

(as shown in Figure 8). This expansion allows them to leverage their nonrival intangible assets across a larger scale, increasing their global market share s_{it}.

The scalable complementarity mechanism suggests that the interaction between intangible accumulation and globalization should manifest primarily through the covariance term. Lower intangible costs increase the dispersion of φ_{it} (by benefiting high-z firms more), while lower expansion barriers increase the correlation between φ_{it} and market share s_{it}. This decomposition serves as a structural validation of the *scalable complementarity* mechanism central to our theory. In standard trade models with rival capital, productivity gains often manifest uniformly, primarily driving the unweighted mean $\bar{\varphi}_t$. In contrast, our framework implies that the economic value of intangible capital is realized largely through scale: because intangibles are nonrival, high-productivity firms are incentivized to expand their market share s_{it} via multinational production. Consequently, the interaction between globalization and intangible investment should not merely lift the average firm, but rather strengthen the correlation between size and measured productivity. By isolating the covariance term, we quantify the extent to which aggregate TFP growth is driven by this endogenous selection and the specific capacity of MNEs to leverage nonrival assets across borders.

Table 4: Olley–Pakes Decomposition of Model-Implied TFP Growth

Counterfactual Scenario	**Total Δ TFP**	**Δ Unweighted Mean** (Technical Eff.)	**Δ Covariance** (Allocative Eff.)
1. Intangible Costs Only ($MC \downarrow$)	XX	XX	XX
2. Globalization Only ($\overline{C}^J \downarrow$)	XX	XX	XX
3. Joint Counterfactual	XX	XX	XX

Notes: This table reports the Olley–Pakes decomposition of model-implied aggregate TFP growth into changes in the unweighted mean of firm-level productivity (technical efficiency) and the covariance between productivity and market share (allocative efficiency), following Equation (22). All entries are expressed in the same units as ΔTFP and sum to the total change reported in the first column. The covariance component captures allocative efficiency gains driven by the expansion and reallocation of activity toward high-productivity, high-intangible multinational firms.

In Table 4, we report the change in these components across our counterfactual scenarios. We find that while the *Intangible Cost Only* counterfactual primarily drives the unweighted mean, the *Joint Counterfactual* generates a superlinear increase in the allocative efficiency term, confirming that the rise in aggregate TFP is driven by the concentration of economic activity in intangible-intensive MNEs.

7 Conclusion

This paper studies the joint rise of intangible capital, multinational production, and international profit shifting. Using firm-level evidence, we document that intangible intensity, global footprint, and profit-shifting activity are tightly linked and increasingly concentrated among high-productivity firms. To interpret these patterns, we develop a general equilibrium framework in which firms endogenously choose intangible investment, multinational expansion, and profit shifting, and in which intangible capital is nonrival and scalable across production locations.

The central mechanism in the model is scalable complementarity: declines in the cost of intangible investment and reductions in barriers to operating across borders reinforce one another, amplifying firms' incentives to scale globally and to accumulate intangibles. Profit shifting emerges endogenously from this interaction, as greater intangible intensity both lowers effective tax rates and expands the scope for reallocating profits across jurisdictions. Quantitative exercises show that these interactions are critical for understanding firm-level behavior and have first-order implications for aggregate productivity, operating primarily through reallocations toward intangible-intensive multinational firms.

These findings have important implications for the interpretation of recent productivity trends and for the design of international tax policy. Policies that affect globalization, intangible investment, or profit-shifting incentives cannot be evaluated in isolation: their aggregate effects depend crucially on the complementarities between firm scale and scalable technologies. More broadly, the framework provides a structural lens through which to analyze how technological change, globalization, and tax policy jointly shape firm organization and long-run macroeconomic outcomes.

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Appendix

A Proofs of the Theory Section

Proof of Proposition 1. From Lemma 2, under $\theta = 1$ (fully nonrival intangibles), equilibrium intangible capital is:

$$z \propto \left(\frac{\sum_j \mathcal{P}_{ij} \cdot \mathcal{D}_j}{MC_{zi}} \right)^{\gamma}, \quad \gamma = \frac{1}{1 + (\rho - 1)\alpha}, \tag{23}$$

where $\mathcal{P}_{ij} = ((1 - \sigma_{ij})A_j)^{\rho - 1}$ and $\mathcal{D}_j = \left(Y_j^{1/\rho} P_j \right)$.

By Definition 2, intangible intensity is proportional to z:

$$s_i^z = \frac{z}{\sum_{j \in J_F \cup \{i\}} l_{ij}}.$$

Taking the derivative with respect to MC_{zi}:

$$\frac{\partial s_i^z}{\partial MC_{zi}} \propto \frac{\partial z}{\partial MC_{zi}} < 0 \quad \text{(since } z \propto MC_{zi}^{-\gamma}\text{)}.$$

The elasticity is:

$$\varepsilon_{s_i^z, MC_{zi}} = \frac{\partial \ln s_i^z}{\partial \ln MC_{zi}} = -\gamma < 0. \tag{24}$$

From Equation (39), expansion propensity depends on profit differentials:

$$p_i = \frac{\exp\left(\frac{\pi_i^G(a,1) - \pi_i^G(a,\emptyset)}{\sigma_\kappa} \right)}{1 + \exp\left(\frac{\pi_i^G(a,1) - \pi_i^G(a,\emptyset)}{\sigma_\kappa} \right)}.$$

Profit differentials $\pi_i^G(a, 1) - \pi_i^G(a, \emptyset)$ depend on z (via Equations 16–19). Since $z \downarrow$ as $MC_{zi} \uparrow$, we have:

$$\frac{\partial p_i}{\partial MC_{zi}} < 0.$$

For $\theta > 0$, the term $\sum_j \mathcal{P}_{ij} \cdot \mathcal{D}_j$ in (23) grows due to nonrival deployment (scalability). This amplifies the sensitivity of z to MC_{zi}:

$$\frac{\partial |\varepsilon_{s_i^z, MC_{zi}}|}{\partial \theta} > 0, \quad \frac{\partial |\varepsilon_{p_i, MC_{zi}}|}{\partial \theta} > 0.$$

□

Proof of Proposition 2. From Lemma 2, equilibrium intangible capital under $\theta = 1$ is:

$$z \propto \left(\frac{\sum_j \mathcal{P}_{ij} \cdot \mathcal{D}_j}{MC_{zi}} \right)^{\gamma}, \quad \gamma = \frac{1}{1 + (\rho - 1)\alpha}, \tag{25}$$

where $\mathcal{P}_{ij} = ((1 - \sigma_{ij})A_j)^{\rho - 1}$. Higher FDI barriers ($\sigma_{ij} \uparrow$) reduce $\mathcal{P}_{ij}$, lowering z.

By Definition 2, $s_i^z \propto z$. Taking derivatives with respect to σ_{ij} and κ_{ij}:

$$\frac{\partial s_i^z}{\partial \sigma_{ij}} \propto \frac{\partial z}{\partial \sigma_{ij}} < 0, \quad \frac{\partial s_i^z}{\partial \kappa_{ij}} \propto \frac{\partial z}{\partial \kappa_{ij}} < 0.$$

Elasticities are:

$$\varepsilon_{s_i^z, \sigma_{ij}} = \frac{\partial \ln s_i^z}{\partial \ln \sigma_{ij}} = \frac{(\rho - 1)\sigma_{ij}}{1 - \sigma_{ij}} > 0 \quad (\text{but } \sigma_{ij} \uparrow \text{ reduces } z),$$

$$\varepsilon_{s_i^z, \kappa_{ij}} = \frac{\partial \ln s_i^z}{\partial \ln \kappa_{ij}} < 0.$$

From Equation (39), p_i depends on profit differentials:

$$\pi_i^G(a, 1) - \pi_i^G(a, \emptyset) \propto \underbrace{\left(\frac{(1 - \sigma_{ij})A_j}{MC_{zi}} \right)^{\rho - 1}}_{\text{Term affected by } \sigma_{ij}} - \kappa_{ij}.$$

Higher σ_{ij} or κ_{ij} reduces profit differentials, lowering p_i:

$$\frac{\partial p_i}{\partial \sigma_{ij}} < 0, \quad \frac{\partial p_i}{\partial \kappa_{ij}} < 0.$$

Higher θ amplifies the term $\sum_j \mathcal{P}_{ij} \cdot \mathcal{D}_j$ in (25), making z more sensitive to σ_{ij} and κ_{ij}:

$$\frac{\partial |\varepsilon_{s_i^z, \sigma_{ij}}|}{\partial \theta} > 0, \quad \frac{\partial |\varepsilon_{s_i^z, \kappa_{ij}}|}{\partial \theta} > 0.$$

□

Proof of Propositon 3. Under $\theta = 1$ (fully nontrival intangibles), the equilibrium intangible capital z from Lemma 2 simplifies to:

$$z \propto \left(\frac{\sum_j \mathcal{P}_{ij} \cdot \mathcal{D}_j}{MC_{zi}} \right)^{\frac{1}{1+(\rho-1)\alpha}}, \tag{26}$$

where $\mathcal{P}_{ij} = ((1-\sigma_{ij})A_j)^{(\rho-1)}$. Intangible intensity s_i^z is proportional to z (Definition 2). Individual elasticities are:

$$\varepsilon_{s_i^z,\sigma_{ij}} = \frac{\partial \ln s_i^z}{\partial \ln \sigma_{ij}} = \frac{(\rho-1)\sigma_{ij}}{1-\sigma_{ij}} > 0, \tag{27}$$

$$\varepsilon_{s_i^z,MC_{zi}} = \frac{\partial \ln s_i^z}{\partial \ln MC_{zi}} = -\frac{1}{1+(\rho-1)\alpha} < 0. \tag{28}$$

The interaction term is:

$$\begin{aligned} \frac{\partial^2 \ln s_i^z}{\partial \ln \sigma_{ij} \partial \ln MC_{zi}} &= \frac{\partial}{\partial \ln MC_{zi}} \left(\frac{(\rho-1)\sigma_{ij}}{1-\sigma_{ij}} \right) \\ &= \frac{(\rho-1)\sigma_{ij}}{(1-\sigma_{ij})^2} > 0. \end{aligned} \tag{29}$$

This positive cross-term confirms complementarity. The combined elasticity of s_i^z with respect to σ_{ij} and MC_{zi} is:

$$\varepsilon_{s_i^z,(\sigma_{ij}\cdot MC_{zi})} = \varepsilon_{s_i^z,\sigma_{ij}} + \varepsilon_{s_i^z,MC_{zi}} + \frac{\partial^2 \ln s_i^z}{\partial \ln \sigma_{ij} \partial \ln MC_{zi}}.$$

Substituting from (27), (28), and (29):

$$\varepsilon_{s_i^z,(\sigma_{ij}\cdot MC_{zi})} > \varepsilon_{s_i^z,\sigma_{ij}} + \varepsilon_{s_i^z,MC_{zi}}.$$

This inequality establishes superlinearity. Analogous steps hold for p_i. □

Proof of Proposition 4. From Lemma 2, equilibrium intangible capital z depends on:

$$\Omega_{ij}(\lambda) = 1 + \alpha \left(\frac{(\tau_j - \tau_i) + (\tau_i - \tau_H)(1-\mu)\lambda - (1-\tau_i)W_i\mathcal{C}(\lambda)}{1-\tau_j} \right)$$

where $(\tau_i - \tau_H)$ directly scales profit-shifting incentives. Elasticity derivation:

$$\varepsilon_{s_i^z,(\tau_i-\tau_H)} = \frac{\partial \ln z}{\partial \ln(\tau_i - \tau_H)} \propto \frac{(\tau_i - \tau_H)}{1 + (\rho - 1)\alpha} \cdot \theta$$

The term θ enters multiplicatively due to the aggregator constraint:

$$z \geq \left(\sum\nolimits_j z_{ij}^{\frac{1}{1-\theta}} \right)^{1-\theta}$$

The intuition here is that higher θ enables reuse of z across subsidiaries, amplifying marginal returns to tax arbitrage. Firms with scalable intangibles ($\theta \uparrow$) therefore exhibit greater sensitivity to tax differentials.

Comparative statics for enforcement costs:

$$\frac{\partial s_i^z}{\partial \mathcal{C}_i(\lambda)} \propto -\theta \cdot \frac{(1 - \tau_i)W_i}{(1 - \tau_j)}$$

The negative relationship strengthens with θ because scalable intangibles require profit shifting to offset upfront R&D costs. Cross-partial derivative shows asymmetric impact:

$$\frac{\partial^2 s_i^z}{\partial \mathcal{C}_i(\lambda)\partial\theta} < 0$$

Higher θ makes firms more vulnerable to enforcement shocks. □

Proof of Proposition 5. For $x \in \{s_i^z, p_i, ps_i\}$, express $\ln x$ in terms of $\ln z$:

$$\ln x = \eta_x \ln z + \text{constants}, \quad \eta_x = \begin{cases} 1 & (x = s_i^z) \\ \frac{\rho-1}{\rho} & (x = p_i) \\ 2 & (x = ps_i) \end{cases}.$$

The combined elasticity satisfies:

$$\varepsilon_{x,(\sigma_{ij},\mathcal{C}_i(\lambda))} = \eta_x \left(\varepsilon_{z,\sigma_{ij}} + \varepsilon_{z,\mathcal{C}_i(\lambda))} + \frac{\partial^2 \ln z}{\partial \ln \sigma_{ij} \partial \ln \mathcal{C}_i(\lambda)} \right).$$

From Lemma 2:

$$\varepsilon_{z,\sigma_{ij}} = -\frac{(\rho - 1)\sigma_{ij}}{1 - \sigma_{ij}}, \quad \varepsilon_{z,\mathcal{C}_i(\lambda))} = -\frac{\alpha(1 - \tau_i)W_i\mathcal{C}_i(\lambda)}{1 - \tau_j}.$$

Then cross-partial derivative of z

$$\frac{\partial^2 \ln z}{\partial \ln \sigma_{ij} \partial \ln \mathcal{C}_i(\lambda)} = \frac{(\rho - 1)\alpha\theta}{(1 - \sigma_{ij})(1 - \tau_j)} > 0.$$

Substitute into the combined elasticity:

$$\varepsilon_{x,(\sigma_{ij}, \mathcal{C}_i(\lambda))} = \eta_x \left(-\frac{(\rho - 1)\sigma_{ij}}{1 - \sigma_{ij}} - \frac{\alpha(1 - \tau_i) W_i \mathcal{C}_i(\lambda)}{1 - \tau_j} + \frac{(\rho - 1)\alpha\theta}{(1 - \sigma_{ij})(1 - \tau_j)} \right).$$

Since $\eta_x > 0$ and $\theta > 0$:

$$\varepsilon_{x,(\sigma_{ij}, \mathcal{C}_i(\lambda))} > \varepsilon_{x,\sigma_{ij}} + \varepsilon_{x,\mathcal{C}_i(\lambda))}.$$

The interaction term scales with θ:

$$\frac{\partial}{\partial \theta} \left(\frac{\partial^2 \ln x}{\partial \ln \sigma_{ij} \partial \ln \mathcal{C}_i(\lambda)} \right) = \eta_x \cdot \frac{(\rho - 1)\alpha}{(1 - \sigma_{ij})(1 - \tau_j)} > 0.$$

□

B Productivity and Selection: Additional Evidence

This appendix provides additional evidence on the relationship between firm-level productivity and the key outcomes of interest: multinational status, intangible intensity, and profit shifting. These results complement Section 2.5 by presenting full regression specifications and examining the robustness of the productivity gradient across alternative measures and controls.

We estimate the following baseline specification:

$$y_{it} = \alpha + \beta \cdot \text{TFP}_{it} + X_{it}'\gamma + \mu_{n(i)} + \delta_t + \varepsilon_{it} \tag{30}$$

where y_{it} denotes the outcome of interest for firm i in year t. Across Tables 5–7, we consider several outcome variables: an indicator for multinational status, the number of foreign countries in which the firm operates subsidiaries, the foreign sales share, intangible intensity, an indicator for tax-haven subsidiary presence, and the share of profits shifted to low-tax jurisdictions. The regressor TFP_{it} denotes firm-level total factor productivity, estimated using the control function approach of Ackerberg et al. (2015), and residualized by industry-year fixed effects to remove common productivity shocks. The vector X_{it} includes time-varying firm-level controls (e.g., firm size), and $\mu_{n(i)}$ and δ_t denote 2-digit NAICS industry and year fixed effects, respectively. Standard errors are clustered at the industry and year level to account for correlated shocks within industries and across firms over time.

The coefficient of interest, β, captures the productivity gradient for each outcome. A positive estimate indicates that higher-productivity firms exhibit greater multinational activity, higher intangible intensity, or more aggressive profit-shifting behavior, consistent with the selection mechanisms emphasized in Section 3. In select specifications examining intangible intensity (Table 6), we augment equation (30) with a quadratic term in TFP_{it} to test for nonlinearities in the productivity–intangible intensity relationship.

B.1 Productivity and Multinational Activity

Table 5 examines how firm-level TFP relates to multinational activity along both extensive and intensive margins. Column (1) shows that a one-standard-deviation increase in TFP is associated with a 15 percentage point increase in the probability of being an MNE, controlling only for year fixed effects. This estimate remains economically large (11 percentage points) after adding industry fixed effects and controlling for firm size in column (2), indicating that the productivity–MNE relationship operates within industries and is not driven solely by scale.

Columns (3)–(4) examine the intensive margin using the number of foreign countries in which firms operate subsidiaries. The coefficient of 4.2 in the preferred specification (column 4) implies that high-productivity firms maintain substantially broader geographic footprints conditional on MNE status. Columns (5)–(6) confirm this pattern using foreign sales shares: more productive firms derive a larger fraction of their revenue from foreign operations.

Table 5: Productivity, Multinational Status, and Global Scope

Dependent Var	MNE Indicator		Foreign Countries		Foreign Sales Share	
	(1)	(2)	(3)	(4)	(5)	(6)
Revenue TFP	0.15^{***}	0.11^{***}	5.40^{***}	4.20^{***}	0.08^{***}	0.06^{***}
	(0.01)	(0.02)	(0.96)	(0.96)	(0.01)	(0.02)
Industry FE	N	Y	N	Y	N	Y
Control for log assets	N	Y	N	Y	N	Y
Observations	24,688	24,688	24,688	24,688	24,688	24,688

Notes: This table reports OLS estimates of the relationship between firm-level total factor productivity (TFP) and measures of multinational activity. The dependent variable in columns (1)–(2) is an indicator equal to one if the firm reports at least one foreign subsidiary in Exhibit 21 of its SEC 10-K filing. The dependent variable in columns (3)–(4) is the number of distinct foreign countries in which the firm operates subsidiaries. The dependent variable in columns (5)–(6) is the share of foreign segment revenue in total consolidated revenue. TFP is estimated using the Ackerberg et al. (2015) control function approach, with cost of goods sold as the proxy variable, and residualized by industry-year fixed effects. All specifications include year fixed effects. Columns (2), (4), and (6) additionally include 2-digit NAICS industry fixed effects and control for log total assets. Standard errors, reported in parentheses, are clustered at the industry and year level. Significance levels: $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$.

These results are consistent with the theoretical prediction that only the most productive firms find it profitable to incur the fixed costs of multinational expansion (Helpman et al., 2004). However, the strength of the productivity gradient, particularly the finding that productivity explains variation in multinational scope even after controlling for firm size, suggests that productivity operates through mechanisms beyond simple scale effects. In our model, this reflects the complementarity between productivity and intangible capital: high-productivity firms have stronger incentives to invest in scalable intangibles, which in turn raises the returns to geographic expansion.

B.2 Productivity and Intangible Intensity

Table 6 documents a strong positive relationship between TFP and intangible intensity. Column (1) shows that a one-standard-deviation increase in TFP is associated with a 6 percentage point increase in intangible intensity. This relationship is robust to the inclusion of industry fixed effects (column 2), indicating that the productivity–intangible relationship operates within rather than across industries.

Table 6: Productivity and Intangible Intensity

Dependent Var	Intangible Intensity			
	(1)	(2)	(3)	(4)
Revenue TFP	0.06***	0.06***		0.13***
	(0.006)	(0.006)		(0.02)
Revenue TFP (linear)			0.06***	
			(0.006)	
Revenue TFP (quadratic)			0.005**	
			(0.002)	
Industry FE	N	Y	Y	Y
Control for log assets	N	N	N	Y
Observations	24,688	24,688	24,688	24,688

Notes: This table reports OLS estimates of the relationship between firm-level total factor productivity (TFP) and intangible intensity. The dependent variable in all columns is intangible intensity, defined as the ratio of intangible assets (including capitalized R&D following Peters and Taylor 2017) to total assets. TFP is estimated using the Ackerberg et al. (2015) control function approach, with cost of goods sold as the proxy variable, and residualized by industry-year fixed effects. Column (3) includes both linear and quadratic terms in TFP to test for nonlinearities in the productivity–intangible intensity relationship. All specifications include year fixed effects. Columns (2)–(4) additionally include 2-digit NAICS industry fixed effects. Column (4) controls for log total assets. Standard errors, reported in parentheses, are clustered at the industry and year level. Significance levels: $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$.

Column (3) tests for nonlinearities by including both linear and quadratic terms in TFP. The positive and statistically significant coefficient on the quadratic term (0.005) indicates that the productivity–intangible intensity relationship is convex: intangible intensity increases more steeply at higher productivity levels. This pattern is consistent with our theoretical result (Proposition 3) that cost reductions have larger effects for high-productivity firms, implying that the induced increase in intangible intensity should be concentrated among the most productive firms.

Column (4) adds a control for log total assets. The coefficient on TFP increases substantially (from 0.06 to 0.13), indicating that conditioning on firm size strengthens the productivity–intangible intensity relationship. This pattern suggests that, within size categories, more productive firms are substantially more intangible-intensive, consistent with productivity and intangible investment being complements in production.

B.3 Productivity and Profit Shifting

Table 7 examines the relationship between productivity and profit-shifting activity. Columns (1)–(2) show that higher-productivity firms are substantially more likely to operate subsidiaries in tax-haven jurisdictions: a one-standard-deviation increase in TFP is associated with an 11 percentage

Table 7: Productivity and Profit Shifting

Dependent Var	Tax-Haven Indicator		Profit Shifter		Profit-Shifting Ratio	
	(1)	(2)	(3)	(4)	(5)	(6)
Revenue TFP	0.15***	0.11***	0.08***	0.07***	0.01***	0.01**
	(0.01)	(0.02)	(0.02)	(0.02)	(0.002)	(0.005)
Industry FE	N	Y	N	Y	N	Y
Control for log assets	N	Y	N	Y	N	Y
Observations	24,688	24,688	24,688	24,688	3,511	3,511

Notes: This table reports OLS estimates of the relationship between firm-level total factor productivity (TFP) and measures of profit-shifting activity. The dependent variable in columns (1)–(2) is an indicator equal to one if the firm has at least one subsidiary in a tax-haven jurisdiction identified by Tørsløv et al. (2022). The dependent variable in columns (3)–(4) is an indicator for firms engaging in profit shifting, defined as having positive shifted profits. The dependent variable in columns (5)–(6) is the share of profits shifted to low-tax jurisdictions, using firm-year estimates from Delis et al. (2024); this measure is available only for the subset of MNEs with sufficient data to estimate profit-shifting intensity, resulting in a smaller sample. TFP is estimated using the Ackerberg et al. (2015) control function approach, with cost of goods sold as the proxy variable, and residualized by industry-year fixed effects. All specifications include year fixed effects. Columns (2), (4), and (6) additionally include 2-digit NAICS industry fixed effects and control for log total assets. Standard errors, reported in parentheses, are clustered at the industry and year level. Significance levels: $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$.

point increase in tax-haven presence after controlling for industry and size.

Columns (3)–(4) examine an indicator for profit-shifting status, while columns (5)–(6) use the continuous profit-shifting ratio from Delis et al. (2024). The latter specification restricts attention to MNEs with sufficient data to estimate shifting intensity, reducing the sample to 3,511 observations. Despite this restriction, the productivity gradient remains positive and statistically significant, indicating that conditional on multinational status, more productive firms shift a larger share of profits to low-tax jurisdictions.

These findings are consistent with our model's prediction that productivity, intangible intensity, and profit shifting are jointly determined. High-productivity firms select into multinational status, accumulate larger stocks of intangible capital, and have greater incentives to exploit transfer-pricing opportunities. The positive coefficient on TFP in the profit-shifting regressions, even after controlling for industry fixed effects, suggests that productivity operates through channels beyond industry composition, consistent with the firm-level complementarities emphasized in our theoretical framework.