Intangible Capital Around the World

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Abstract

We estimate the value of intangible capital around the world through the valuation approach of a neoclassical model of investment with two heterogeneous types of capital inputs: physical capital and intangible capital. Using data on public listed firms across 77 countries, we infer the importance of intangible capital for the firm's market value in each country. We find that intangible capital accounts for over half of firms' market value globally, with significant cross-country heterogeneity. To understand the drivers of intangible capital accumulation we explore the variation in the economic and legal environment across countries. We find that protection of intellectual property right, cost of contract enforcement significantly influence the cross-country variation in the value of intangible capital.

Key Words: Valuation, Neoclassical Investment, Structural Estimation, Intangible Capital

JEL Classification: D21, D22, E22, E24, G12, G32

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1 Introduction

How much does intangible capital contribute to a firm's market value? And what are the economic drivers of intangible capital accumulation? To address these questions, we use cross-country variation in the economic and legal environment and a neoclassical model of investment with two inputs—physical capital (e.g., plants and machinery) and intangible capital (e.g., brand name, stock of knowledge). To quantify the relative importance of intangible capital for firm value across the world, we estimate the model using data from a large set of publicly traded firms in 77 countries spanning the period from 2000 to 2020. We find that, while there is substantial cross-country heterogeneity, intangible capital is consistently a crucial determinant of firm value, accounting for over 50% of a firm's market value in the past decade. In addition, the importance of intangible capital in each country is closely linked to country characteristics. We show that institutions, economic and financial market factors—especially the intellectual property right protection and contracting procedural cost—significantly influence the cross-country variation in the value of intangible capital. Taken together, our findings show that intangible capital is a key driver of firm value, and its accumulation is strongly influenced by a country's institutional environment.

We use a generalized neoclassical model of investment to decompose the market value of a firm between physical and intangible capital. In the model, changing the quantity of the capital inputs is costly, which we capture through standard adjustment cost functions. The market value of the firm is contingent on the shadow price and the quantity of each installed input. These shadow prices capture the replacement cost of the input and can be easily estimated from investment data once we specify an adjustment costs function. If both the operating profit and the adjustment costs functions exhibit homogeneity of degree one, the market value of each input is the product of the input's shadow price and the corresponding stock variable. Consequently, the total market value of the firm becomes the sum of the market values of all inputs. This additive characteristic facilitates a straightforward computation of each input's contribution to the firm's overall value.

We estimate the model using data from a large cross section of publicly traded firms around the world. To measure the firm-level stocks of each capital input, we use accounting information data of listed companies from the Compustat (North America and Global) database. For physical capital, the data is readily available from the firm's balance sheet. For intangible capital, we follow Eisfeldt and Papanikolaou (2013) and Peters and Taylor (2017), to construct firm-level measures of intangible stock using accounting data related to Selling, General and Administrative (SG&A) expenses. This is a well populated variable in our multi-country database and Lev and Radhakrishnan (2005) document SG&A serves as a comprehensive measure of investment expense of intangible capital, encompassing multiple types of intangible capital. It reflects the value of skilled labor force (capturing training costs), knowledge capital (often including R&D expenditures), brand capital (accounting for advertising expenses), and other operational expenses. We employ the perpetual inventory method to aggregate these expenditures, enabling us to derive the capital stocks for intangible capital.

To estimate the model we minimize the difference between observed and model-generated valuation ratios, specifically the market value of equity plus net debt-to-book value of capital stocks. We estimate adjustment cost parameters for both physical and intangible capital at the individual country and regional levels. For large equity markets, we estimate country specific adjustment cost parameters. These are 17 countries including all major economies in the world. For other countries, we adopt a strategy of pooling these nations into the geographic areas based on United Nations statistics criteria, and estimate region-specific adjustment parameters. In total, our analysis covers 77 countries, whose the listed companies represent 40% of world GDP and 13% of global value added. Due to data availability most of our analysis focus on the last 15 years, the start date varies per country, mostly starting in the mid 2000 and ends in 2020. Leveraging the estimated adjustment cost parameters, we apply our model to decompose the value of firms into physical and intangible capital for each of these countries.

Our main empirical findings can be summarized as follows. First, we show that neoclassical model of investment with two heterogeneous capital inputs aligns well with the data across diverse economies. In major markets where country-specific parameters are estimated, the model effectively accounts for both time-series and cross-sectional variations in valuation ratios across portfolios. In the worldwide, the cross-country time-series R^2 stands at 57%, while the cross-sectional R^2 reaches 87%. The model exhibits robust explanatory power, across sub-samples of continents. In Asia, the time-series R^2 is 60% and a cross-sectional R^2 of 90%. In Europe, the time-series R^2 is 43% and a cross-sectional R^2 of 80%. In Americas, the time-series R^2 is 67% and a cross-sectional R^2 of 88%.

Including intangible capital and allowing for heterogeneity in the capital inputs, the neoclassical model successfully explains the variation of firm valuation across the world.

Second, we find that the estimated adjustment cost of intangible capital varies across countries and that this heterogeneity is important for capturing firm value. Examining larger equity markets, the physical capital adjustment cost parameter varies from 0.78 for Japan to 8.10 for the USA. Across the countries and regions, the average parameter is 3.87 and a standard deviation of 1.73. For Canada, Thailand, and China, the estimated parameters hover around this average, registering values of 3.73, 3.88 and 3.31, respectively. In contrast, the intangible capital adjustment cost parameter displays greater variability, ranging from 2.91 for Japan to 32.54 for China. The cross-country average stands at 11.63, with a standard deviation of 6.10. The Germany, Canada, and Malaysia align closely with this average, featuring estimated values of 10.27, 11.53, and 11.82, respectively.

Third, our findings show that intangible capital significantly contributes to the market value of firms across all countries. Utilizing the estimated parameters of geography-specific and capital-specific adjustment costs, we calculate the market share of intangible capital for each firm and each time point. In the country-specific estimation, the cross country average value of intangible capital represents 53.88% of the firm's market value. Importantly, there exists substantial heterogeneity in the market share of intangible capital, ranging from 68.93% in China to 33.31% in Canada. Apart from China, the top five countries with the highest intangible market shares include the USA (64.39%), the UK (63.09%), Germany (61.87%), and France (61.71%).

Finally, for all countries that the model directly estimates the specific coefficient, the cost of adjusting intangible capital is higher than the cost of adjusting physical capital. In the worldwide, the adjustment cost of intangible capital is twice as large as that of physical capital, where the market share of intangible capital 53.83% surpasses book value 30.90%. Collectively, these findings underscore the pivotal role of intangible capital as a key input in the production and value creation for firms worldwide.

Our results highlight the significance of geographical variation in adjustment costs for understanding differences in market value among firms and their inputs across countries. To investigate the key country characteristics that drive these cross-country differences we investigate three dimensions of country-level characteristics that may influence adjustment costs: (a) Protection of Intellectual Property Rights, (b) Ease of Contract Enforcement, (c) Economic and Financial Development. We model adjustment costs as a function of these characteristics and re-estimate the neoclassical investment model using this specification. This approach allows us to leverage the heterogeneity of smaller economies within regions, as well as time series variations in firm value and investment rates, to accurately identify the significance of country characteristics. Our findings indicate that the model in which adjustment costs depend on country characteristics fits the data well for all regions except Africa, closely aligning with the parameters in benchmark model.

The extended model translates the cross-country difference in status of institutional infrastructure, economic and financial market development into the amount of capital valuation directly impacted. The marginal compensation value for the under-development of institutional infrastructure and financial market is estimated. Our analysis shows that institutions, particularly the intellectual property rights and the contracting procedures, play significant roles in the cross-country variation of intangible capital value, while similar factors affect physical capital but to a lesser extent. The cross-country variation in intellectual property rights protection contributes to 6.18% standard deviation in variation of firm value, by changing the valuation of intangible capital, while the analogous outcome is 0.74% standard deviation via the channel of impacting physical capital value. The cross-country difference in cost of contract enforcement contributes to 9.65% standard deviation in variation of firm value, by changing the intangible capital value, and 5.69% via changing the physical capital value. Overall, these results emphasize the critical interplay between country characteristics and the valuation of both physical and intangible capital across different economic contexts.

Related Literature. Our research is closely aligned with the extensive literature on valuation and production-based asset pricing, with a specific focus on the role of intangible capital. Hall (2001) discusses the valuation of securities is overly high compared to the price of installed capital in late 1990s. The omitted intangible capital provides a candidate explanation. Belo et al. (2022) provides a decomposition of the value of North American firms, considering physical capital, labor, and two types of intangibles—brand capital and knowledge capital. Crouzet and Eberly (2021) explains the quantitative tension between physical-capital investment rate and the firm valuation, using the adjustment cost estimates from Belo et al. (2022) to decompose the long-run evolution of firm valuation. Peters and Taylor (2017) incorporate organization capital for the total book capital, adjust the measure for the Tobin's Q, and to explain the total firm investment. Eisfeldt and Papanikolaou (2013) show that firms with more organization capital are riskier than firms with less organization capital. In Baker, Baugh, and Sammon (2023), firm operating activity and equity return are prone to the shift of customer base, suggesting the firm payout is exposed to shocks specific to the customer capital. Eisfeldt, Kim, and Papanikolaou (2020) and Gulen et al. (2022) include intangible capital for Value factor. Adjusted measure of firm valuation ratio improves the asset pricing factor models. Hansen, Heaton, and Li (2012) study the risk characteristics of intangible capital. In international macro-finance, research on the cross-section of equity valuation is emerging. To our knowledge, our paper is the first attempt for quantifying market value of intangible capital in global economy. We find that adjustment cost of intangible capital is larger than that of physical capital in most countries. Furthermore, our cross-country analysis allows us to study the importance of country's fundamental characteristics in driving the importance of each input in the firm's market value.

We investigate whether institutions, specifically, weak enforcement of intellectual property, the complex procedures in contract enforcement, will impede the long-run growth of a country via the friction in accumulating the intangible capital . We examine this question by estimating their roles in determining the adjustment cost of capitals owned by firms. Using a dynamic general equilibrium model, Antill et al. (2023) quantify the extent how plaintiff rights in the litigation influences innovation. Strengthening protection to incumbent patent increases the monopoly rent and the firm value, but discourages the innovation of new entrant. Similarly, Crouzet et al. (2022a) argue that stronger property rights can hinder growth by limiting access to intangible capital. Our empirical examination indicates that countries with stronger patent protections experience lower adjustment costs for intangible capital, which, when keeping investment levels constant, leads to a reduced value of that capital. Djankov et al. (2003) documented the heavier formalism and procedural cost in civil law countries. Acemoglu and Johnson (2005) documented countries end up with low GDP if they are associated with the procedural cost in operating the firm reduces the long-run growth in a country. Our empirical examination supplements the literature, by confirming the friction in adjusting capital amount can be reduced if the procedural cost is mitigated, both for the physical capital and the intangible capital.

Our work talks to the recent literature of modern corporate sector in international finance. Karabarbounis and Neiman (2014) document the declining labor share of income in national accounting data, both in the United States and globally. Chen, Karabarbounis, and Neiman (2017) investigated the increasing corporate saving in the private corporate sector. Falato et al. (2022) provide an explanation for the simultaneous shift toward the intangible capital and the corporate saving. Altomonte et al. (2021) claim that the frictions in intangible investments can lead to the dispersion of markup at firm-level. Our work investigates the role of capital market environment in the valuation of intangible capital, by quantifying the difficulty of intangible capital investment for countries. High valuation of intangible capital can be the result of its high shadow price.

Our research complements to the extensive literature on cross-country difference of valuation (firm average Q) and investment. What determines the firm value in a country? La Porta et al. (2002) investigate the ownership of the large listed firms in different countries, document that block shareholder impedes the corporate governance and erodes corporate value. The higher firm valuation is the result of the higher cash-flow growth benefiting from the investor protection. McLean, Zhang, and Zhao (2012) extend the investment-Q regression, document the investment is more sensitive to firm value, in countries with better investor protection. Aforementioned research only considers the homogeneous capital, but intangible capital is crucial for modern corporation. Chemmanur and Yan (2009) document the simultaneous advertising expenditure and the firm equity issuance activity. Larkin (2013) discusses how the brand perception mitigates the difficult in firm financing. Acharya, Baghai, and Subramanian (2014) found patent application and economic importance measured by citation increases after a state in the U.S. adopted the Wrongful Discharge Laws. Calcagnini, Ferrando, and Giombini (2014) document firm valuation tends to be lower in economies with stronger protection of employment contract. Bena, Ortiz-Molina, and Simintzi (2022) document increase in firm process innovation when the labor dismissal cost increases. We utilize the model of adjustment cost function that are determined by the institutional development in multiple aspects, to disentangle the joint effects over capital value from the protection of intellectual property right, the efficacy of contract enforcement, the economic development and the fairness of financial market.

The sensitivity of firm value to investment rate elicits the adjustment cost, conveys the shadow price of capital. The estimation doesn't find significant impact from the shareholder rights, dismissal protection and the tenure contract, conditional on the same status of contracting institutions and financial market. Our estimation confirms that the cross-country variation in firm value is largely contributed by status of country in intellectual property protection and contracting enforcement, via changing the value of intangible capital.

The remainder of the paper is structured as follows: Section 2 presents the model, while Section 3 introduces the functional forms and outlines the estimation procedure. Section 4 details the data used. Section 5 discusses the contribution of intangible capital to firm value and the cross-country difference in cost of investing intangible capital. Section 6 examines the heterogeneity of economic and institutional environment in countries, models the cost parameters as a function of country fundamentals. Section 7 addresses various robustness checks, and finally, Section 8 concludes the paper. Additional results and robustness analyses can be found in the Appendix.

2 The Model of the Firm

We consider a neoclassical model of the firm as in Belo et al. (2022)(we use the consistent notation with Belo et al. (2022) whenever possible) with several quasi-fixed inputs. Time is discrete and the horizon is infinite. Firms choose costlessly adjustable inputs (e.g., materials, energy) each period, while taking their prices as given, to maximize operating profits (revenues minus the expenditures on these inputs). Because we treat intangible capital as quasi-fixed inputs, investments in intangible capital is excluded from our definition of operating profits. Then, taking these operating profits as given, firms optimally choose the physical and intangible capital investments, and debt to maximize their market value of equity.

To save on notation, we denote a firm's i set of capital as $\boldsymbol{K_{it}}$ (variables in bold represent a vector). This set includes the physical capital stock (K_{it}^P) and the intangible capital stock (K_{it}^I). Similarly, we denote a firm's i set of investments in the inputs at time t, as $\boldsymbol{I_{it}}$. This set includes the investment in physical capital (I_{it}^P) and the investment in intangible capital (I_{it}^I).

The law of motion of the firm's capital inputs is given by:

$$K_{it+1}^{P} = I_{it}^{P} + (1-\delta_{it}^{P})K_{it}^{P} \quad (1)$$

$$K_{it+1}^{I} = I_{it}^{I} + (1-\delta_{it}^{I})K_{it}^{I} \quad (2)$$

where δ_{it}^{P} and δ_{it}^{I} are the exogenous depreciation rates of physical and intangible capital, respectively.

2.1 Technology

The operating profit function for firm i at time t is $\Pi_{it} \equiv \Pi(\boldsymbol{K_{it}}, \boldsymbol{X_{it}})$, in which $\boldsymbol{X_{it}}$ denotes a vector of exogenous aggregate and firm-specific shocks. Firms incur adjustment costs when investing. The adjustment costs function is denoted $C_{it} \equiv C(\boldsymbol{I_{it}}, \boldsymbol{K_{it}})$. This function is increasing and convex in investment, and decreasing in the capital stocks. For physical and intangible capital inputs these costs include, for example, planning and installation costs, and costs related with production being temporarily interrupted. We assume that the firm's operating profit function and adjustment costs function are both homogeneous of degree one and we specify the functional forms in the empirical section below.

2.2 Taxable Profits and Firm's Payouts

Firms can issue debt to finance their operations.[1] At the beginning of time t, firm i issues an amount of debt, denoted B_{it+1}, which must be repaid at the beginning of time $t+1$. r_{it}^{B} denotes the gross corporate bond return on B_{it}.

We can write taxable corporate profits, denoted TCP, as operating profits minus intangible capital investments (which are expensed), physical capital depreciation, adjustment costs, and interest expense:

$$TCP_{it} = \Pi_{it} - I_{it}^{I} - \delta_{it}^{P}K_{it}^{P} - C_{it}.$$

Thus, adjustment costs are expensed, consistent with treating them as foregone operating profits.

[1] We include debt in the model to better fit the data, but for parsimonious reasons we keep the financing side of the firm as simple as possible.

Let τ_{it} be the corporate tax rate. The firm' payout, denoted D_{it}, is then given by:[2]

$$D_{it} \equiv (1-\tau_t)[\Pi_{it} - C_{it} - I^I_{it}] - I^P_{it} + B_{it+1} - r^B_{it} B_{it} + \tau_t \delta^P_{it} K^P_{it} + \tau_t (r^B_{it} - 1) B_{it}, \tag{3}$$

in which $\tau_t \delta^P_{it} K^P_{it}$ is the depreciation tax shield, and $\tau_t (r^B_{it} - 1) B_{it}$ is the interest tax shield.

2.3 Equity Value

Firm i takes the stochastic discount factor, denoted $M_{t+\triangle t}$, from period t to $\triangle t$ as given when maximizing its cum-dividend market value of equity:

$$V_{it} \equiv \max_{\{\mathbf{I}_{it+\triangle t}, \mathbf{K}_{it+\triangle t+1}, B_{it+\triangle t+1}\}_{\triangle t=0}^{\infty}} E_t \left[\sum_{\triangle t=0}^{\infty} M_{t+\triangle t} D_{it+\triangle t} \right], \tag{4}$$

subject to a transversality condition given by $\lim_{T\to\infty} E_t[M_{t+T} B_{it+T+1}] = 0$, and the laws of motion for the capital inputs given by equations (1).

Let $P_{it} \equiv V_{it} - D_{it}$ be the ex-dividend equity value. In the online appendix we show that, given the homogeneity of degree one of the operating profit and adjustment costs functions, the firm's value maximization implies that:

$$P_{it} + B_{it+1} = q^P_{it} K^P_{it+1} + q^I_{it} K^I_{it+1}, \tag{5}$$

in which

$$q^P_{it} \equiv 1 + (1-\tau_t) \partial C_{it} / \partial I^P_{it} \tag{6}$$

$$q^I_{it} \equiv (1-\tau_t) \left[1 + \partial C_{it} / \partial I^I_{it} \right] \tag{7}$$

and $\partial C_{it}/\partial x$ denotes the first derivative of the adjustment costs function with respect to variable x, q^P_{it}, and q^I_{it} measure the shadow prices of physical capital and intangible capital, respectively (the Lagrange multipliers of equations (1) to (2)). The valuation equation (5) is simply an extension of

[2] Note that physical capital investment and intangible capital investments are treated differently given the different accounting rules. Investment in physical capital is spread out over time and expensed as depreciation, while the intangible capital costs are mostly treated as expenses at the time that they occur.

Hayashi (1982)'s result to a multi-factor inputs setting. Note that there is subtle difference between the shadow price of the two inputs, which comes from the different tax treatment of the inputs.

According to equation (5) the firm's market value is given by the sum of the value of the firm's installed capital inputs. This additive feature allows us to compute the fraction of firm value that is attributed to each input (henceforth referred simply as "input-shares") in a straightforward manner as follows:

$$\mu_{it}^P = \frac{q_{it}^P K_{it+1}^P}{q_{it}^P K_{it+1}^P + q_{it}^I K_{it+1}^I} \tag{8}$$

$$\mu_{it}^I = \frac{q_{it}^I K_{it+1}^I}{q_{it}^P K_{it+1}^P + q_{it}^I K_{it+1}^I} \tag{9}$$

The fundamental goal of the empirical analysis is to characterize these input-shares, including their variation across countries and over time.

3 Estimation Methodology

In this section we specify the functional forms and describe the estimation procedure. In subsection 3.1 we discuss the functional forms used to model adjustment costs which define the specification of firm equity value. In subsection 3.2 we describe the estimation procedure used that focuses on using portfolios to minimize the idiosyncratic noise in the data, and the definition of country and regions that we use to estimate the model.

3.1 Functional Forms

The valuation equation (5) only requires the specification of the adjustment costs function, not of the operating profit function. We consider the following quadratic adjustment costs function:

$$C_{it} = \frac{\theta_{P,c(i)}}{2}\left(\frac{I_{it}^P}{K_{it}^P}\right)^2 K_{it}^P + \frac{\theta_{I,c(i)}}{2}\left(\frac{I_{it}^I}{K_{it}^I}\right)^2 K_{it}^I, \tag{10}$$

in which $\theta_{P,c(i)}, \theta_{I,c(i)} > 0$ are the parameters that control the magnitude of the adjustment costs of each input. The subscript $c(i)$ is the country (or region as we describe below) of firm's i headquarters. Accordingly, in the baseline of the model, we let the adjustment cost parameters to vary across countries to capture the cross-country differences in the market environment for physical capital and intangible capital investment. These variation might arise due to differences in the judicial system, culture, regulation of financial sector, among other.[3]

This functional form implies that the shadow prices of the capital inputs can be inferred from firm-level data on investment, capital stocks, and taxes, and are given by:

$$q_{it}^P \equiv 1 + (1 - \tau_{c(i),t})\theta_{P,c(i)} \left(\frac{I_{it}^P}{K_{it}^P} \right) \tag{11}$$

$$q_{it}^I \equiv (1 - \tau_{c(i),t}) \left[1 + \theta_{I,c(i)} \left(\frac{I_{it}^I}{K_{it}^I} \right) \right] \tag{12}$$

We adopt a simple quadratic adjustment cost specification for parsimonious reasons and to avoid parameter proliferation. There are several implicit assumptions in our simple specification, such as using gross flows, smooth, convex and symmetric adjustment costs. See Belo et al. (2022) for a discussion of these assumptions.

Denote the firm's total (effective) dollar amount of capital inputs (physical capital stock and intangible capital stock) as $A_{it} = K_{it}^I + K_{it}^P$. Accordingly, we write a firm's valuation ratio ($VR_{it} \equiv (P_{it} + B_{it+1}) / A_{it+1}$) as:

$$VR_{it} = q_{it}^P \frac{K_{it+1}^P}{A_{it+1}} + q_{it}^I \frac{K_{it+1}^I}{A_{it+1}}. \tag{13}$$

If the adjustment cost coefficients depend on institutions and economic development status, a cost function will summarize this relation. The vector of country-level characteristics $\mathbf{X}_{\mathrm{c}}$ includes various aspects of the market environment and is collected at the national level. The adjustment cost coefficients exogenous for the firm are denoted as $\theta_P(\mathbf{X}_{\mathrm{c}})$ and $\theta_I(\mathbf{X}_{\mathrm{c}})$. Therefore, for a firm i residing in country $c(i)$, the firm valuation ratio is defined as follows:

[3] Capital adjustment cost captures the flexibility in implementing the investment plan. The resource reallocation, internal coordination within the corporation is costly, but not directly reported in the firm cashflow statement.For example, in a country where the business secret is easily leaked to competing firms, firm is unwilling to invest, in the fear or being copied by the cohort firms. When there is new demand for the vehicle-design or cost optimization in assembly, despite the future profit flow is lucrative from the investment action, the concern of being copied by competitors, the expectation of coping competitors in the later round, would push the producers simultaneously postpone or taper the effort in launching the new design/investment. Though one doesn't see the direct payment to installing the new design, the manager and the in-house engineers all spent quite a lot of time in monitoring the industry and contemplating the decision of allocating the investment budget.

$$
\begin{aligned}
V\hat{R}_{it} = \quad & \left[1+\theta_P(\mathbf{X}_{c(i)})\cdot(1-\tau_{c(i),t})\left(\frac{I^P_{it}}{K^P_{it}}\right)\right]\frac{K^P_{it+1}}{A_{it+1}} \\
& +(1-\tau_{c(i),t})\left[1+\theta_I(\mathbf{X}_{c(i)})\cdot\left(\frac{I^I_{it}}{K^I_{it}}\right)\right]\frac{K^I_{it+1}}{A_{it+1}}
\end{aligned} \quad . \tag{14}
$$

We use this specification to investigate to what extent a universal model can explain the firm valuation ratio in multiple countries jointly. For this state-contingent adjustment cost model, we will estimate the linear approximated function as:

$$
\begin{aligned}
\theta_I(\mathbf{X}) = \quad & \theta_{I,g} + \boldsymbol{\gamma^I}\cdot\mathbf{X}_{\mathrm{c}} \\
\theta_P(\mathbf{X}) = \quad & \theta_{P,g} + \boldsymbol{\gamma^P}\cdot\mathbf{X}_{\mathrm{c}}
\end{aligned} \quad . \tag{15}
$$

The intercept coefficients $\theta_{I,g}$ and $\theta_{P,g}$ are the global average level of cost for each capital input, as each country characteristic are expressed as the deviation from the global average.[4] The vector of the incremental cost coefficients $\boldsymbol{\gamma^I}$, describes how deviation of a country in institutional environment and economic development, adds to the cost of investing intangible capital. Analogously, the vector γ^P is for investing the physical capital.

We conduct the estimation in steps. First, we directly estimate the country-specific cost parameters, to ensure the minimal assumptions. The main empirical findings will be detailed in Section 5. After verifying the dynamic investment model with intangible capital can reasonably explain the firm investments and valuation in most countries, we next unveil how the institution status determines the cross-country heterogeneity in adjustment costs. Description of countries and the model estimation outcome will be detailed in Section 6. Our strategy enables us to leverage the cross-section and time-series variation in firm value and investment rates, as well as the heterogeneity of economies, to properly identify the importance of country characteristics.

3.2 Estimation Procedure

We estimate the model separately in each country (or region, as explained below). Hence, to save notation, in this section we omit the country/region subscript in the model parameters.

The valuation equation (5) links firm value to the value of its capital inputs. The left-hand side

[4] In other words, $\frac{1}{N_c}\sum_c \mathbf{X}_c = \mathbf{0}$ holds by construction. These coefficients $\theta_{I,g}$ and $\theta_{P,g}$ indicate the level of adjustment costs when all country characteristics are set to their global averages

(LHS) of equation (13) can be directly measured in the data from equity price and debt data (and measures of the capital stocks, which we discuss below). The right hand side (RHS) of equation (13) is the predicted valuation ratio from the model, which we will denote as $\widehat{VR}_{it}$, and depends on firm-level real variables and model parameters.

Equation (13) establishes an exact relationship between a firm's observed valuation ratio and its model-implied valuation ratio at each time-period. However, due to the noise in firm-level data and the sensitivity of their moments to entry and exit and missing observations, using equation (13) and firm-level data to directly estimate the model parameters is challenging. Therefore, we follow the same methodology as Belo et al. (2022) and estimate portfolio-level moments. The portfolio estimation methodology targets the cross-sectional mean at the portfolio level and aligning the realized time series of portfolio-level valuation ratios with the model's predictions, provide robust estimates.

We proceed as follows. In theory, at each point in time, any cross-sectional moment of the observed firm-level valuation ratios in the LHS of equation (13) should be equal to any corresponding cross-sectional moment of the model-implied firm-level valuation ratios in the RHS of equation (13). Accordingly, in each country, for each portfolio j and for each year t, we compute the cross-sectional mean observed and model-implied valuation ratios ($\overline{VR}_{jt}$ and $\widehat{\overline{VR}}_{jt}$, respectively) of the firms in the portfolio as follows:

$$\overline{VR}_{jt} = \sum_{i} \frac{VR_{it}}{N_{jt}}$$

$$\widehat{\overline{VR}}_{jt}\left(\Theta\right) = \sum_{i} \frac{\widehat{VR}_{it}}{N_{jt}} \ , \ i \in \text{portfolio } j,$$

where Θ represents the vector of structural parameters in a given country, $\Theta = [\theta_P, \theta_I]$, and N_{jt} is the number of firms in portfolio j at time t. We target cross-sectional mean valuation ratios because these moments capture the economic behavior of a typical (average) firm in the economy, which is what the theoretical model is designed to study.

We then proceed under the standard assumption that the portfolio-level valuation ratio moments are observed with error by the econometrician:

$$\overline{VR}_{jt} = \widehat{\overline{VR}}_{jt}(\Theta) + \varepsilon_{jt}, \tag{16}$$

where ε captures measurement error in the portfolio-level moments.[5] Based on equation (16), in each country, we then estimate the model parameters by minimizing the squared distance between the portfolio-level observed and model-implied valuation ratio moments at each point in time:

$$\widehat{\Theta} = \arg\min_{\Theta} \frac{1}{TN} \sum_{t=1}^{T} \sum_{j=1}^{N} \left(\overline{VR}_{jt} - \widehat{\overline{VR}}_{jt}(\Theta) \right)^2, \tag{17}$$

where T is the number of years in the sample, and N is the number of portfolios. An attractive feature of our estimation approach is that it corresponds to a simple linear ordinary least squares (OLS) estimation of (modified) portfolio-level average valuation ratios on portfolio-level averages of firm-characteristics. To show this, define the following variable,

$$\overline{VR}^{M}_{jt} = \frac{1}{N_{jt}} \sum_{i \in j} \frac{\left(P_{it} + B_{it+1} - K^{P}_{it+1} - (1-\tau_t) K^{I}_{it+1} \right)}{A_{it+1}}$$

as the modified (M) valuation ratio. In addition, define the variables

$$\overline{IPA}_{jt} = \frac{1}{N_{jt}} \sum_{i \in j} (1-\tau_t) \frac{I^{P}_{it}}{K^{P}_{it}} \frac{K^{P}_{it+1}}{A_{it+1}}$$

and

$$\overline{IKA}_{jt} = \frac{1}{N_{jt}} \sum_{i \in j} (1-\tau_t) \frac{I^{I}_{it}}{K^{K}_{it}} \frac{K^{I}_{it+1}}{A_{it+1}},$$

which are the portfolio-level average physical and intangible capital, respectively, contribution to firm value. We can then write equation (16) simply as:

$$\overline{VR}^{M}_{jt} = \theta_P \overline{IPA}_{jt} + \theta_I \overline{IKA}_{jt} + \varepsilon_{jt} \tag{18}$$

[5] Mismeasured components of the valuation ratio such as the market value of debt and the capital inputs can be better observed by firms than by econometrician. Furthermore, the intrinsic value of equity can temporarily diverge from the market value of equity.

which establishes a linear relation between the portfolio-level modified valuation ratio and portfolio-level characteristics. Thus, our objective function in (17) corresponds to a simple linear OLS regression of equation (18). The functional forms outlined in equation (15) enter linearly in the value ratio of equation (14), allowing us to estimate the set of parameters, global average cost θ_g and incremental cost coefficients γ using the portfolio-level estimation method outlined. Importantly, this method ensures that countries with a large number of firms do not skew the parameter estimates, as each country or each region of the remaining area within continents is represented by an equal number of observations—specifically, the number of portfolios.

3.3 Geographic Areas and Portfolio Sorts

As noted above, the estimation is performed at the portfolio-level and separately for each country or region.

Geographic Areas. To link a firm to a country, we use the firm's headquarter.[6] Ideally, we would like to estimate the model separately for all the countries in the sample. This approach is not possible, however, as the number of firms and observations is too small in some countries. In these cases, we combine multiple countries from a similar geographic area into a region.

Specifically, we define large equity markets as those countries having data for at least 200 firms in the time-series average during the sample period, and medium equity market as the countries with at least 100 firms. We estimate the model for the economies with large-size equity market, and the rest of area in each continent separately.

In the continent of *Asia*, countries (or territories) China, Hong Kong, India, Indonesia, Japan, Malaysia, Singapore, South Korea, Taiwan, Thailand have large-size equity markets, under this criterion. In the remaining area of Asia, Israel, Pakistan, Turkey, Vietnam have the medium-size equity markets. Small-size countries are: Southern Asia (Bangladesh, Sri Lanka), South-Eastern Asia (Philippines), Western Asia (United Arab Emirates, Bahrain, Cyprus, Jordan, Kuwait, Oman, Palestine, Qatar, Saudi Arabia).

In the continent of *Europe*, France, Germany, Poland, United Kingdom, are economies with the large number of listed companies. In the remaining area of Europe, Greece, Italy, Sweden,

[6]For robustness check, we also consider defining the location of firm as its residing country of incorporation. The result are similar.

Switzerland have the medium-size equity market. Small-size countries are: *Southern Europe* (Spain, Croatia, Malta, Serbia, Slovenia), *Eastern Europe* (Bulgaria, Hungary, Romania, Russia, Ukraine), *Northern Europe* (Denmark, Estonia, Finland, Ireland, Iceland, Lithuania, Latvia, Norway), *Western Europe* (Austria, Belgium, Luxembourg, Netherlands, Portugal).

In the continent of *Americas*, Canada, United States of America are large economies. In the remaining area of Americas, Brazil has the medium-size equity market. Small-size countries are: *Latin America and the Caribbean* (Argentina, Chile, Colombia, Cayman Island, Jamaica, Mexico, Peru).

We estimate the adjustment cost parameters for each country and remaining regions separately. This procedure avoids double-accounting of observations. In *Oceania*, we don't have valid observations of listed firms locating in this continent after the large economy Australia is selected out. In *Africa*, South Africa is has the largest equity market and falls under the medium-sized equity market category in our global classification. Other small-size countries in Africa include *Northern Africa* ountries (Morocco and Tunisia) and *Sub-Saharan African countries* (Cote D'ivoire, Kenya, Mauritius, Nigeria).

In summary, we use a simple classification of four regions: *Rest of Asia*, *Rest of Europe*, *Latin America*, and *Africa*. The Oceania sample for estimation includes only one large economy, Australia. Hence, our analysis covers 77 countries across five continents. For simplicity, the model of country-specific adjustment cost assumes countries of a small market locating in the same region have identical adjustment cost. This simple model equates to separated estimations in 21 different geographic areas: 17 countries with large equity markets, and four regions– *Rest of Asia*, *Rest of Europe*, *Latin America*, and *Africa*.[7] This assumption will be relaxed in the formal universal model of state-contingent adjustment cost, where observations in all countries jointly identify the determinant of adjustment cost.

Portfolio sorts. For each one of 21 geographic areas, we form portfolios sorted on the following variables: $\left(\frac{I_{it}^P}{K_{it}^P}\right)\left(\frac{K_{it+1}^P}{A_{it+1}}\right)$, $\left(\frac{I_{it}^I}{K_{it}^I}\right)\left(\frac{K_{it+1}^I}{A_{it+1}}\right)$. Sorting on these variables generates a large dispersion in the explanatory variables which helps for the identification of the model parameters. (In the

[7]Distribution of the 21 geographic areas in the five continents are: *Asia* (China, Hong Kong, India, Indonesia, Israel, Japan, Malaysia, Singapore, South Korea, Taiwan, Thailand, *Rest of Asia*), *Europe* (France, Germany, Poland, United Kingdom, *Rest of Europe*), *Americas* (Canada, United States of America, *Latin America*), *Oceania* and *Africa*.

online appendix, we show that the model results are robust across different sorting variables.) We then follow Fama and French (1993) in constructing the portfolios. Specifically, all firms in each year t are two-way sorted into 9 portfolios based on the quintile of the each sorting variable of each firm for the fiscal year ending in $t-1$. The portfolios are re-balanced at the end of each year. This procedure gives a total of $9 \times 21 = 189$ portfolios from all countries in the sample.

4 Data

In this section, we provide a general description of the data.

We construct firm-level measures of market value, input investment, and stock using the financial reports of publicly traded firms in each country. For firms in the United States and Canada, we collect annual balance sheet information from Compustat North America Annual Fundamentals and stock price data from the Compustat-CRSP linked dataset. For firms in other countries, we gather annual information from Compustat Global Annual Fundamentals and stock prices from Compustat Global Security Daily. [8]

We set the currency as the U.S. dollar for all countries. The frequency is annual and varies by country. We deflate the variables using the country-specific consumer price index. We set the starting-year as the year when the country has sufficient firm-year observations. For major economies, the data spans 2000-2020 (see Table OT.1 for individual country samples, and the starting year for each country or region). The sub-samples of countries in Asia start around 2000, while those for main countries in Europe and Africa start around 2006.[9]. The full records for listed companies in North America date back further; however, for estimation to be comparable to other countries worldwide, we use the sample for Canada and the United States starting from 2000. The end-year is 2020 for all countries and regions.

[8] Additional details about the data sources and the harmonization of measures are available in the Section D of the online appendix.

[9] Gauging the amount of intangible capital requires detailed income statement information that conforms to the international financial statement reporting standard. The sub-sample of listed companies in different countries doesn't start in the same years. This is partly constrained by the adoption of common accounting standard around the year 2005.

4.1 Capital stocks and other variables

4.1.1 Physical Capital

The initial physical capital stock, K_{it}^P, is given by net property, plant, and equipment (data item PPENT). The capital depreciation rate, δ_{it}^P, is calculated as the amount of depreciation (data item DP) divided by the beginning of the period capital stock. We then construct a measure of the firm's capital stock at current prices. Specifically, we construct an investment-price adjusted capital stock that accounts for changes in the real cost of physical capital investment by repricing last period's capital stock using today's price of investment (P_t^P) as $K_{it+1}^P = K_{it}^P(1-\delta_{it})\frac{P_{t+1}^P}{P_t^P} + I_{it+1}$. Following Belo et al. (2022) we infer physical capital investment from the law of motion of capital using this equation (adjusted for inflation). This procedure ensures that the investment and capital stock are consistent with the law of motion for physical capital in the model.

4.1.2 Intangible Capital

Following Eisfeldt and Papanikolaou (2013) we construct a measure of intangible capital based on Selling, General, and Administrative (SG&A) expense data (Compustat data item XSGA).[10] We calculate the installed amount of capital using the perpetual inventory method as follows:

$$K_{it+1}^I = \mathrm{I}_{it+1}^I + (1-\delta^I) \cdot K_{it}^I \cdot \frac{P_{t+1}^I}{P_t^I}. \tag{19}$$

where P_t^I is approximated as the CPI of home country in local currency. The depreciation rate, δ^I, is calibrated as 20%. We set investment expenditure equal to 30% of SG&A expense following Eisfeldt and Papanikolaou (2013) and Peters and Taylor (2017).[11] We set the initial amount of

[10] In the US and Canada, firms report the detailed expenditure of R&D and advertising, estimation could differentiate heterogeneous capital inputs such as knowledge and brand, (see Belo et al. (2022)). Firms in other countries don't universally report these details. The quantity of investment in intangible capital cannot be inferred from the historical records related to goodwill and other intangible assets in balance sheet. These are valuation-based measures. When comparing the valuation of firms across countries, the SG&A expense is the most comparable measure for the investment expenditure in intangible capital.

[11] The fraction of firms disclosing detailed expense of R&D and advertising, is not comparable across countries. Section 7.4 examines the estimation using alternative calibration, by adapting the procedure in Peters and Taylor (2017) in other countries. Section 7.4 examines the model estimation in which the quantity of intangible capital is inferred using the firm operating profit. The conclusion for the importance of intangible capital, and cross-country variation are similar.

capital as

$$K_{i0}^I = \frac{I_{i0}^I}{g_{\text{Ind}(i)}^I + \delta^I - \pi_{\text{Ind}(i)}^I \cdot (1 - \delta^I)}. \tag{20}$$

in which I_{i0}^I is the firm's investment in intangible capital in the first year in the sample, and $\pi_{\text{Ind}(i)}^I$ is the average price growth rate, in the industry, in each country. We let $g_{\text{Ind}(i)}^I$ be industry-specific and set it equal to the average growth rate of the SG&A expense in that industry. We consider the first 2-digits of NAICS industry code to classify the industry in each country. Once we have the initial amount of capital, we derive the new amount of capital in equation (19), using the depreciation rate, SG&A expenses, and investment price index. The investment rate on intangible capital is then given by the ratio of the current period investment and the amount of intangible capital at the beginning of the period I_{it}^I/K_{it}^I.

4.1.3 Additional Variables

We measure the debt value B_{it}, as the book value of net total debt, following Belo et al. (2022). We calculate net debt as long-term debt (Compustat data item DLTT) plus short-term debt (data item DLC), minus cash (data item CHE). When these values are missing, we set the measure to zero. The market value of equity, P_{it}, is the closing price per share (data item PRCCF) multiplied by the number of common shares outstanding (data item CSHO). The market value is based on the year-end price during the firm's fiscal year. All nominal values in local currency are converted into nominal USD using the annual-average exchange rate.

We measure the tax rate, τ_t, as the corporate income tax rate from the Tax Foundation, available for each country. If corporate income tax rate information is unavailable, we use data from Compustat Global-Economic Indicators. Stock variables with subscript t ($t+1$ for debt) are measured and recorded at the end of year t, while flow variables with subscript t are measured over the course of year t and recorded at the end of year $t+1$.

4.2 Summary Statistics

Our sample of 77 countries is representative of the total production across the world. Our sample includes 29,631 firms in total, with sales representing 40.15% of world GDP in the end year of sample period. Table OT.1 reports the descriptive statistics. [12]

Table 1 reports key summary statistics of the observed valuation ratios and their model-implied components according to equation (13), for the major equity markets and regions. The median valuation ratio across all major markets is 1.44, but there is substantial heterogeneity across countries. While China has the highest average valuation ratio, at 2.95, Japan has the lowest, at 0.87.

According to equations (11) and (12), the investment rates determine the shadow prices of the labor and capital inputs. Together with relative magnitude of each capital stock, these variables determine the relative importance of each input for firm value. Columns (3) and (4) in Table 1 show that investment in intangible capital is, on average, higher than investment in physical capital across all countries. The global median investment rate in intangible capital is 25%, with a maximum of 34% in China and a minimum of 20% in Indonesia. The global median investment rate in physical capital is 15%, with a maximum of 24% in the USA and a minimum of 8% in India. In terms of relative magnitudes of the capital stocks, column (5) shows that intangible capital is about 38% of total (physical plus intangible) capital across the globe. Again, this average exhibits substantial variation across countries, with a maximum of 67% in France and a minimum of 21% in Canada.

Column (6) of the table reports the cross-correlations of investment rates. As expected, the investment rates are all positively correlated, ranging from 21% to 37% across major equity markets. These correlations are significantly less than one, suggesting that the investment rates for different types of capital inputs exhibit distinct variations in the data. Distinguishing the shadow prices could help explain the observed variation in market value.

[12] In Asia, the 10 large equity markets and 16 countries in the Rest of Asia, include 16,133 firms, with sales representing 41.73% of GDP in these countries in 2020. For these large countries, per capita GDP in 2020 ranges from $1,849 in India to $56,423 in Singapore. In Europe, the 4 main equity markets and the 27 countries in the Rest of Europe include 5,380 firms, with sales representing 35.28% of GDP in these countries. In Canada, the United States, and 8 countries in Latin America, the sample includes an average of 6,480 firms, with sales representing 44.07% of GDP in these countries. In Australia, listed companies in the sample have sales equal to 23.23% of GDP. For the 9 countries in Africa, the sales of the listed companies in the sample represent around 15.05% of the GDP in these countries.

5 Estimation Results

This section presents the main empirical findings. Subsection 5.1 reports the parameter estimates and the baseline model's overall fit. Subsection 5.2 discusses the model-implied breakdown of firm value, decomposing market value into physical and intangible capital. This analysis underscores the significance of intangible capital in capturing a firm's market. Subsection 5.3 examines the heterogeneity in the market share of intangible capital, distinguishing between quantity and price variations. The analysis highlights the importance of country-specific adjustment costs in explaining cross-country differences in firm value.

5.1 Parameter Estimates and Model Fit

In Table 2, columns (2-3) and (8-9) present the estimates of adjustment cost parameters for the model applied to larger equity markets and regions. All estimates are positive and statistically significant. The intangible capital adjustment cost parameter (θ_I) is consistently higher than the adjustment cost parameter for physical capital (θ_P), but there is considerable heterogeneity across countries in the estimate magnitude of each parameter. The summary statistic for the "world" region shows that the cross-country average adjustment cost coefficient for physical capital is 3.87, while the average adjustment cost coefficient of intangible capital is 11.63.[13] In addition, the dispersion in the estimated adjustment cost coefficient of intangible capital θ_I is more pronounced than that for physical capital. The standard deviation of estimates across countries for physical capital is 1.73, ranging from 0.78 for Japan to 8.10 for USA.[14] In contrast, the cross-country standard deviation for intangible capital estimates is 6.10.

Notably, θ_I estimates are relatively low for European countries such as France (7.75), Germany (10.27), and the U.K. (8.91), but high in North American countries such as United States (16.32)

[13]The cross-country average outcome is calculated including the regions, where there are multiple countries within. As previously mentioned, we assume identical adjustment cost function for countries with the small-size equity market in the same region, considering they have the similar cultural background and legislation origin. This ensures the sufficient sample size to accurately identify the model. Hereafter, the name of terminology of statistics don't differentiate between the countries and the regions of the remaining area in each continent.

[14]As explained in previous section of estimation methodology, within the Latin America, we assume the identical adjustment cost function for the medium-size country Brazil, and other small-size countries. The calculation of standard deviation describes the variation across the 17 large-size countries and the 4 regions where the constituent countries are assumed to be of identical parameters within each region. We explore the more granular estimates in the extended estimation of country-characteristic model.

and Canada (11.53). The pattern is less clear in Asia, where estimates of the intangible capital adjustment cost parameter are low for Japan (2.91), South Korea (5.72), Hong Kong (6.97), and Singapore (6.99), but high for China (32.54), India (19.83), and Taiwan (15.23). In contrast, European countries such as France and Germany show only small differences in the estimated adjustment cost coefficient of intangible capital. The dispersion of the estimated adjustment cost coefficient of intangible capital is much larger in Asia, reflecting the varying levels of economic development and, consequently, the different market environments in which firms operate.

To assess the economic significance of the adjustment cost estimates and evaluate whether the model matches the data with economically reasonable parameter values, we use the functional form specification in equation (10) and the parameter estimates to calculate the realized adjustment costs of each input (denoted as CP and CI). These values are computed as a fraction of a firm's total annual sales as follows:

$$\frac{CP_{it}}{Y_{it}} = \frac{\frac{\theta_{P,c(i)}}{2}\left(\frac{I^P_{it}}{K^P_{it}}\right)^2 K^P_{it}}{Y_{it}} \tag{21}$$

$$\frac{CI_{it}}{Y_{it}} = \frac{\frac{\theta_{I,c(i)}}{2}\left(\frac{I^I_{it}}{K^I_{it}}\right)^2 K^I_{it}}{Y_{it}}. \tag{22}$$

Table 4, columns (2) and (3), report the average realized adjustment costs of each input, computed as the time-series average of cross-sectional medians of the ratios in equations (21) and (22). China stands out as having the highest adjustment cost of intangible capital, at 18.19% of annual sales, followed by 12.13% in the US. For physical capital, the US and European countries top the list.

Table 4 reports the numbers for all firms in our sample (the World). In each year, we calculate the median cost among all firms. In the most recent five years of our sample, the average intangible capital adjustment cost is 5.56% of sales. This cost is higher than the adjustment costs for physical capital, which is about 1.26% of sales. The aggregate cost, expresses as a percentage of the aggregate sales, shows a similar distribution across types of capital and the countries. The fact that the median statistic is higher than the aggregate ratio, reflects that adjustment cost for capital investment matter more for small- to medium-sized firms in each country.

The model with both physical and intangible capital fits the data well when we evaluate model-fitness using the cross-sectional and the time-series fitness measures. In Table 3, the summary panel shows that the cross-sectional R^2 is high, at 87% across all portfolios worldwide, even though the model estimation does not explicitly target this moment. The average time-series R^2 is 57%.

In terms of average valuation ratio errors, the model scaled mean absolute error (m.a.e./$\overline{\text{VR}}$) is 24% on average. Since the subset of portfolios in each country independently identify the adjustment cost coefficients specific to that country, we also report the fitness statistics for individual large countries and regions in Table 2. There is less variation within the country compared to the worldwide. However, the model performs well in most countries, including Indonesia, India, South Korea and United Kingdom. The good model-fit implies that the generalized neoclassical model with intangible and physical capital describes the valuation of firms well across a wide variety of countries.[15]

Overall, the estimation results show that adjustment costs of inputs vary across countries and regions, particularly for intangible capital. The results in Table 2 highlight the importance of quantifying heterogeneous market environments using country-specific adjustment cost parameters.

5.2 The Value of Intangible and Physical Capital

The parameter estimates allow us to compute the model-implied shadow prices of each input and evaluate the contribution of each input to firm value (input shares) based on each input's market value. Specifically, using the estimates reported in Table 2, we compute the model-implied scaled value of each capital input, the values of $q^P_{it}\frac{K^P_{it+1}}{A_{it+1}}$ and $q^I_{it}\frac{K^I_{it+1}}{A_{it+1}}$, for each firm in each year. We then substitute these values into equations (8) and (9) to compute the shares of each capital input.[16] To

[15]There is no simple linear relationship between the firm valuation, the investment rate of physical capital, and that of intangible capital. Especially, the bi-variate distribution of the firm valuation and the intensity of intangible capital, is not the simple monotonic relationship.

Table OT.13 examines the portfolios where firms are grouped using the lagged period investment rate of physical capital, the investment rate of intangible capital. We derive the firms valuation ratio using the parameter estimates in Table 2, then the portfolio-level valuation ratio is calculated for these portfolios of alternative firm characteristic variables. Each firm characteristic variable has 10 decile portfolios. In total, there are 21×20 portfolios cross countries and regions. In these alternative portfolios that are not directly used for model estimation, the measurement error is sufficiently diversified. In each set of portfolios in those 21 countries and regions, the fitness of the model is high, with comparable statistics value to Table 2. The model with the country-specific cost and two capital inputs explain the firm valuation successfully.

[16]Note that, by construction, the input shares sum to 100%. For brevity, we report the share of intangible capital in firm valuation.

characterize the data in a comprehensive yet parsimonious manner, we summarize the properties of the firm-level input shares in the economy. We compute the median of the intangible share in each year and each country, then calculate the mean across years for each country.

In Table 4, Columns (2) and (8) show the estimated importance of intangible capital for each country and region within each continent. Given the firm-level decomposition of capital, we can calculate the worldwide median market share of intangible capital, which is about 53.88. This indicates that the contribution of intangible capital to a firm's market value across the globe is higher than the contribution of physical capital.

Overall, this analysis shows that intangible capital is an important determinant of firms' market values across the world. As summarized in Table 3, we re-estimate the counterfactual model, where the firm uses only physical capital for the capital inputs in production. [17] This counterfactual model assumes zero contribution from intangible capital to firm value. To provide a meaningful comparison of the model fit in terms of R^2, we employ the same set of firms used in the baseline model estimation. Comparing the model fitness of the physical capital-only model, which exhibits mostly negative R^2 values, offers another perspective on the importance of intangible capital in firm value.

When an input is costly to adjust, the installed values of the inputs become valuable to the firm because accumulated capital inputs help avoid adjustment costs in the future. If adjustment costs are zero, the shadow prices of the inputs in equations (11) and (12) are simply one (for physical capital) and $(1 - \tau_t)$ (for intangible capital). As a result, the value of each capital input is equal to its book-value (adjusted for the tax rate). Columns (5) and (11) list the book share of intangible capital, $\overline{\mu_I}$, in the counterfactual estimation of the contribution of intangible capital to firm value assuming zero adjustment costs. Compared to the 53.83% average cross-country market share, the cross-country average book share is 30.90% for the major equity markets. China stands out with a 24.22% book share of intangible capital versus a 68.93 market share.

The observed high market value of intangible capital can be attributed to two distinct channels. The first is the quantity channel, where a high book share corresponds to a high market share. This pattern is evident in the United Kingdom, United States and developed European countries. The

[17]Table OT.5 in the online appendix, reports the details of parameter estimates and model fitness.

second channel is the price channel, where a high market share is observed when implied shadow price is high due to the costly investment in intangible capital. This is particularly true for East Asia. Notably, China exhibits the highest intangible investment cost ,θ_I, in the entire sample. These findings highlight the interplay between the quantity and price channels in explaining the market value of intangible capital across different economies.

In summary, the findings presented in this section underscore the importance of the intangible capital input in modern corporations that heavily rely on a high-skill labor force and new technology.

5.3 Heterogeneity of Intangible Capital Value Around the World

The contribution of intangible capital to firm value (μ_I) exhibits substantial dispersion. In Table 4, across the 17 countries and 4 regions where the heterogeneous adjustment cost parameters are directly estimated, the standard deviation is 9.32%. While China sits at the top of the intangible market share, with about 68.93% of the market valuation coming from it, Canada is at the bottom with 33.31. Large economies such as the USA and the UK also have above-average intangible capital market shares, at 64.39 and 63.09, respectively.

Figure 1 provides a visual description of the share of intangible capital across all the countries in our sample. The darkness of the color indicates the share of intangible capital, with darker shades representing higher shares. Countries in the Northern and Western Europe exhibit particularly high intangible market shares, while countries in East Asia show relatively lower shares. Within Asia, the median intangible market share in China is 68.93%, notably higher than Japan's 47.85%. There is significant heterogeneity among individual countries in the contribution of intangible capital to firm value, with a standard deviation of 12.97% across the 77 countries. [18]

The quantity channel and the price channel jointly determine the level of firm value and, correspondingly, the composition of capital in firm value. In countries where the cost coefficient of intangible capital is larger than the worldwide average, intangible capital becomes more important for firm valuation, and vice versa. When adjustment costs vary across countries, the importance of intangible capital in firm value changes accordingly.

If the adjustment cost function is homogeneous across all countries, the shadow price of the

[18] Detailed statistics are provided in Table OT.4.

capital inputs in each country would lead to biased estimation outcomes. We re-estimate the counterfactual model with a homogeneous cost function, summarized in Table 3. [19] The cost parameter for physical capital is 3.63, while that for intangible capital is 11.73. Although these cost coefficients have significantly positive point estimates, this model provides a poor description of the geographical variation in firm value.

In Table 4, columns (6) and (12) present the counterfactual estimation of the contribution of intangible capital to firm value, assuming identical adjustment cost parameters across all countries. Under this assumption, the contribution of intangible capital to firm value ,$\hat{\mu}_I$, for China is 46.51% on average during 2016–2020, compared to the true estimate of 68.93%. A similar underestimation occurs in India. Conversely, assuming global homogeneous capital adjustment costs results in an overestimation for countries like South Korea, where the counterfactual estimate of $\hat{\mu}_I$ is 45.37%, while the true estimate is 40.65%. France exhibits a similar overestimation scenario.

These findings align with the parameters reported in Table 2, which show that adjustment cost parameters for intangible capital in China and India are much higher than the global homogeneous cost, whereas those for South Korea and France are below the global average. In countries such as Thailand and Germany, where the adjustment costs for physical and intangible capital are close to the global average, the counterfactual estimate of $\hat{\mu}_I$ closely matches the true estimate of intangible capital's contribution.

We re-estimate the counter-factual model, where intangible capital has the varying cost, investing in physical capital involves the country-invariant adjustment cost, summarized in Table 3. [20] By comparing this restricted model and the benchmark model, we are able to understand the role of cross-country variation in intangible capital cost, in explaining the firm valuation around the globe. We find the model fitness is much better than the counter-factual model of homogeneous cost, but still distant from the benchmark model with both costs varying in countries.

Overall, the estimation results show that the composition of capital in valuation varies across countries. This geographical variation is jointly determined by the quantity of capital and the heterogeneity of capital adjustment costs.

[19] Table OT.6 in the online appendix, reports the details of model fitness.

[20] Table OT.7 in the online appendix, reports the details of parameter estimates and model fitness.

6 Economic Drivers of Intangible Capital Investment

A modern corporation is a sophisticate organization of managers, engineers and professionals, not a simple electrical machine. Investment activities involve indirect cost from implementation: internal communication and learning, compliance of legal and industry regulation, lobbying and networking for external resources. The difficulty of verifying the authentic information generates the cost in implementing decisions that involve the high opacity and uncertainty, especially for the intangible capital. Given the same total expenditure, larger fraction evaporates as the adjustment cost, while only a smaller amount is accumulated as the new intangible capital that lasts long for creating profit. The indirect expense for investing intangible capital is more sensitive to the legislation system, efficiency, and financing regulation, in comparison to physical capital.

The findings from the previous section highlight the importance of geographical variation in adjustment costs in explaining cross-country differences in firms' market values and their inputs. In this section, we explore the key factors driving these differences in adjustment costs and input market values. To do so, we re-estimate an universal model using an adjustment cost function that incorporates country-specific characteristics likely to affect firms' ability to invest, and analyze the importance of these characteristics for firm valuation. Subsection 6.1 provides a brief overview of the data used to quantify these country characteristics.

6.1 Country Characteristics Data

Building on previous studies (discussed below), we evaluate three dimensions of country-level characteristics that may impact the adjustment costs of inputs: (a) Protection of Intellectual Property Rights; (b) Ease of Contract Enforcement; (c) Economic and Financial Development.

Protection of Intellectual Property Rights. Antill et al. (2023) quantify the effect to social welfare from the style of legal system in the decision of patent litigation. The patent litigation system in an economy, determines how an incumbent firms can deter the entry of new firm with similar patents. A patent litigation system favoring the existing patent holder encourages more investment in innovation. In Crouzet et al. (2022b), the ease of imitating product design determines the cross-section distribution of firm size, firm value, and the factor share. For intellectual property rights institutions, our primary measure uses expert and professionals' assessment over the respect of trade secrets and industrial patents, collected by the Institutional Profiles Database. This measure of business environment describes the ease of securing the ownership of the intangible asset that generates exclusive corporate cashflows. Driven by the local culture and historical origin, this measure is of high similarity to copyrights and other intangible goods, the (dis)respect for the industrial counterfeiting, and the summary indicator of IPR protection provided by the WIPO. [21] Hence this is a representative measure describing the ease of creating new intangible capital.

Ease of Contract Enforcement. The complex, costly, and slow legal procedures will undermine trust and increase uncertainty, add unnecessary cost to business activities. For contracting institutions, we use expert and professionals' assessment over the cost of enforcing private contracts, specifically the non-eviction commercial case. Djankov et al. (2003) documented the efficiency of judicial system differs by the legal origin of a country. eg. British colonies with common law systems versus countries with civil law traditions. They found the heavier formalism and procedural cost in civil law countries. Originating from the work by Djankov et al. (2003) , the World Bank maintains the Ease of Business survey to continuously monitor the status of contract enforcement worldwide. Our primary measure is the number of procedures necessary to resolve a court case collecting the commercial debt. Despite the expansion of public service sector and the introduction of automation technologies, the contract complexity is under the slow evolution. Among the sub-sample of countries with early investigation by Djankov et al. (2003) , our measures of procedures cost have strong similarity to the index of legal formalism.

Other than the two primary state variables related to the intellectual property right institution and the contracting institution, we include the out-of-model state variables of economic development and financial market development. These supplementary state variables are income per capita, the population, and the market power of bank. The real GDP per capita is collected using the version of United Nation statistics [22]. The market power of bank is measured as the ratio between the bank

[21] The Variable B6020 is reported as a discrete score in range of {0, 1, 2, 3, 4}, with higher scores indicating stronger legal protections. Institutional Profiles Database reports additional variables related to intellectual property protection, such as industrial counterfeiting (Variable B6021), copyrights and intangible goods ((Variable B6022), and an index (Indicator B602). These variables show a high correlation with the variable we selected, leading us to omit them from our analysis. Similarly, the World Intellectual Property Organization provides an index that is also highly correlated with our chosen variable. The appendix provides the estimation of extended model, in which the supplementary characteristic of product market entry barrier is included, to describe the cost of leaking intangible capital to rivalry companies.

[22] The national account statistics for the territory of Taiwan is from the Penn World Table, imputed to be comparable with other countries in UN statistics.

income and the operating cost, derived using the World Financial Development database. [23]

We collected country characteristics for 73 out of the 77 countries analyzed. [24] Table 5 describes how the adjustment cost coefficients in baseline estimation of Section 5 coincides to the strength in protecting intellectual property right and the procedure cost in contract enforcement. We report the average adjustment cost for the 17 large countries with available direct estimates of individual cost coefficient in previous section. For simple comparison of how country-specific cost parameter determines the adjustment cost, we assume the artificial firm with investment rate $i^I = 20\%$ in intangible capital, use the adjustment cost coefficient $\theta_{I,c}$ to calibrate the cost per unit of installed capital $\frac{C^I}{K^I} = \frac{\theta_{I,c}}{2} \cdot (i^I)^2$. Within a group of countries, the average cost $\frac{1}{N_c} \sum_c \frac{\theta_{I,c}}{2} \cdot (i^I)^2$ is reported. Among the two emerging countries China and India of weak intellectual property protection, the average adjustment cost is 50.94% of installed intangible capital. Among the countries with the highest rating in intellectual property protection, Australia, France , UK , Japan, South Korea, Singapore , USA , the average cost in investing intangible capital is 16.93% of installed intangible capital, smaller in comparison to the countries with the medium rating and weak rating. But we didn't observe significant discrepancy in adjustment cost of physical capital. Analogously, we report the joint distribution of contract procedures and the adjustment cost. We use the 33%, 67% breakpoints of characteristic variables, to classify the countries into group of simple procedures, and of complicate procedures. Countries such as Indonesia and India have lengthy procedures of contract enforcement, coincide to those of high adjustment cost in intangible capital. The observed discrepancy in adjustment cost of physical capital is relatively smaller, in comparison

[23]The income-cost ratio has slow time-series variation in each country. We use the time series averages from 2016 to 2020.

[24]Table OT.8 in the appendix provides an overview of the country characteristics analyzed. The Institutional Profiles Database does not include data for Cayman Islands, Palestine, or Zambia. Romania is not included in the Doing Business survey of United Nations. In Columns (7) to (10) of Table OT.8, we present the correlation of each characteristic with the adjustment cost parameters discussed in subsection 5.1. As expected, strong protection of intellectual property rights is associated with lower adjustment costs, particularly for intangible capital. Conversely, a higher number of procedures correlate with higher adjustment costs. Table OT.9 describes the joint-distribution of country institutions and the firm valuation outcome. These are the descriptive statistics in Table 1, in summarizing the firms for each countries, calculated as the time-series average level within a country. The correlation between the firm valuation and the strength of protecting intellectual property rights is negative -0.44, and weak positive correlation 0.27 to the procedures of contract enforcement. Firm valuation tends to be higher among those countries with weak institutions. However, there is a different landscape between the status of institutions and the firm investment. Strength of protecting intellectual property rights has positive correlation to the firm physical capital investment rate. Both the physical capital investment rate and the intangible capital demonstrate positive correlation to the complexity in contract enforcement. The contrary correlations observed in firm valuation and the firm investment rate is driven by the subtle role of friction in accumulating the capitals, parameterized as adjustment cost.

to the intangible capital.

These descriptive evidence motivates a formal model to separate the effects of institutions, economic and financial development in the adjustment cost of capitals. We specify the dependence of adjustment cost parameters on these variables $\theta(\mathbf{X}) = \theta_g + \boldsymbol{\gamma} \cdot \mathbf{X}_{\mathrm{c}}$, estimate the model with state-contingent cost described in equation (16). Denote the set $\mathbf{X}_c = (\mathbf{X}_1, \mathbf{X}_2)$ as the country characteristics. To begin with the simple state variables, the primary characteristics explaining the adjustment cost are $\mathbf{X}_1 = \{X_z\}_{z \in \mathbf{Z}}$, in which the set $\mathbf{Z}$ include (a) the intellectual property protection, (b) the contract enforcement cost, and (c) the background characteristic of economic development, population, bank power. The $\mathbf{X}_2$ is a fixed effect that reflects the usage of intangible capital is intensive in a given country. [25] This allows for the different steady states among those countries with small amount of intangible capital, and those countries with large amount of intangible capital. The estimation identifies the global average costs θ_g and incremental cost coefficients γ. We detail the estimation outcome in subsection afterward.

6.2 Estimation Results

Here we present the results from the estimation of the model using the adjustment cost parameter specification from equation (15). The results for the baseline specification are reported in columns (1) and (2) of Table 6. In previous description of the one-by-one correlation of each country characteristic with the adjustment costs estimated in subsection 5.1 is presented, we note that the sign of the correlation may also reflect the relationship of that characteristic with other variables. By employing joint estimation to assess the sensitivity of the adjustment cost parameters to all

[25]We categorize countries based on their average book share of intangible capital (K_I/A), classify the group in the highest quartile. Appendix Table OT.10 report the descriptive statistics of country characteristics conditional on their endowed intangible capital. We group the countries into 4 basket, based on the intensity of intangible capital with respect to the physical capital. Among those large countries, the United States, United Kingdom, France and Germany belong to the top quartile of countries, with the high accumulated amount of intangible capital and intensive usage. As shown by the table, there is high protection of intellectual property rights, smaller number of procedures required by completing a standard property law contract, also the bank profitability is much lower. The countries that intensively utilize intangible capital in the production, show adapted institution environment and financial intermediary sector. Alternative robustness estimation show that this conditional effects are approximately close among the lowest three quartiles. In estimation, the lowest intensity group is set as the basis group, latent parameters $(\theta_{I,g} - \gamma^I_{2,n\leq 3}, \gamma^I_{2,n=4} - \gamma^I_{2,n\leq 3})$ are directly estimated. Then we implement the linear transformation using condition $\frac{3}{4}\gamma^I_{2,n\leq 3} + \frac{1}{4}\gamma^I_{2,n=4} = 0$ to infer the parameters $\theta_{I,g}$. For physical capital, we similarly require $\sum_{n=1}^{4} \gamma^P_{2,n} = 0$, and the identification of parameters $(\theta_{P,g}, \{\gamma^P_{2,n\leq 3}, \gamma^P_{2,n=4}\})$ is similar. For informative notations, we denote $\gamma^I_{2,n=4}$ as $\gamma^I_{2,\mathrm{Top25\%}}$ and $\gamma^P_{2,n=4}$ as $\gamma^P_{2,\mathrm{Top25\%}}$. The linear model is derived from the local perturbation of adjustment cost function. The detailed derivation of regime switch adjustment cost is provided in the Mathematical appendix.

characteristics simultaneously, we isolate the individual effects of each characteristic.

First, note that the intercepts ($\theta_{I,g}$ and $\theta_{P,g}$), which capture the average global values of each adjustment cost, are significantly higher for intangible capital than for physical capital (11.89 compared to 4.22). This finding aligns with the baseline country-level results. Additionally, countries with stronger protection for trade secrets and industrial patents experience lower costs for investing in intangible capital. The cost of procedures leads to higher adjustment costs for intangible capital. The incremental cost coefficients $\boldsymbol{\gamma}$ assess which characteristics are most critical for capturing the dynamics of a firm's market value. Columns (3) and (4) of Table 6 reports the point estimate $\boldsymbol{\gamma_z} \cdot \sigma(\mathbf{X_{z,c}})$ for the model where the non-binary country characteristic variables are normalized $\frac{X_{z,c}}{\sigma(\mathbf{X_{z,c}})}$with standard deviation as 1. Protection of intellectual property rights have negative point estimate of -2.70. Per 1 standard deviation increase in this characteristic reduces intangible adjustment costs by 2.74 from the global average cost of 11.74. Procedural cost of contract have positive point estimate of 0.73. Per 1 standard deviation increase in this characteristic increases intangible adjustment costs by 4.79. Among other characteristic variables, bank profitability, GDP per capita have large positive point estimates. Higher profits in the banking sector are associated with increased adjustment costs for intangible capital. Finally, wealthier countries, as indicated by higher GDP per capita, exhibit significantly higher adjustment costs. This may reflect the impact of a more expensive labor force. Product innovations in larger countries exhibit scale effects, making competition deterrence more challenging. Consequently, larger countries face higher costs for investing in intangible capital. Qualitatively, Table 6 indicates the cost of intangible capital investment increases with cost of contract enforcement, bank power. but decreases with protection of intellectual property rights. [26]

Overall, we find that the characteristics model fits the data well, with an R^2 of 0.86 for the cross-section and 0.55 for the time series. These values are comparable to the direct estimates in the baseline country-specific models. Figure 4 compares the parameter estimates and fit of sub-sample relative to the benchmark model from subsection 5.1. Notably, the simple universal model of characteristics performs well in most countries and regions except for African countries. We conclude that country fundamentals effectively capture the dynamics of market values for firms

[26]Section 7.5, shows negligible improvement from including other characteristics to describe the country heterogeneity in adjustment cost, reported in Table OT.21 of appendix.

across different countries.

Table 7 summarizes the distribution of firm valuation, composition of capitals across countries that differs in the replacement cost of intangible capital. This adjustment cost parameter of intangible capital is estimated from this universal model that incorporates status of countries in institutions and economic development, and utilizes the firm-level dispersion in investments rates and accumulated quantity of intangible capital within each country. Referring the literature, the firm valuation ratio is defined as the Average-Q, the market valuation in ratio of total amount of capitals.[27]. Among countries, South Korea, Japan, Singapore, the replacement cost of intangible capital is low, the median level of firm valuation ratio is 1.02. Among the costly countries, Indonesia, India, China, the median level of firm valuation ratio is 2.06, much higher than the counterpart statistic in the countries of low cost. Table 7 confirms the the cross-country variation of firm valuation largely aligns with the replacement cost of intangible capital, via lifting up the market price of formed intangible capital.

Next we formally apply the country characteristics model to evaluate the importance of each component of country institutions in determining the value of inputs contributing to a firm's market value. The valuation of intangible capital contributed by country-specific characteristic of institutional environment and economic development is,

$$q_z^I X_{z,c} \cdot K^I = \gamma_z^I \cdot X_{z,c} \cdot (1 - \tau_c) \cdot i^I K^I \tag{23}$$

for characteristic variable $X_{z,c}$, and symmetrically $\{q_z^P X_{z,c} \cdot K^P\}_z$ for the physical capital. Definition equation 23 uses the incremental cost coefficients $\boldsymbol{\gamma^I}$ of intangible capital and $\boldsymbol{\gamma^P}$ of physical capital. In combination with the composition of capitals and observed investment rates, it translates cross-country differences in institutional infrastructure and financial market development into the resulting impact on capital valuation. This is achieved by applying a correction weight of investment decisions observed in the history.

A significant portion of firm value variation is the value of intangible capital influenced by the protection of intellectual property rights, the cost of contracting. Table 8 reports the value

[27]Different from the physical capital with tax shield, book value of intangible capital has the discount from paying corporate tax continuously. Combining the low replacement cost and discount in paying tax, market price of intangible capital can be smaller than 1.

of intangible capital impacted by country characteristic variables, in share of total firm value. Each component of value, its share in the total firm value, $\frac{q_z^I \cdot K^I}{V} \cdot X_{z,c}$, has the following standard deviations: 6.18% for the protection of intellectual property rights, 9.65% for the cost of contract enforcement and 11.39% for economic development. [28] If a country's value for a specific characteristic is above (or below) the global average, the sign of the impact matches (or is opposite to) the sign of the coefficient γ. For a country characteristic variable that delineates a specific aspect of institutional environment or the development of market infrastructure, a large magnitude for the incremental cost coefficient, combined with substantial cross-country variation, indicates that the characteristic is economically important for explaining the geographical variation in capital value.

This finding aligns with economic intuition, as an efficient legal system and stronger protection of trade secrets and patents can help mitigate the adjustment costs for intangible capital. Additionally, economic development—measured by GDP per capita and population—affects labor costs. Developed countries tend to have a more expensive labor force, resulting in higher adjustment costs and valuations for intangible capital. Since intangible capital is riskier and more challenging to collateralize, the financial sector's ability to finance these investments is crucial. A more robust financial sector can lead to lower adjustment costs for intangible capital, thereby increasing its value.

Turning to the value of physical capital, we observe that the protection of intellectual property rights has a negligible effect on the heterogeneity of physical capital value, while contract enforcement and economic development play a prominent role. However, the cross-country dispersion associated with these characteristics is smaller compared to that of intangible capital. The standard deviation is 5.69% for contract enforcement and 2.63% for economic development. The greater variation in the value of intangible capital associated with intellectual property rights suggests that the difficulties in securing the asset have a significant effect on their valuation.

[28] Figure 5 illustrates the contribution of each characteristic to the value of intangible capital (top panel) and physical capital (bottom panel) across countries and regions.

7 Robustness

7.1 Domestic Firms

Domestic investment and oversea investment, simultaneous determine the total firm value. This paper didn't explicitly estimate heterogeneous capitals operated in different countries. As the simplified examination, Table OT.14 excludes the multinationals from the sample, estimates the model using the domestic firms. We define the domestic firms as firms whose headquarter is identical with the incorporation. Firms residing in Hong Kong are often incorporated in China or Europe. Given the smaller sample of completely local firms, we didn't construct the portfolios for those firms residing and incorporating in Hong Kong. For firms residing in China and incorporating in China, the new parameter estimate of the intangible capital adjustment cost coefficient is 37.84, larger than the outcome of baseline estimation of 32.54. Table OT.18 reports the country-characteristic model using this alternative sample of domestic firms. Estimated distribution of adjustment cost is quantitatively similar, as we observe weak institution is associated with the higher cost.

7.2 Firm-level Method

Section 5 documented substantial variation in the country-specific cost coefficient of intangible capital. In this subsection, we use the alternative method of firm-level equation to estimate the model. This estimation approach is more familiar for the literature, for example Peters and Taylor (2017) discussed when the total firm asset and investment include the knowledge capital and organization capital, firm valuation ratio (total Q, or often named as average Q) can better explains the total investment in the firm-level. We use this estimation to confirm the geographical heterogeneity in capital adjustment cost function.

We estimate the true model of heterogeneous capitals, using the firm-level approach. [29]The firm-level estimation has similar point estimate for country-specific cost coefficient of intangible capital θ_I, but smaller point estimate for the cost coefficients of physical capital θ_P. An intuitive explanation is the attenuation bias. The variation of observed investment of physical capital contains noise irrelevant of the model. The estimator assigns the small θ_P to reduce the equation error. On the

[29]The comparison of the parameters and statistics of fitness are reported in Figure OF.1 and OF.2.

contrary, point estimate of θ_I in the firm-level estimation resembles that of the baseline estimation, especially in countries such as Indonesia, India, Germany, the U.K. and the U.S.. The variation of investment rate and amount of intangible capital is crucial for explaining the variation of firm valuation ratio. As such, the model estimated using the firm-level method has fitness comparable to baseline estimation of portfolio-level approach, with slight deviation.

7.3 Sector-Heterogeneity within Country

We also estimate the model allowing for sector-specific heterogeneity in each country. In the online appendix, we show that within a country, sectors have qualitatively similar point estimates in cost parameters. In Table OT.17, the resulting increase in both the time-series and cross-sectional R^2 values is, in general, very small. This result indicates that cross-country heterogeneity in adjustment costs is important for the model fit, but, perhaps surprisingly, sector heterogeneity plays only a minor role.

7.4 Estimate of Intangible Capital

By the year of 2010, 49 countries out of 77, adopted the IFRS (International Financial Report Standard) or the local standards similar to IFRS. Financial reports of listed companies are highly standard, but there exist slight difference in localized practice. Our estimations use the firm information collected by Compustat. Compustat manually harmonizes the financial reports into the format of the Compustat-Global and Compustat-North American. In addition, we take two approaches to address whether heterogeneity in accounting standard is large enough to intervene the model estimation.

(a) In the first approach, based on manual verification and conjecture, we build the alternative measure of quantity of intangible capital, by accruing the XRD expense separately. The estimation outcome using this alternative sample of measured intangible capital is reported in Table OT.16 for the country-specific cost model (benchmark estimation was reported in Table 2), and the country-characteristic model in Table OT.18 (benchmark estimation was reported in Table 6). We observe point estimates and model fitness that are quantitatively similar to the benchmark estimations.

(b) In the second approach, we utilize the firm operating profit, measured as the EBIT, and the firm valuation, to jointly infer the quantity of intangible capital, by identifying the conversion rate of XSGA and the depreciation rate in intangible capital. Though not targeting the equation of firm valuation, characteristics related to the institutional environment explains the cross-country variation in a larger extent. Column DeepParam in Table OT.18 report the estimation outcome. The model concludes cost in investing intangible capital is associated to countries with weak protection of intellectual property right, high cost of contract enforcement.

7.5 Model of High-Dimension Characteristics

Aside from the authenticity-model focusing on the institutions, we conduct a systematic review of literature and non-academic discussion, construct the profile of country-level characteristics. This extended model assesses the product market entry barrier, the searching friction in hiring and dismissing employees, the access to physical infrastructure, the friction in monitoring the manager and large shareholder to ensure the dynamically maximized firm valuation. The construction and estimation of high-dimensional model is detailed in the online appendix. [30]

We found positive increase in cost of intangible capital driven by the easy entry of competitors. The weak or zero entry barriers put those industry incumbents, often the large listed companies, in dis-advanced position, in accumulating intangible capital. For the situation in the labor market, the effect of increased usage of tenure contracts on adjustment costs exhibits a large standard error, but the protection of collective dismissal reduces the cost of physical capital in small extent. The threat of suing the large shareholder increases the adjustment cost of physical capital, but have unclear effect to that of intangible capital. We find weak additional improvement from the model of high-dimensional state variables, despite small changes in the incremental cost of institution characteristics. This confirms the sources of cross-country variation in the adjustment cost of capitals are driven by the ease of converting operating expenditure to patents and copyrights that exclusively foster the firm profit, the ease of raising sources and payment for the investment expenditure.

[30] Table OT.20 describes the characteristic variables. Table OT.21 presents the point estimates for the global average cost parameter, the incremental cost coefficients for all characteristics described above.

8 Conclusion

We incorporate intangible capital into the neoclassical model of investment and estimate its contribution of each input for explaining firm market values across 77 countries between 2000 and 2020. For the major markets, where we estimate country specific parameters, the model performs well in explaining both the time-series and the cross-sectional variation of the valuation ratios across portfolios in the worldwide, with time-series R^2 of 57% and a cross-sectional R^2 of 87%.

We find that the importance of the intangible capital for firm value varies across countries and is substantial, ranging from 33.31% to 68.93% . We show that financial markets assign large and positive values to the installed stocks of the capital inputs because they are costly to adjust, thus firm valuation contains the compensation for the cost of adjusting the inputs. The adjustment cost of intangible capital is higher than that of physical capital. When quantifying the market environment for accumulating intangible capital for each country, we observe dispersed point estimates of adjustment cost parameters.

To understand the drivers of intangible and physical capital adjustment costs, we utilize a model in which adjustment cost of capital investment is contingent on country-specific characteristics affecting firms' ability to invest, and analyze the importance of these characteristics for firm valuation. We find that institutions of intellectual property right and contracting significantly influence the cross-country variation in the cost of investing intangible capital and its valuation. While similar factors also impact physical capital, their effect is comparatively less pronounced.

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A Tables

Table 1: Descriptive Firm Statistics

This table reports the median of firm-level selected characteristics across all firms in the each country (or territory). The same statistics are calculated for the remaining area of each continent. The same statistics for the whole continent is reported below countries within the continent. The same statistics for the full sample of all the countries (World) are reported in the final rows. Statistics of individual countries in the region are reported in the Appendix Table OT.3. Data is winsorized with [2%,98%] by country (or territory). Columns (1) and (7) reports the country and territory, the region, for each continent of Asia, Europe, Americas, Australia and Africa. Firm valuation is Q. Installed physical capital is $K^P$with investment flow equal to I^P. Installed intangible capital is $K^I$with investment flow equal to I^I. The median is calculated in each year, the time-series average statistics are reported in the sub-sample of each geographic area (country, territory and region within the continent, or the continent). In Column (6), the correlation $\rho(\frac{I^P}{K^P}, \frac{I^I}{K^I})$ is calculated using all the observations in the sub-sample.

Country/Region (1)	$\frac{Q}{K^I+K^P}$ (2)	$\frac{I^P}{K^P}$ (3)	$\frac{I^I}{K^I}$ (4)	$\frac{K^I}{K^I+K^P}$ (5)	$\rho(\frac{I^P}{K^P}, \frac{I^I}{K^I})$ (6)
China	2.95	0.17	0.34	0.22	0.32
Hong Kong	1.51	0.18	0.29	0.40	0.22
Indonesia	1.38	0.07	0.20	0.27	0.21
India	1.59	0.08	0.23	0.32	0.26
Japan	0.87	0.12	0.22	0.45	0.37
Malaysia	1.26	0.07	0.25	0.26	0.22
Singapore	1.28	0.16	0.28	0.37	0.23
South Korea	1.00	0.11	0.25	0.25	0.31
Thailand	1.56	0.13	0.24	0.28	0.22
Taiwan	1.77	0.13	0.26	0.26	0.33
Rest of Asia	1.55	0.08	0.22	0.28	0.24
Asia	1.38	0.12	0.24	0.32	0.30
France	1.30	0.22	0.24	0.67	0.26
Germany	1.45	0.21	0.24	0.57	0.26
Poland	1.27	0.15	0.28	0.38	0.32
UK	1.51	0.20	0.25	0.60	0.28
Rest of Europe	1.48	0.18	0.25	0.45	0.26
Europe	1.44	0.19	0.25	0.51	0.27
Canada	1.57	0.18	0.28	0.21	0.31
USA	2.14	0.24	0.25	0.61	0.34
Latin America	1.15	0.09	0.21	0.33	0.33
America	1.86	0.21	0.25	0.53	0.35
Australia	1.65	0.21	0.32	0.34	0.23
Africa	1.53	0.10	0.21	0.42	0.23
World	1.49	0.15	0.25	0.38	0.30

Table 2: Parameter Estimates and Model Fit

This table reports the details of parameter estimates. θ_P and θ_I are, respectively, the physical capital and intangible capital adjustment cost coefficients that are specific to country (or territory, region). s.e. stands for Newey-West standard errors with two lags. Columns (1) and (7) report the country and territory, rest of the region, for each region of Asia, Europe, Americas, Australia and Africa. Columns (2) to (3) report the point estimate and the standard error for parameters specific to the country (or territory,region) in Asia. Columns (8) to (9) report the same statistics for countries in Europe and other regions. We calculate model fit for each country (or territory, other countries in the region). In Columns (3) to (5) and Columns (10) to (12), $XS-R^2$ is the cross-sectional R^2 for the subset of portfolios in the country (or territory, region), $TS-R^2$ is the time-series R^2, and $m.a.e./\overline{VR}$ is the mean absolute valuation error scaled by the absolute value of the ratio.

Country/Region		Point Estimate		Model Fit			Country/Region		Point Estimate		Model Fit		
		θ_P	θ_I	XS-R^2	TS-R^2	$m.a.e./\overline{VR}$			θ_P	θ_I	XS-R^2	TS-R^2	$m.a.e./\overline{VR}$
(1)		(2)	(3)	(4)	(5)	(6)	(7)		(8)	(9)	(10)	(11)	(12)
China		3.31	32.54	0.63	0.23	0.30	France		5.86	7.75	0.67	0.27	0.26
	s.e.	(1.13)	(2.75)					s.e.	(0.92)	(0.89)			
Hong Kong		2.70	6.97	0.68	0.27	0.25	Germany		4.15	10.27	0.74	0.23	0.28
	s.e.	(0.41)	(0.81)					s.e.	(1.13)	(1.44)			
Indonesia		4.48	14.75	0.85	0.49	0.22	Poland		3.09	4.80	0.82	0.35	0.31
	s.e.	(0.61)	(1.61)					s.e.	(0.95)	(0.99)			
India		4.38	19.83	0.81	0.32	0.28	UK		5.48	8.91	0.84	0.54	0.21
	s.e.	(0.78)	(2.02)					s.e.	(0.59)	(0.82)			
Japan		0.78	2.91	0.26	0.12	0.19	Rest of Europe		4.42	11.18	0.81	0.53	0.25
	s.e.	(0.36)	(0.39)					s.e.	(0.58)	(1.01)			
Malaysia		2.77	11.82	0.83	0.39	0.18							
	s.e.	(0.52)	(1.10)				Canada		3.73	11.53	0.84	0.49	0.22
Singapore		1.93	6.99	0.61	0.24	0.23		s.e.	(0.28)	(0.73)			
	s.e.	(0.55)	(0.77)				USA		8.10	16.32	0.84	0.61	0.18
South Korea		0.23	5.72	0.68	0.36	0.14		s.e.	(0.84)	(1.06)			
	s.e.	(0.52)	(0.70)				Latin America		4.50	10.95	0.80	0.61	0.20
Thailand		3.88	10.28	0.80	0.29	0.23		s.e.	(0.71)	(1.32)			
	s.e.	(0.61)	(1.31)										
Taiwan		3.88	15.51	0.81	0.26	0.18	Australia		3.27	10.37	0.75	0.42	0.25
	s.e.	(0.50)	(1.25)					s.e.	(0.47)	(0.99)			
Rest of Asia		6.36	12.03	0.78	0.46	0.17							
	s.e.	(1.26)	(1.72)										
							Africa		3.98	12.75	0.25	0.32	0.21
								s.e.	(0.81)	(1.04)			
Summary of Parameter Estimates and Model Fit													
							World	Mean	3.87	11.63	0.87	0.57	0.23
								S.D.	(1.73)	(6.10)			

Table 3: Summary of Models

This table reports the summary of parameter estimates and measures of fit for the benchmark model and counter-factual models. Columns in **Benchmark Model** report the estimation outcome for the benchmark model of country-specific adjustment cost function. Columns in **Model with Physical Capital Only** report the estimation outcome for the model of country-specific adjustment cost function and single capital input of physical capital. We assume the intangible capital plays no role in the production function nor the adjustment cost function. Columns in **Model with Homogeneous Cost** report the estimation outcome for the model of homogeneous adjustment cost function and two capital inputs. We assume the identical adjustment cost function everywhere. Columns in **Model with Varying Intangible Cost** report the estimation outcome for the model of country-specific adjustment cost in intangible capital and homogeneous adjustment cost in physical capital. Column (1) reports the geographic area, all countries used for estimation (World), the regions of Asia, Europe, Americas, Australia and Africa. In Panel (a) of parameter estimates, Columns (2) to (3), Columns (4) to (5), Columns (6) to (7) and Columns (8) to (9) report the summary statistics of average parameters within the geographic area. θ_P and θ_I are, respectively, the physical capital and intangible capital adjustment cost coefficients. Standard deviation for coefficients cross countries are reported for the models of country-specific adjustment cost function. In Panel (b) of model fit, Columns (2) to (4) report the model fit, $XS-R^2$ is the cross-sectional R^2 for the 301 portfolios in the world (or the subset of portfolios in the region), $TS-R^2$ is the time-series R^2, and $m.a.e./\overline{VR}$ is the mean absolute valuation error scaled by the absolute value of the ratio. Columns (5) to (7), Columns (8) to (10) and Columns (11) to (13) report the same statistics for the counter-factual estimation.

Panel (a) Summary of Parameter Estimate

Area		Benchmark Model: Point Estimate			Model with Physical Capital Only: Point Estimate			Model with Homogeneous Cost: Point Estimate			Model with Varying Intangible Cost: Point Estimate	
		θ_P	θ_I		θ_P	θ_I		θ_P	θ_I		θ_P	θ_I
(1)		(2)	(3)		(4)	(5)		(6)	(7)		(8)	(9)
World	Mean	3.87	11.63	Mean	11.59	-	Mean	3.63	11.73	Mean	3.63	11.73
	S.D.	(1.73)	(6.10)	S.D.	(4.44)	-	S.D.	(0)	(0)	S.D.	(0)	(6.80)

Panel (b) Model Fit

Area	Benchmark Model: Model Fit			Model with Physical Capital Only: Counter-factual Model Fit			Model with Homogeneous Cost: Counter-factual Model Fit			Model with Varying Intangible Cost: Counter-factual Model Fit		
	XS-R^2	TS-R^2	$m.a.e./\overline{VR}$	XS-R^2	TS-R^2	$m.a.e./\overline{VR}$	XS-R^2	TS-R^2	$m.a.e./\overline{VR}$	XS-R^2	TS-R^2	$m.a.e./\overline{VR}$
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
World	0.87	0.57	0.23	0.03	-0.29	0.42	0.35	0.24	0.30	0.47	0.32	0.29
Asia	0.90	0.60	0.23	0.25	-0.13	0.40	0.24	0.15	0.33	0.57	0.40	0.29
Europe	0.80	0.43	0.26	-0.39	-0.56	0.44	0.50	0.28	0.29	0.24	0.12	0.31
Americas	0.88	0.67	0.20	-0.14	-0.32	0.43	0.46	0.38	0.26	0.54	0.42	0.27
Oceania	0.75	0.42	0.25	-0.81	-0.72	0.46	0.83	0.42	0.25	-0.79	-0.15	0.34
Africa	0.25	0.32	0.21	-4.11	-1.45	0.46	0.05	0.26	0.22	-0.85	0.07	0.26

Table 4: Capital Accounting: Share of Intangible

This table reports the contribution of intangible capital in the firm valuation. Columns (1) and (6) report the geographic area (country, territory and region within the continent, or the continent). Columns (2) and (7) report the contribution of intangible capital in the firm valuation for each country, denoted as market share μ_I, reported in unite of percentage (%). The same statistics for the region is reported below countries within the region. The same statistics for the full sample of all the countries (World) are reported in the final rows. Other countries are reported in Table OT.4. Columns (3) to (4), and Columns (8) to (9) report the ratio of adjustment cost of capital investment in firm sale, denoted as C^I/Y for the intangible capital and C^P/Y for the physical capital , reported in unite of percentage (%). Columns (5) and (11) report the percentage of intangible capital in the book capitals, denoted as book share $\overline{\mu}_I$. Columns (6) and (12) report the counter-factual estimation assuming the model of homogeneous adjustment cost function in Table 3, denoted as counterfactual estimated share $\tilde{\mu_I}$. Both the statistics of share and estimated adjustment cost are calculated as the median across firms in the geographic area. The time-series average during the year 2016-2020 are reported.

Country/Region	Share	Adjustment Cost		Counterfactual		Country/Region	Share	Adjustment Cost		Counterfactual	
	μ_I	C^I/Y	C^P/Y	$\overline{\mu}_I$	$\tilde{\mu_I}$		μ_I	C^I/Y	C^P/Y	$\overline{\mu}_I$	$\tilde{\mu_I}$
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
China	68.93	18.19	1.20	24.22	46.51	France	61.71	7.35	4.46	56.05	70.78
Hong Kong	58.01	4.39	1.55	43.57	62.11	Germany	61.87	7.23	3.05	47.54	63.68
Indonesia	41.56	5.17	1.07	18.96	37.00	Poland	47.29	2.74	0.98	36.03	58.14
India	54.82	3.85	0.83	27.10	45.08	UK	63.09	6.53	3.95	55.67	69.24
Japan	47.85	1.68	0.32	38.32	58.38	Rest of Europe	57.65	6.64	2.55	40.60	58.17
Malaysia	45.86	4.60	0.89	23.94	43.18	Europe	58.33	6.31	2.74	45.21	61.99
Singapore	50.84	3.46	0.96	35.00	53.84						
South Korea	40.90	2.66	0.06	22.81	45.37						
Thailand	40.85	5.41	1.88	23.75	41.77	Canada	33.31	4.76	3.70	16.46	32.23
Taiwan	51.26	5.98	1.63	26.50	44.88	USA	64.39	12.13	6.89	50.85	65.98
Rest of Asia	40.40	3.79	2.45	21.39	40.20	Rest of America	50.40	4.08	1.43	29.37	50.39
Asia	51.91	4.63	0.78	27.26	47.46	Americas	58.81	8.88	4.96	41.75	59.53
						Australia	49.93	9.00	5.63	30.12	49.49
						Africa	60.13	4.64	1.41	36.49	57.47
						World	53.83	5.41	1.30	30.90	51.10
						S.D.	(9.32)	(3.57)	(1.75)	(11.64)	(10.59)

Table 5: Distribution of Country Characteristics and Share of Intangible

This table reports the distribution of intangible capital, adjustment cost across large countries of different status in intellectual property rights protection and contract enforcement cost. Columns (1) , (2) and (3) report the geographic area with intellectual property rights protection of the low, medium and high status, and examples of large countries within the group of type, the country-average cost within the group. Columns (4) to (5) report the example ratio of adjustment cost of capital investment in existing amount of capital assuming investment rate of 20% , denoted as C^I/K^I for the intangible capital and C^P/K^P for the physical capital , reported in unite of percentage (%). Columns (6) to (7) report the equilibrium rate of investment in capitals, denoted as $i^I = I^I/K^I$ for the intangible capital and $i^P = I^P/K^P$ for the physical capital. Columns (8) to (10) report the quantity effect and the shadow-price effect in the market share of intangible capital. Columns (8) reports the quantity effect, described as the book share $\overline{\mu}_I$. Columns (9) reports the contribution of intangible capital in the firm valuation, denoted as market share μ_I, reported in unite of percentage (%). Columns (10) reports the shadow-price effect, the gap between the book share to the market share. Column (11) reports the firm valuation ratio, the average Q in ratio of total amount of capitals. Both the statistics of share and equilibrium adjustment cost are calculated as the median across firms in the geographic area. The time-series average during the year 2016-2020 are reported. Panel (B) reports the statistics for countries of different type of contract enforcement procedure, in the analogous classification and definition.

Panel (A) Statistics in Countries of Different Intellectual Property Right Protection

Country Characteristic			Calibrated Example Cost (%) for $i = 0.20$		Statistics of Firm Decision and Valuation in Equilibrium: Investment		Share of Intangible Capital			Firm Value
Type	Large Countries of this Type	IPR X_a	Intan C^I/K^I	Phy C^P/K^P	Intan i^I	Phy i^P	Quantity $\overline{\mu}_I$	Value μ_I	Price $\mu_I/\overline{\mu}_I$	Average Q $\frac{Q}{K^I+K^P}$
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Weak	China (1) , India (1)	1.00	52.36	7.69	0.20	0.08	25.66	61.88	2.41	2.50
Medium	Indonesia (2) , Canada (3) , Germany (3) , Hong Kong (3) , Malaysia (3) , Poland (3) , Thailand (3) , Taiwan (3)	2.88	21.48	7.17	0.22	0.14	29.59	47.50	1.61	1.42
Strong	Australia (4) , France (4) , Japan (4) , South Korea (4) , Singapore (4) ,UK (4) , USA (4)	4.00	16.85	7.33	0.22	0.19	41.26	54.10	1.31	1.42
[Globe]		[2.88]								

Panel (B) Statistics in Countries of Different Contract Procedure

Country Characteristic			Calibrated Example Cost (%) for $i = 0.20$		Statistics of Firm Decision and Valuation in Equilibrium: Investment		Share of Intangible Capital			Firm Value
Type	Large Countries of this Type	Contract X_b	Intan C^I/K^I	Phy C^P/K^P	Intan i^I	Phy i^P	Quantity $\overline{\mu}_I$	Value μ_I	Price $\mu_I/\overline{\mu}_I$	Average Q $\frac{Q}{K^I+K^P}$
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Simple	Singapore (21), Hong Kong (26) , Australia (28) , France (29) , Malaysia (29), UK (29) , Germany (31) , Japan (32) , South Korea (32) , USA (32)	28.90	17.61	7.05	0.22	0.18	40.39	54.44	1.35	1.41
Medium	Canada (36) , China (37) , Poland (33) , Thailand (36)	35.50	29.57	7.00	0.24	0.14	25.11	47.59	1.90	1.86
Complicate	Indonesia (40) , India (46) , Taiwan (45)	43.67	33.39	8.50	0.19	0.08	24.18	49.21	2.03	1.59
[Globe]		[35.55]								

Table 6: Parameter Estimates of Country-Characteristic Model

This table reports the parameter estimates for the model specification of country-specific state-contingent adjustment cost function (in abbreviation, country-characteristic model). In Columns (1) to (2), Global Cost Coefficients $\theta_{\mathbf{g}}$ and Incremental Cost Coefficient $\boldsymbol{\gamma}$ for each dimension of country characteristic variables are reported. Columns (3) to (4) report the point estimate where the non-binary country characteristic variables are normalized with standard deviation as 1. In Panel (C), $XS-R^2$ is the cross-sectional R^2 for the 21×25 portfolios in the globe, $TS-R^2$ is the time-series R^2, and $m.a.e./\overline{VR}$ is the mean absolute valuation error scaled by the absolute value of the ratio. P-value of t-stat are indicated using * for p<0.10, ** for p<0.05, *** for p<0.010.

	Point Estimate		Point Estimate (Normalized)	
	(1)	(2)	(3)	(4)
Panel (A) Global Cost Coefficient				
	$\theta_{P,g}$	$\theta_{I,g}$	$\theta_{P,g}$	$\theta_{I,g}$
	4.22 ***	11.74 ***	4.22 ***	11.74 ***
s.e.	(0.28)	(0.49)	(0.28)	(0.49)
Panel (B) Incremental Cost Coefficients				
	γ^P	γ^I	γ^P	γ^I
(a) Intellectual Property (X_{1a})				
Secrets and Patents	0.17	-2.70 **	0.17	-2.73 **
s.e.	(0.36)	(0.66)	(0.36)	(0.67)
(b) Contract Enforcement (X_{1b})				
Procedures	0.15 **	0.73 ***	0.95 **	4.79 ***
s.e.	(0.04)	(0.08)	(0.25)	(0.49)
(c) Economic Development (X_{1c})				
GDP per capita	0.20	3.52 ***	0.24	4.15 ***
s.e.	(0.27)	(0.53)	(0.31)	(0.62)
Population	-0.10	0.69 **	-0.17	1.21 **
s.e.	(0.16)	(0.28)	(0.28)	(0.49)
Bank Profit	0.96 *	13.99 ***	0.41 *	6.05 ***
s.e.	(0.64)	(1.22)	(0.28)	(0.53)
Intensity of Intangible Capital (X_2)				
$\mathbf{1}$(Top25%)	3.20 **	8.87 ***	3.20 **	8.87 ***
s.e.	(0.58)	(0.79)	(0.58)	(0.79)
Panel (C) Statistics				
XS-R^2		0.86		0.86
TS-R^2		0.55		0.55
$m.a.e./\overline{VR}$		0.23		0.23

Table 7: Distribution of Adjustment Cost of Intangible Capital and Firm Valuation

This table reports the distribution of adjustment cost of intangible capital across all countries with complete profiles of characteristics related to institutions, economic and financial development. Adjustment cost of intangible capital is estimated using the model of country-specific state-contingent adjustment cost function (in abbreviation, country-characteristic model). Columns (1) , (2) and (3) report the geographic areas of low cost, medium cost and high cost respectively, examples of large countries within the group of type, the country-average cost within the group. Columns (4) to (5) report the example ratio of adjustment cost of capital investment in existing amount of capital assuming investment rate of 20% , denoted as C^I/K^I for the intangible capital and C^P/K^P for the physical capital , reported in unite of percentage (%). Columns (6) to (7) report the equilibrium rate of investment in capitals, denoted as $i^I = I^I/K^I$ for the intangible capital and $i^P = I^P/K^P$ for the physical capital. Columns (8) to (10) report the quantity effect and the shadow-price effect in the market share of intangible capital. Columns (8) reports the quantity effect, described as the book share $\overline{\mu}_I$. Columns (9) reports the contribution of intangible capital in the firm valuation for each area containing the countries of the same type, denoted as market share μ_I, reported in unite of percentage (%). Columns (10) reports the shadow-price effect, the gap between the book share to the market share. Column (11) reports the firm valuation ratio, the average Q in ratio of total amount of capitals. Both the statistics of share and equilibrium adjustment cost are calculated as the median across firms in the geographic area. The time-series average during the year 2016-2020 are reported. Panel (B) reports the statistics for countries of different type of contract enforcement procedure, in the analogous classification and definition.

Countries grouped by Adjustment Cost $\hat{\theta}_I$			Calibrated Example		Statistics of Firm Decision and Valuation in Equilibrium					
			Cost (%) for $i = 0.20$		Investment		Share of Intangible Capital			Firm Value
Type	Countries of this Type	IntanCost $\hat{\theta}_I$	Intan C^I/K^I	Phy C^P/K^P	Intan i^I	Phy i^P	Quantity $\overline{\mu}_I$	Value μ_I	Price $\mu_I/\overline{\mu}_I$	Average Q $\frac{Q}{K^I+K^P}$
(1)	(2)	(3)	(4)	(5)	(4)	(5)	(8)	(9)	(10)	(11)
Low	South Korea (3.53), Japan (3.67), Poland (5.83), Hong Kong (7.11), Singapore (7.56); Israel (5.93), South Africa (7.53) and others	4.74	9.49	6.57	0.21	0.15	34.71	44.04	1.27	1.02
Medium	France (8.00), Germany (9.11), Australia (9.24),UK (9.82), Malaysia(10.46),Canada (10.59), Thailand (11.50); Switzerland (7.71) , Greece (8.60) , Viet Nam (11.59) and others	10.18	20.37	8.32	0.21	0.15	30.71	48.66	1.58	1.43
High	ndonesia (14.44) , Taiwan (15.07) , USA (16.09) , India (20.98) , China (32.42) ; Pakistan (14.35) , Italy (15.31) , Sweden (15.92) , Turkey (16.55) , Brazil (19.25) and others	21.38	42.75	10.76	0.21	0.13	28.94	59.63	2.06	2.05
[Globe]		[12.50]								

Table 8: Composition of Country-Specific Value

This table reports the composition of country-characteristic-specific valuation of capitals, in percentage of total firm value. Columns (2a) to (2c), report the share of intangible capital value affected by the characteristic variables in total firm value in each scope of institutional environment and economic development $\gamma_z^I \cdot X_{z,c} \cdot (1-\tau)\left(\frac{I^I}{K^I}\right)\frac{K^I}{V}$ respectively: (a) Protection of Intellectual Property Rights (in abbreviation IPR) , (b) Ease of Contract Enforcement (in abbreviation Contract), and (c) Economic Development (in abbreviation Devp.). Columns (3a) to (3c) report the share of physical capital value affected by the characteristic variables in total firm value in each scope $\gamma_z^P \cdot X_{z,c} \cdot (1-\tau)\left(\frac{I^P}{K^P}\right)\frac{K^P}{V}$ respectively.

Country/Region	Intangible Capital			Physical Capital		
	Characteristic-Specific Value (%)			Characteristic-Specific Value (%)		
	IPR	Contract	Devp.	IPR	Contract	Devp.
(1)	(2a)	(2b)	(2c)	(3a)	(3b)	(3c)
China	8.41	1.77	27.88	-1.22	0.82	2.11
Hong Kong	-0.91	-19.26	13.57	0.16	-10.83	3.34
Indonesia	4.58	6.32	-1.38	-0.78	3.45	-2.01
India	8.20	12.42	-2.04	-1.01	4.90	-2.01
Japan	-14.43	-12.39	-1.01	1.19	-3.26	-2.09
Malaysia	-0.57	-8.28	10.48	0.12	-5.56	2.08
Singapore	-6.40	-22.52	24.79	1.62	-18.17	7.92
South Korea	-12.77	-10.97	-1.48	1.24	-3.41	-1.33
Thailand	-0.69	0.69	4.11	0.17	0.55	-0.17
Taiwan	-0.58	12.05	-1.83	0.14	9.47	-0.88
Rest of Asia	0.25	4.35	8.04	0.23	4.40	2.88
France	-10.80	-17.12	-9.09	1.05	-5.34	-2.24
Germany	-0.91	-9.12	-15.32	0.13	-4.12	-4.02
Poland	-1.08	-6.08	-4.83	0.17	-3.13	-1.72
UK	-7.26	-11.51	-1.76	0.98	-4.97	-1.48
Rest of Europe	-5.87	-7.45	-1.68	0.59	-2.10	-0.37
Canada	-0.61	0.60	1.96	0.13	0.41	-0.43
USA	-7.56	-6.50	8.33	0.80	-2.21	-1.03
Latin America	5.34	5.96	-6.10	-0.42	1.41	-1.06
Australia	-7.48	-13.66	20.46	1.04	-6.04	2.62
Africa	1.17	-9.09	-15.11	-0.28	-2.48	-1.83
Summary						
Large Countries (Territories), Regions of Remaining Area						
Mean	-2.38	-5.23	2.76	0.29	-2.20	-0.08
S.D.	6.18	9.65	11.39	0.74	5.69	2.63

B Figures

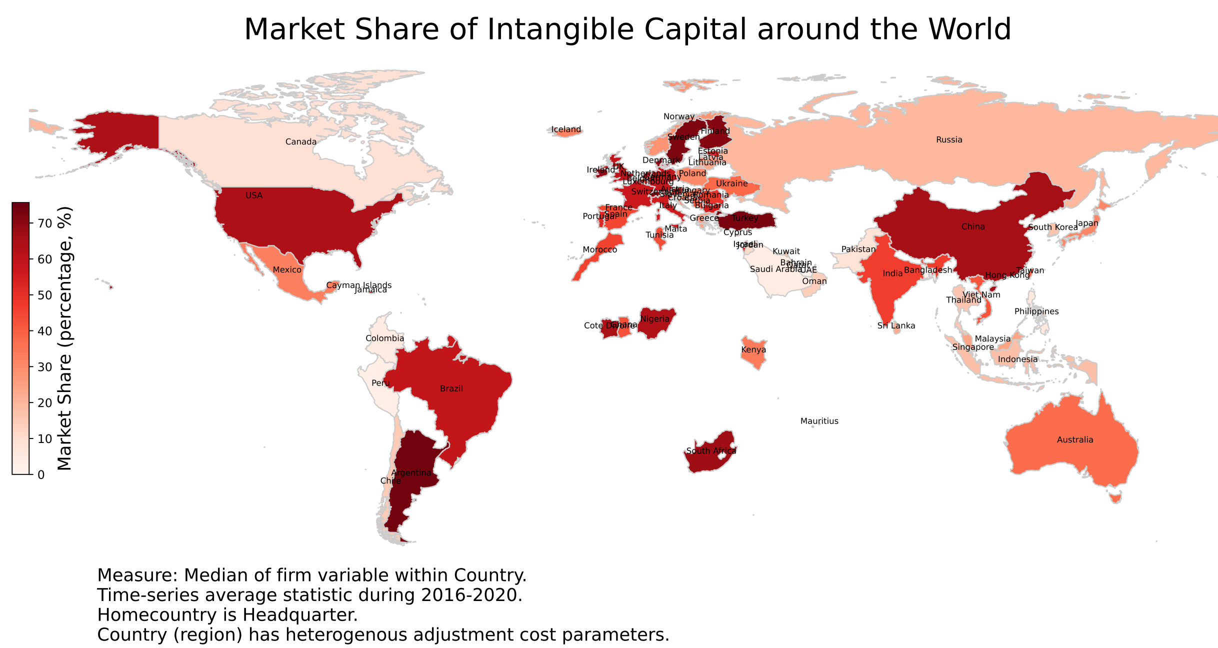

Figure 1: Contribution of Intangible Capital in Firm Value across Globe

This figure plots the contribution of intangible capital in the firm valuation in individual countries, using the heatmap. The statistics are plotted for countries in Table 4 and Appendix Table OT.4. The statistic for the contribution of intangible capital in the firm valuation are graphed. The statistic is the time-series average of median market share μ_I from the year 2016 to the year 2020, using the available firm-year observations inside the country. The market share μ_I is estimated using the Benchmark model and estimation specification in Table 2 . For countries with insufficient observations of public listed firms, they are omitted in the heatmap.

Figure 2: Distribution of Share of Intangible and Country Characteristics

This figure reports the distribution of intangible capital across countries of different status in intellectual property rights protection (IPR protection), contract enforcement cost (Contract Procedures), and cost coefficient of intangible capital explained by observed country characteristics (Cost of Intangible). Subfigure (1a) reports the example ratio of adjustment cost of capital investment in existing amount of capital assuming investment rate of 20% , denoted as C^I/K^I for the intangible capital. 17 large countries are classified into three types of groups, in weak, medium and strong protection of intellectual property rights. Subfigure (1b) reports the analogous statistic C^P/K^P for the physical capital. Subfigure (1c) reports the contribution of intangible capital in the firm valuation for each area containing the countries of the same type, denoted as market share μ_I, reported in unite of percentage (%), the share of intangible capital in the book capitals, denoted as the book share $\overline{\mu}_I$. Both the statistics of share and equilibrium adjustment cost are calculated as the median across firms in the geographic area. The time-series average during the year 2016-2020 are reported. Subfigures (2a), (2b) and (2c) report the statistics for countries of different type of contract enforcement procedure, in the analogous classification and definition. Subfigures (3a), (3b) and (3c) report the statistics for countries of different adjustment cost of intangible capital, estimated from the country-characteristic model, summarizing the intellectual property rights protection, contract enforcement cost, economic and financial development. Countries are classified into three types of groups, in low, medium and high adjustment cost of intangible capital.

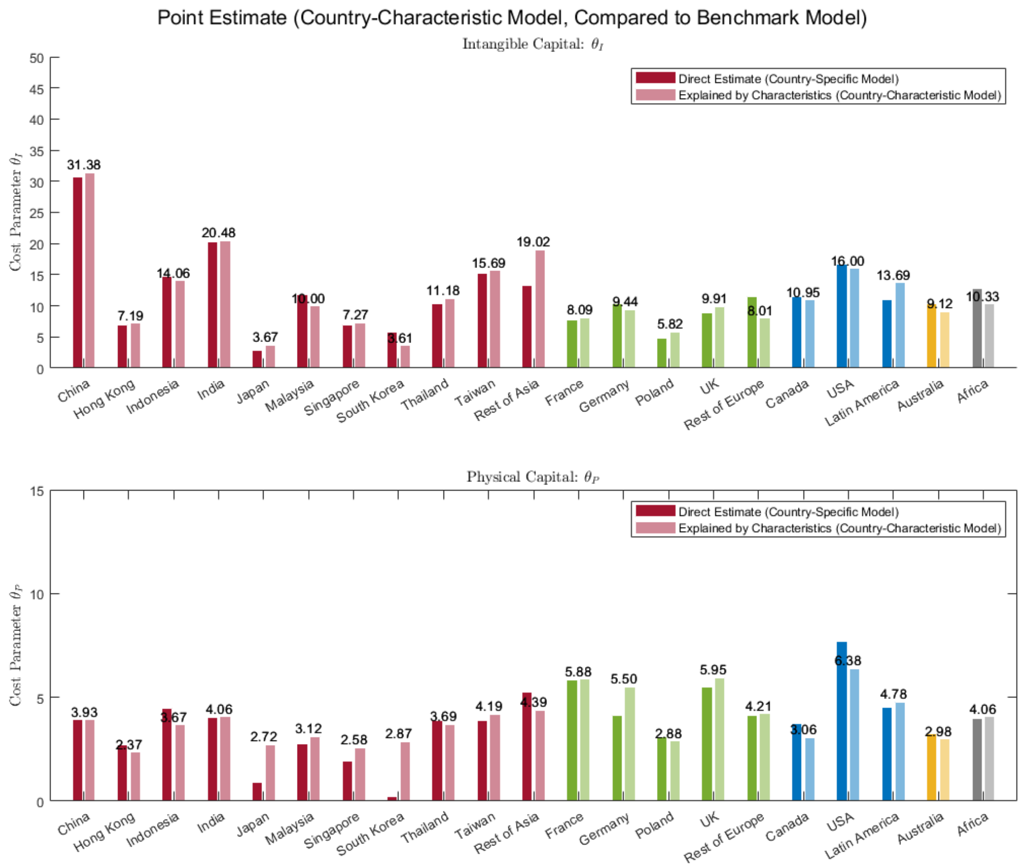

Figure 3: Estimates of Cost Coefficients in Country Characteristic Model

This figure compares the parameter estimates in the baseline model of country-specific adjustment cost and the parameter estimates in the alternative model of country characteristics. The subfigure in first row reports the parameters for intangible capital. The bar of dark color describes the estimation outcome for the baseline model. For each of the 17 countries, 4 regions, the quadratic cost coefficient in the adjustment cost function is estimated. The bar of light color describes the model-implied quadrature cost coefficient using the characteristic model. For each of the 73 countries, the quadratic cost coefficient in the adjustment cost function is a function over the status of intellectual property rights protection, cost of contract enforcement, economic and financial development. For the 56 countries in the 4 regions (Rest of Asia, Rest of Europe, Latin America, Africa), the average outcome of model-implied quadrature cost coefficient are plotted. The subfigure in the second row reports the parameters for the physical capital. The bar of dark red color, the light red color describes the estimation outcomes of the two specifications respectively, for countries and the remaining area in Asia. The dark and light green colors are for countries and the remaining area in Europe. The blue colors are for Americas. The yellow colors are for Australia (Oceania). The gray colors are for Africa.

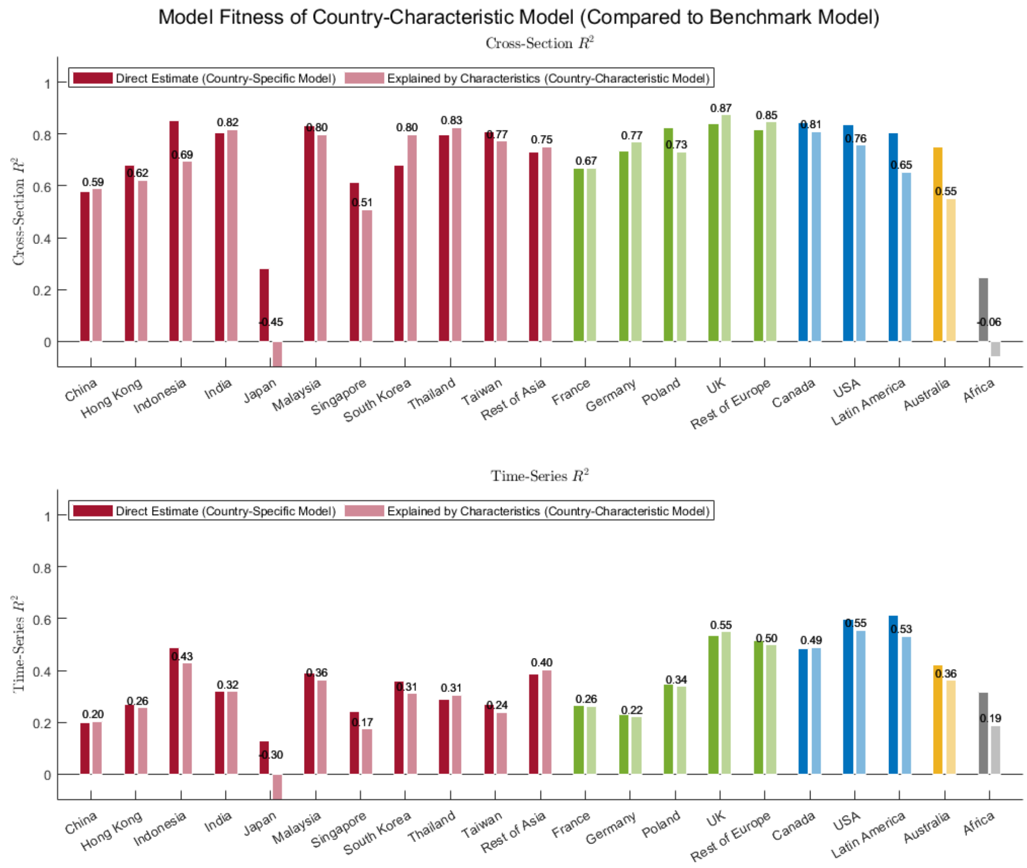

Figure 4: Fitness of Country Characteristic Model

This figure compares the fitness of model of country-specific adjustment cost function, and the alternative model of country characteristics. Estimation outcome of model of country-specific adjustment cost function is from the Baseline estimation. The country-characteristics model is estimated using the portfolio-level moment of the subsample of 17 countries and 56 countries in the 4 regions of remaining area. Country characteristic variables are the respect to the trade secrets and industry patents, cost of contract enforcement, economic and financial development. The subfigure in first row reports the cross-section R^2. The bar of yellow color describes the estimation outcome of the country-specific model. The bar of purple color describes the estimation outcome of the country-characteristics model. The data label of numbers denote the cross-section R^2 of the country-characteristics model. The subfigure in second row reports the time-series R^2. The bar of dark color describes the estimation outcome of the country-specific model. The bar of light color describes the estimation outcome of the country-characteristics model. The data label of numbers denotes the time-series R^2 of the country-characteristics model. Within each geographic area (of 17 countries, Rest of Asia, Rest of Europe, Latin America, Africa), firms are grouped into portfolios. Model-implied valuation is calculated for each model, then the statistics of fitness are calculated using the portfolio-level moments. The construction of portfolios, calculation of statistics are identical with Table 2 in the draft. The bar of dark red color, the light red color describes the estimation outcomes of the two specifications respectively, for countries and the remaining area in Asia. The dark and light green colors are for countries and the remaining area in Europe. The blue colors are for Americas. The yellow colors are for Australia (Oceania). The gray colors are for Africa.

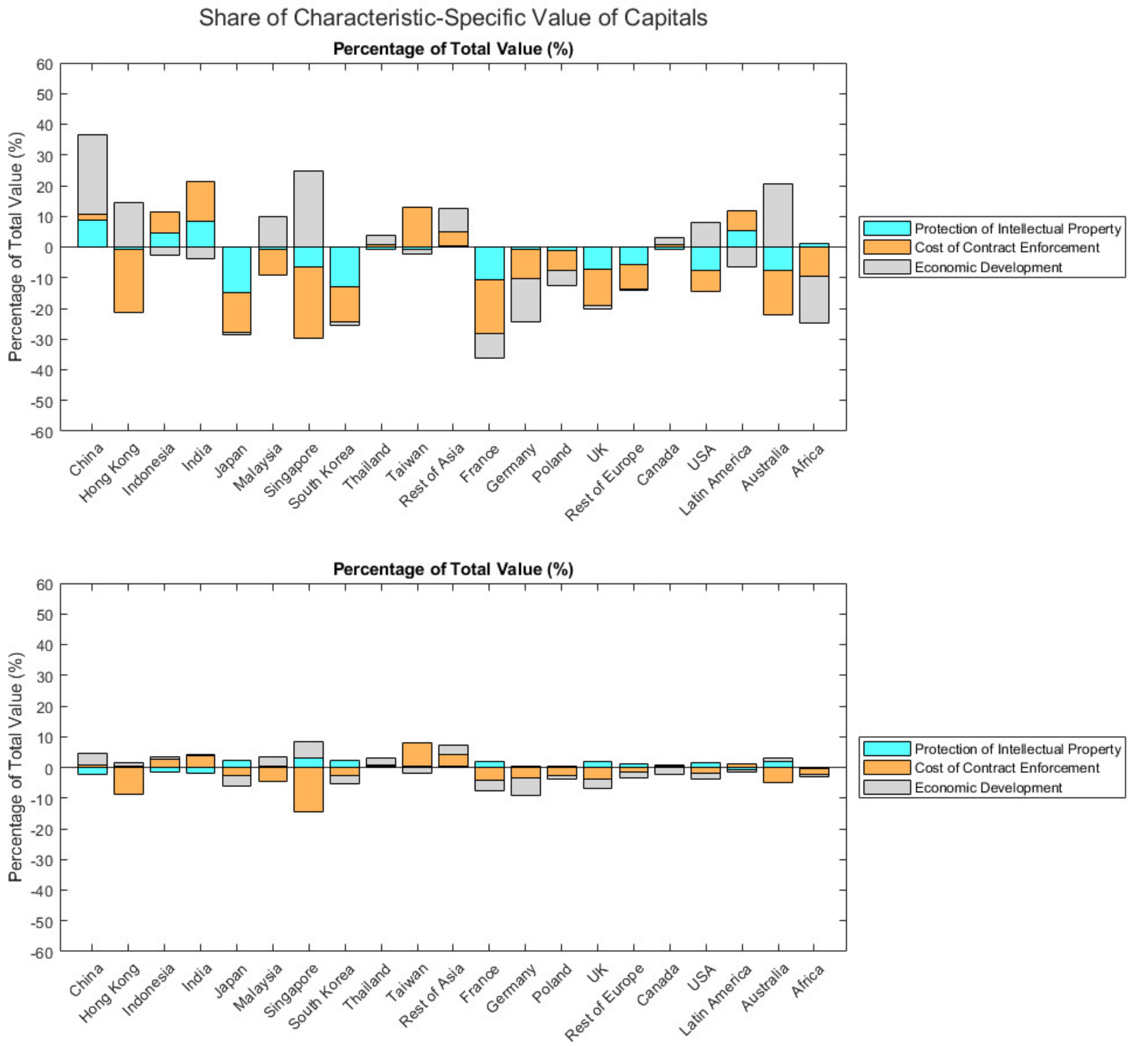

Figure 5: Share of Characteristic-Specific Value

This figure reports the model-implied characteristic-specific valuation for the model of country-specific state-contingent adjustment cost function (in abbreviation, country-characteristic model). The valuation of intangible capital from country-characteristic variables in percentage of the total firm value is reported in the first row. For each aspect z of country-characteristic variables, the cost compensation in value of intangible capital is calculated as $\{\gamma_z^I \cdot X_{z,c} \cdot (1-\tau) \cdot i^I \cdot K^I\}_z$, then its contribution to total firm value $\{\frac{\gamma_z^I \cdot X_{z,c} \cdot (1-\tau) \cdot i^I \cdot K^I}{V}\}_z$ is reported. The component $\frac{(1-\tau) \cdot i^I \cdot K^I}{V} = \frac{1}{T}\sum_t \frac{\sum_i (1-\tau_{c,t}) \cdot i_{it}^I K_{it+1}^I}{\sum_i V_{it}}$ is calculated as the aggregate statistic for each geographic area (of 17 countries, 4 regions of Rest of Asia, Rest of Europe, Latin America, Africa) and each year during 2016-2020. The similar statistic is reported for physical capital in the second row.

C Math Appendix

C.1 Theorem of Firm Valuation Decomposition

This appendix section provides the proof for the valuation equation 5. The proof is direct extension of (Hayashi, 1982) with consideration of multiple types of capital inputs and debt.

Theorem [Hayashi,1982]: Denote $P_{it} \equiv V_{it} - D_{it}$ be the ex-dividend equity value. If profit function $\Pi(.)$ and cost function $C(.)$ are Constant Return to Scale, firm's value maximization implies that

$$P_{it} + B_{it+1} = q^P_{it} K^P_{it+1} + q^I_{it} K^I_{it+1}, \tag{24}$$

in which

$$\begin{aligned} q^P_{it} &= 1 + (1-\tau_t) \cdot \tfrac{\partial C_{it}}{\partial I^P_{it}}, \\ q^I_{it} &= (1-\tau_t) \cdot (1 + \tfrac{\partial C_{it}}{\partial I^I_{it}}). \end{aligned} \tag{25}$$

Proof:

The Bellman equation of firm equity valuation is

$$V(X_{it}, K^P_{it}, K^I_{it}) \equiv \max_{\{L_{it+\triangle t}, \mathbf{I}_{it+\triangle t}, \mathbf{K}_{it+\triangle t+1}, B_{it+\triangle t+1}\}^{\infty}_{\triangle t=0}} D_{it} + E_t\left[M_{t+1} \cdot V(X_{it+1}, K^P_{it+1}, K^I_{it+1})\right], \tag{26}$$

$$s.t. \quad \begin{aligned} D_{it} \equiv (1-\tau_t)[\Pi_{it} - C_{it} - I^I_{it}] \quad & -I^P_{it} + B_{it+1} - r^B_{it} B_{it} \\ & +\tau_t \delta^P_{it} K^P_{it} + \tau_t (r^B_{it} - 1) B_{it}. \end{aligned} \tag{27}$$

$$K^P_{it+1} = I^P_{it} + (1-\delta^P_{it}) K^P_{it} \tag{28}$$

$$K^I_{it+1} = I^I_{it} + (1-\delta^I_{it}) K^I_{it} \tag{29}$$

The X_{it} is vector of state variables of aggregate productivity and firm productivity. Optimal physical capital investment reflects the marginal value of physical capital (K^P_{it+1}):

$$\underbrace{1 + (1-\tau_t)\frac{\partial C_{it}}{\partial I^P_{it}}}_{q^P_{it}\text{: Physical Capital Marginal q}} = E_t\left[M_{t+1} \cdot \frac{\partial V}{\partial K^P}(X_{it+1}, K^P_{it+1}, K^I_{it+1})\right] \tag{30}$$

Optimal intangible capital investment reflects the marginal value of intangible capital (K^I_{it+1}):

$$\underbrace{(1-\tau_t)\left[1+\frac{\partial C_{it}}{\partial I^I_{it}}\right]}_{q^I_{it}:\text{ Intangible Capital Marginal q}} = E_t\left[M_{t+1}\cdot\frac{\partial V}{\partial K^I}(X_{it+1},K^P_{it+1},K^I_{it+1})\right] \tag{31}$$

We assume the Modigliani-Miller environment, total firm valuation is irrelevant of capital structure. Equity value maximization implies the total firm valuation maximization, $r^B_{it}B_{it} + V(X_t,\mathbf{K}_{it}) = \overline{V}(X_t,\mathbf{K}_{it})$. If profit function $\Pi(.)$ and cost function $C(.)$ are Constant Return to Scale w.r.t $\mathbf{K}_{it} = (K^P_{it}, K^I_{it})$, firm's value maximization implies that

$$\overline{V}(X_t, a\cdot K^P_{it}, a\cdot K^I_{it}) = a\cdot\overline{V}(X_t, K^P_{it}, K^I_{it}), \tag{32}$$

Homogeneity of Degree One implies the equation below,

$$\frac{\partial\overline{V}}{\partial K^P}(X_t, a\cdot K^P_{it}, a\cdot K^I_{it})\cdot K^P_{it} + \frac{\partial\overline{V}}{\partial K^I}(X_t, a\cdot K^P_{it}, a\cdot K^I_{it})\cdot K^I_{it} = a\cdot\overline{V}(X_t, K^P_{it}, K^I_{it}), \tag{33}$$

At $a = 1$, the total firm valuation is quantity of capital(s) multiplied by the marginal valuation of capital(s). In the Modigliani-Miller environment, total firm valuation is irrelevant of debt. Marginal value of physical capital for the equity valuation is identical with the first-order partial derivative of total firm valuation,

$$\frac{\partial V}{\partial K^P}(X_t,\mathbf{K}_{it}) = \frac{\partial\overline{V}}{\partial K^P}(X_t,\mathbf{K}_{it}), \tag{34}$$

The similar equation holds for the new amount of intangible capital. Previously, we denote the $q^P_{it}(X_t) = E_t\left[M_{t+1}\cdot\frac{\partial V}{\partial K^P}(X_{it+1},\mathbf{K}_{it+1})\right]$, substituting the equation (34) yields $q^P_{it} = E_t\left[M_{t+1}\cdot\frac{\partial\overline{V}}{\partial K^P}(X_{it+1},\mathbf{K}_{it+1})\right]$, shadow price of physical capital is the expected marginal value for total firm valuation. Replacing the expected marginal value of capital, The expected total firm valuation is written as

$$\begin{aligned} E_t\left[M_{t+1}\cdot\overline{V}(X_{it+1},\mathbf{K}_{it+1})\right] &= E_t\left[M_{t+1}\cdot(\tfrac{\partial\overline{V}}{\partial K^P}(X_{it+1},\mathbf{K}_{it+1})\cdot K^P_{it+1}+\tfrac{\partial\overline{V}}{\partial K^I}(X_{it+1},\mathbf{K}_{it+1})\cdot K^I_{it+1})\right] \\ &= q^P_{it}(X_t)\cdot K^P_{it+1}+q^I_{it}(X_t)\cdot K^I_{it+1} \end{aligned},$$

Recall the total firm valuation is equity plus the debt, we arrive to the expected equity value $E_t\left[M_{t+1}\cdot(V(X_{it+1},\mathbf{K}_{it+1})\right]$ prior to dividend payout,

$$\begin{aligned} E_t\left[M_{t+1}\cdot\overline{V}(X_{it+1},\mathbf{K}_{it+1})\right] &= E_t\left[M_{t+1}\cdot(V(X_{it+1},\mathbf{K}_{it+1})+r^B_{it+1}B_{i,t+1})\right] \\ &= E_t\left[M_{t+1}\cdot(V(X_{it+1},\mathbf{K}_{it+1})\right]+E_t\left[M_{t+1}\cdot r^B_{it+1}B_{i,t+1}\right] \end{aligned},$$

The model considers the one-period debt. The new amount of debt equals the expected repayment in next period, $B_{i,t+1}=E_t\left[M_{t+1}\cdot r^B_{it+1}B_{i,t+1}\right]$. Equity value of current period is the payout and the expected equity value of next period, $V_{it}=D_{it}+E_t\left[M_{t+1}\cdot V(X_{it+1},\mathbf{K}_{it+1})\right]$. Combining these equations, we conclude, if profit function $\Pi(.)$ and cost function $C(.)$ are Constant Return to Scale w.r.t $\mathbf{K}_{it}$, firm's value maximization implies that

$$V_{it}+B_{it+1}=D_{it}+q^P_{it}(X_{it})\cdot K^P_{it+1}+q^I_{it}(X_{it})\cdot K^I_{it+1}, \tag{35}$$

Let $P_{it}\equiv V_{it}-D_{it}$ be the ex-dividend equity value, the equation is further simplified as

$$P_{it}+B_{it+1}=q^P_{it}(X_{it})\cdot K^P_{it+1}+q^I_{it}(X_{it})\cdot K^I_{it+1}, \tag{36}$$

Q.E.D.

C.2 Derivation of Country-Characteristic Model

Linear Approximation: Consider the observed institutional characteristic $\widetilde{X}_{1,c}$, its steady state $\overline{\mathbf{X}}_{\mathbf{1,n}}$ depends on the endowment of intangible capital in that country , which we simplified as discrete value in the range of $n\in\{1,2,3,4\}$, sorted by the relative ranking $\frac{K^I}{K^I+K^P}$. The deviation of institutional characteristic from cohort steady state $\widetilde{\mathbf{X}}_{\mathbf{1,c}}-\overline{\mathbf{X}}_{\mathbf{1,n}}$ have identical incremental effect $\boldsymbol{\gamma^I_1}$ to the firm-level adjustment cost. Combining the innate global average cost $\theta_{I,g}$, firm-level adjustment cost in a country with characteristic profile $\mathbf{X}$ is

$$\begin{aligned}\theta_I(\mathbf{X}) = & \ \theta_{I,g} + \sum_{n=1}^{4} \mathbb{1}(X_{Intan,c} = n) \cdot \boldsymbol{\gamma_1^I} \cdot (\widetilde{\mathbf{X}}_{\mathbf{1,c}} - \overline{\mathbf{X}}_{\mathbf{1,n}}) \\ = & \ \theta_{I,g} + \boldsymbol{\gamma_1^I} \cdot (\widetilde{\mathbf{X}}_{\mathbf{1,c}} - \tfrac{1}{4}\sum_{n=1}^{4} \overline{\mathbf{X}}_{\mathbf{1,n}}) + \sum_{n=1}^{4} \mathbb{1}(X_{Intan,c} = n) \cdot \boldsymbol{\gamma_1^I} \cdot (\overline{\mathbf{X}}_{\mathbf{1,n}} - \tfrac{1}{4}\sum_{n=1}^{4} \overline{\mathbf{X}}_{\mathbf{1,n}}) \\ = & \ \theta_{I,g} + \boldsymbol{\gamma_1^I} \cdot \mathbf{X}_{\mathbf{1,c}} + \sum_{n=1}^{4} \mathbb{1}(X_{Intan,c} = n) \cdot \gamma_{2,n}^I. \\ = & \ \theta_{I,g} + \boldsymbol{\gamma^I} \cdot \mathbf{X_c}\end{aligned} \tag{37}$$

In this equation 37, the global-demeaned country characteristic is denoted as $\mathbf{X}_{\mathbf{1,c}} = \widetilde{\mathbf{X}}_{\mathbf{1,c}} - \frac{1}{4}\sum_{n=1}^{4} \overline{\mathbf{X}}_{\mathbf{1,n}}$. The unconditional global average steady state is denoted as $\overline{\mathbf{X}}_{\mathbf{1,g}} = \frac{1}{4}\sum_{n=1}^{4} \overline{\mathbf{X}}_{\mathbf{1,n}}$. The fixed effect coefficient $\gamma_{2,n}^I$ summarizes the cohort steady state $\gamma_{2,n}^I = \boldsymbol{\gamma_1^I} \cdot (\overline{\mathbf{X}}_{\mathbf{1,n}} - \frac{1}{4}\sum_{m=1}^{4} \overline{\mathbf{X}}_{\mathbf{1,m}})$. By construction, $\sum_{n=1}^{4} \gamma_{2,n}^I = \sum_{n=1}^{4} \boldsymbol{\gamma_1^I} \cdot (\overline{\mathbf{X}}_{\mathbf{1,n}} - \frac{1}{4}\sum_{m=1}^{4} \overline{\mathbf{X}}_{\mathbf{1,m}}) = \boldsymbol{\gamma_1^I} \cdot (\sum_{n=1}^{4} \overline{\mathbf{X}}_{\mathbf{1,n}} - \frac{1}{4}\sum_{m=1}^{4} \overline{\mathbf{X}}_{\mathbf{1,m}}) = 0$. Under the simple situation where the fixed effects are identical among the lowest 3 quartiles, estimation only requires distinguishing the 4th quartile $\{\gamma_{2,n\leq 3}^I, \gamma_{2,n=4}^I\}$. Under this simple situation, we denote the fixed effect of the top quartile as $\gamma_{2,\text{Top25\%}}^I$ for informative notations. This model can be further simplified as equation 15 where the $\mathbf{X_1}$ is the global-demeaned institutional characteristics, and the indicator variable $\mathbf{X}_2$ for whether endowment of intangible capital in the country belongs to the highest quartile.

Remark: The countries that intensively utilize intangible capital in the production, show adapted institution environment. Approximation with fixed effect incorporates the different steady states. For example, the specialists in evaluating the originality of technology, creation will help law firm to collect evidence for the infringement of intellectual property, or the bank to accurately gauge value for the intangible capital owned by the firm. Such supporting infrastructure has fixed cost in modifying the college education system and the legal system at the country level.

Definition of Valuation contributed by Country Characteristic: The firm valuation ratio (average Q) combines physical and intangible capital were defined in equation 13. The market value of each input can be decomposed into three components,

$$\begin{aligned}\frac{q^I \cdot K^I}{K^P+K^I} = & \ (1-\tau_c)\frac{K^I}{K^P+K^I} + (1-\tau_c)\theta_{I,g}\left(\frac{I^I}{K^I}\right)\frac{K^I}{K^P+K^I} + (1-\tau_c) \cdot \boldsymbol{\gamma^I} \cdot \mathbf{X_c} \cdot \left(\frac{I^I}{K^I}\right)\frac{K^I}{K^P+K^I} \\ \frac{q^P \cdot K^P}{K^P+K^I} = & \ \frac{K^P}{K^P+K^I} + (1-\tau_c)\theta_{P,g}\left(\frac{I^P}{K^P}\right)\frac{K^P}{K^P+K^I} + (1-\tau_c) \cdot \boldsymbol{\gamma^P} \cdot \mathbf{X_c} \cdot \left(\frac{I^P}{K^P}\right)\frac{K^P}{K^P+K^I}\end{aligned} \ . \tag{38}$$

with intangible capital book value $(1-\tau_c)\frac{K^I}{K^P+K^I}$, global value $(1-\tau_c)\theta_{I,g}\left(\frac{I^I}{K^I}\right)\frac{K^I}{K^P+K^I}$ and a characteristic specific value $(1-\tau_c)\cdot\boldsymbol{\gamma}^{\boldsymbol{I}}\cdot\mathbf{X_c}\cdot\left(\frac{I^I}{K^I}\right)\frac{K^I}{K^P+K^I}$, and analogously for the physical capital. The last component capture the drivers of the heterogeneity in the value of each input that depends on the country characteristics modeled. Taking the observed investment rates and firm valuation, one can use equation 38 to gauge the direct effect over firm valuation from underdeveloped institutional infrastructure and financial market. Formally, the price of capital in a country c is determined as

$$\begin{aligned} q^I &= (1-\tau_c) + q_g^I + \mathbf{q}_X^I \cdot \mathbf{X_c} \\ q^P &= 1 + q_g^P + \mathbf{q}_X^P \cdot \mathbf{X_c} \end{aligned} \tag{39}$$

Given the observed firm investment rates, the common valuation assuming global average cost is determined as

$$q_g^I = \theta_{I,g}\cdot(1-\tau_c)\cdot i^I \quad , \quad q_g^P = \theta_{P,g}\cdot(1-\tau_c)\cdot i^P \tag{40}$$

The marginal compensation value q_z for country characteristic variable $X_{z,c}$ is determined by the incremental cost coefficient γ_z,

$$q_z^I = \gamma_z^I\cdot(1-\tau_c)\cdot i^I \quad , \quad q_z^P = \gamma_z^P\cdot(1-\tau_c)\cdot i^P \tag{41}$$

The valuation of intangible capital contributed by country-specific characteristic of institutional environment and economic development in Equation 23 can be correspondingly derived.

Remark: Ex-post we cannot tell whether the realized low investment rate is discouraged by the anticipated high adjustment cost in the future, or the high discount rate from the risk premium. Such investigation requires fully parameterizing the firm operating profit process (how it is affected by the product market competition and aggregate shocks), and the stochastic discount factor comoving with the aggregate shocks. It would be meaningful to further quantify the indirect effect through discouraging or distorting the investment rate. This decomposition in equation 39 uses the observed investment rate in realized equilibrium outcome, estimates the component in the price of capital that is directly attributed to country characteristic $q_z^I X_{z,c}$.

Online Appendices

D Data Appendix

D.1 Construction of Data

D.1.1 Summary of Data

1. Firm Fundamental
   - Data Source: Compustat Global, Compustat North America
   - Main data fields: Capital Stock, Capital Expenditure, Depreciation
2. Stock Price
   - Data Source: Compustat Global-Security Daily, Compustat-CRSP linked
   - Main data fields: Capital Stock, Capital Expenditure, Depreciation
3. Deflator
   - Data Source: CPI in OECD statistic
   - Main data fields: Capital Price
4. Tax Rate of Corporate Income
   - Data Source: Tax Foundation, Compustat Global -Economic Indicators
   - Main data fields: Corporate Tax

D.1.2 Main Measure

Variable	Measure	Alternative Measure
Price, Physical Capital	OECD CPI	UN stat
Price, Intangible Capital	OECD CPI	UN stat
Quantity, Physical Capital	Compustat, PPENT	-
Quantity, Intangible Capital	Compustat, XSGA	-
Value of Equity	Compustat-Security Daily	Datastream
Value of Debt	Compustat, Book Debt	-
Home Country	Headquarter	-

D.2 Detailed Construction of Variable

D.2.1 Firm-level Data

We use Compustat Global from Capital IQ to collect the accounting information of listed firms incorporated in United Kingdom and Continental European countries. We use the information in the annual financial report.

Definition of Country: We use the location of headquarter as the home country of a firm. We use the location of incorporation of a firm to crosswalk the corporate tax rate.

Financial Statement : For firms with both international version of financial report (DATFMT as HIST) and domestic version of financial report (DATFMT as Standard) in the same fiscal year, we use the international-version of financial report. For firms with restatement of financial reports, we use the most recent version of financial report.

Industry Code: We remove firms in financial service industry (SIC:6000-6999), utility industry (SIC: 4900-4999), and public service industry (SIC: 9000-9999).

Corporate Event: We check the firm-year observations with major acquisition event, using the footnote variables `SALE_FN`. For firms with major merge and acquisition event, the `SALE_FN` is flagged as AC. Based on this criteria, this situation is rare for the European countries, hence, we didn't implement this filter.

Currency Conversion: We conduct conversion of currency for all nominal variables. The currency uses the reports by Compustat-Fundamental. We use the sub-dataset Exchange Rate provided by Compustat Global to convert the currency of financial reports into nominal USD amount. We use the 12-month (backward) moving-average exchange rate to convert the currency. For example, if a firm reports its income statement on Dec-31st-2010, we use the average month-end exchange rate during Jan-2010 and Dec-2010.

Equity Value: We use the sub-dataset Security Daily provided by Compustat Global to calculate the market value of outstanding common stock issued by the firms. Each firm in Compustat Global has the unique identifier `GVKEY`, a unique identifier `PRIROW` for the primary issued common stock. Each common stock in Security Daily has a unique identifier `IIN` and a unique firm identifier `GVKEY`. We require the security `IIN` matched with the firm `PRIROW`, and the identical firm identifier

GVKEY. We calculate the market value as the market-close price multiplied by the outstanding shares $V = PRCCF \cdot CSHOC$.

Quantities of Capitals: We use the month-end market value in the month of financial report date. We use the currency uses the reports by Compustat-Security Daily, convert the market value into the nominal USD amount, in the similar method with the firm fundamental variables. The nominal amount of intangible capital is estimated using the Perpetual Inventory Method, given the history of firm investment nominal amount and country-level inflation. We use CPI reported by OECD to construct the amount of capital. The national account statistics harmonized by OECD cover the early sample period of Compustat North America and Compustat Global. When the country is not covered by the OECD, we use the national account statistics harmonized by the United Nation. To avoid the measurement noise from hyper-inflation, we restrict the ceiling of inflation rate as 25% per year, in computing the investment rate and capital stock. The quantity of investment in physical capital is inferred by history of capital stock and depreciation. We restrict the ceiling of the depreciation rate to be no larger than 1, in calculating the amount of investment.

D.3 Classification of Geographic Areas

The United Nations Statistics Division (UNSD) classifies 5 large regions (17 sub-regions): Africa (Northern Africa, Sub-Saharan Africa), Americas (Northern America, Latin America and the Caribbean), Asia (Eastern Asia, Southern Asia, South-eastern Asia, Melanesia, Micronesia, Polynesia, Central Asia, Western Asia),Oceania (Australia and New Zealand), Europe (Southern Europe, Eastern Europe, Northern Europe, Western Europe) [31]. For ease of description, we refer the 5 large regions as the ***continents***. We decide geographic areas in each continent following the procedure below:

- We impose the basic quality requirement for the firm-level observations, summarize the sample by each country.
- When the number of firm-level observation inside the country surpasses 9 observations, we start to include the country in our sample.

[31] Formerly, this classification refers the UNSD-M49 standard.

- If the average number of firm-level observations surpass 200 observations, we label the country as an independent large economy. The remaining countries are then classified as the constituent country in the rest of the continent.

- Due to the extreme years of hyper-inflation, the sample of Egypt and the sample Zimbabwe are discontinued after the preliminary sample requirement of firm investment rates. We remove the two countries to ensure the stationary sample.

After implementing above procedure, we end up with 17 large countries and 4 regions.

The 17 large economies are Australia, Canada, China, Germany, France, UK, Hong Kong, India, Indonesia, Japan, South Korea, Malaysia, Poland, Singapore, Thailand, Taiwan, USA.

For the region as Oceania, we don't have valid observations of listed firms locating. The large economy such as Australia is considered separately. Subsample of New Zealand has small number of firms. Estimation doesn't have the sufficient observations.

After these steps, we arrive to the 4 regions: Rest of Asia, Rest of Europe, Latin America, and Africa.

In summary, our world-wide sample contains 5 continents. Each continent contains the large countries within and the region of remaining area. Each region contains the countries of medium size and sub-regions of remaining area. Definitions of these geographic areas are in hierarchical relationships.

D.4 Sample Requirement

The sample requirement refers (Belo et al, 2022). Additional requirement for firm-level observations is included, to address the firm-level noise in economies of small sample. We decide the qualified firm-year observations following the criteria and procedure below: In the 1st stage, we require firms have non-missing capital information, investment, valuation and tax rate:

- We require non-missing and positive sale $Y_{i,t}$, previous-period sale $Y_{i,t-1}$, 2-period lagged sale $Y_{i,t-2}$, 3-period lagged sale $Y_{i,t-3}$.

- We require non-missing and positive current and historical physical capital $K^P_{i,t}, K^P_{i,t-1}, K^P_{i,t-2}$, and similarly for intangible capital $K^I_{i,t}, K^I_{i,t-1}, K^I_{i,t-2}$.

- We require non-missing firm valuation $Q_{i,t}$ (equity valuation plus net debt value), investment rate in physical capital $i^P_{i,t}$, investment rate in intangible capital $i^I_{i,t}$, corporate income tax rate $\tau_{i,t}$.

In the 2nd stage, we exclude extreme firm-year observations based on the distribution of firm variables within each country.

- We require the physical capital greater than 1 million USD dollars, the intangible capital greater than 1 million USD dollars, to avoid the extreme firm-year observations among tiny firms.

- We require firm-year observations with non-zero intangible investment rate in the current year and previous year. We remove abnormal firm-year observation reporting zero XSGA-expense in continuously recent two years.

- We remove abnormal firm-year observation reporting physical capital depreciation rate $\delta^P_{j,t} > 0.999$ or $\delta^P_{j,t-1} > 0.999$ in recent two years. This avoids those firm-year observation with surprisingly high investment rate (flat capital growth in PPENT and reported large depreciation).

- We require the change of firm sale $\frac{Y_{i,t}-Y_{i,t-1}}{Y_{i,t-1}}$ within the percentile $(2\%, 98\%)$ with respect to its country-year panel, to avoid the extreme firm-year observations.

- We require the ratio of firm valuation $\frac{Q_{i,t}}{K^P_{i,t}+K^I_{i,t}}$ within the percentile $(2\%, 98\%)$ with respect to its country-year panel, to avoid the extreme observations of firm valuation in the left-tail and right-tail.

- For most of the countries, we require the firm size (physical capital and intangible capital together) within the percentile $(2\%, 100\%)$ with respect to its country-year panel, to avoid the high idiosyncratic noise among tiny firms.
  - In Japan and South Korea, the firm size is required to be within the $(30\%, 100\%)$ with respect to its country-year panel. We check the coverage of aggregate sale, physical capital and intangible capital, removal of tiny-small firms generates small impact.

  - The firm size is required to be within the $(30\%, 100\%)$ with respect to its country-year panel in China, and the same requirement for the amount of intangible capital simultaneously. This avoids the tiny firms especially the firms with tiny amount of intangible capital and of high valuation, which would lead to abnormally large cost parameter in estimation. The sample of China covers the main fraction in its aggregate sale, physical capital and intangible capital.

- Outliers not captured by above standard universal procedures were manually excluded, listed as below

  - Gvkey {64987,212653,247885,253638,259070,278186,285319}, outliers in Australia. These firms have abnormal investment in physical capital, due to the inconsistent PPENT around the year 2006.
  - Gvkey {324744}, outliers in Cayman Island (Latin America). This firm have abnormal valuation ratio $\frac{Q_{i,t}}{K^P_{i,t}+K^I_{i,t}}$, larger than 100, stays in sample for 3 years (after standard cleaning procedures).
  - Gvkey {324294}, outliers in Poland. This firm have abnormal decline of sale from approximately 1(million USD) to near zero and consecutively near-zero sale for about three years.

As described in D.3, large country or area are classified as the long panel with the sufficient observations of firms within each year. This arrives to the sample described in Table OT.1 and Table 1. We report the statistics of sample construction in Table OT.2.

OT Online Table Appendix

OT.1 Descriptive Statistics and Estimation Outcome for Countries

Table OT.1: Descriptive Statistics for Countries

The table below reports the descriptive statistics of listed corporations, and the snapshot of national statistics in the year 2020. **Start** is the start year where the analysis is performed for each country, the end year is 2020 for all countries. **Firm Number (Total)** counts the number of listed firms with qualified financial reports during the full sample period, **Firm Number (Mean)** for the average number comparable during period from 2006 and 2020, and **Firm Number (2020)** for the number in the year 2020. $\frac{Y}{GDP}$ reports the ratio of total output produced by firms, over the GDP of home-country, in the unit of percentage. $\frac{VA}{GDP}$ reports the ratio of total value-added (SALES-COGS) by firms, over the GDP of home-country, in the unit of percentage. **Per capita** reports the GDP per capita of firms' home-country, in the unit of dollars in year 2020 (in constant price of year 2015). National accounting statistics during the end of sample period are reported, respectively. The same statistics are reported for each region of remaining area. The same statistics for the whole continent is reported below countries and region within the continent. The same statistics for the full sample of all the countries (**World**) are reported in the final rows. All national statistics comes from the UN-stat. All statistics of listed corporations are calculated by authors. The world-wide GDP uses the all the countries.

Country/Region	Start	Firm Number			Economic Importance		Per Capita (USD)
		Total	Mean	2020	$\frac{Y}{GDP}$ (%)	$\frac{VA}{GDP}$ (%)	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
China	2001	2824	1362	2167	20.46	4.95	10166
Hong Kong	2002	1049	523	509	162.90	63.47	41715
Indonesia	2000	475	244	360	15.44	4.66	3757
India	2002	2337	1328	1531	32.37	11.09	1849
Japan	2000	2328	1474	1404	113.34	32.15	34637
Malaysia	2002	915	511	543	34.83	9.24	10617
Singapore	2003	611	297	230	49.70	9.55	56423
South Korea	2000	1052	470	748	78.09	22.93	31674
Thailand	2000	587	346	449	51.27	12.15	6199
Taiwan	2001	1845	1182	1365	98.25	23.73	26008
Rest of Asia	2000	2110	1118	1359	20.45	8.77	5282
Asia	2000	16133	8855	10665	41.73	12.04	7249
France	2007	476	270	214	40.38	18.32	35700
Germany	2006	492	258	240	32.35	11.92	40992
Poland	2006	434	224	214	16.48	3.62	14681
UK	2000	1387	465	368	52.40	16.07	42455
Rest of Europe	2000	2591	1232	1201	31.13	12.20	21874
Europe	2000	5380	2431	2237	35.28	13.25	27036
Canada	2000	961	324	273	31.36	8.82	42391
USA	2000	4767	1713	1493	51.07	17.60	58148
Latin America	2000	752	392	410	16.94	5.99	8555
Americas	2000	6480	2512	2176	44.07	15.09	29093
Australia	2004	1122	395	340	23.23	9.60	53244
Africa	2006	516	264	270	15.05	5.42	2704
World	2000	29631	14373	15688	40.15	13.19	12383

Table OT.2: Statistics of Sample Construction

This table reports statistics of constructing the sample for the benchmark estimation. Column (2) and Column (3) report the number of observations, the number of firms in the initial sample of data constructed with Compustat Global and Compustat North-America (utility sector and financial sector are not included). Column (4) and Column (5) report the analogous statistics in the interim sample of data, after requirement of reporting XSGA and PPENT (the raw accounting information to infer capitals). Column (6) and Column (7) report the analogous statistics in the final sample of data, after removing firms of extreme growth and tiny size. Description of sample requirement is in Data Appendix. **Sale, Asset, Physical** and **Intangible** report the coverage of nominal dollar amount of sale, Compustat Item-AT, physical capital stock, intangible capital stock, during the 2nd stage of sample preparation, where extreme firm-year observations are excluded from the sample. All ratios are calculated for the snapshot year of 2020, reported in percentage (%). Table continues in next page, for other countries in each region.

Country/Region	Sample Size						Coverage in 2nd-stage (%)			
	Compustat Sample		Interim Sample		Qualified Sample		Sale	Asset	Physical	Intangible
(1)	(2) Obs	(3) Firm	(4) Obs	(5) Firm	(6) Obs	(7) Firm	(8)	(9)	(10)	(11)
China	65113	6273	41377	4616	22763	2824	86.27	83.68	82.39	84.89
Hong Kong	17973	1412	10532	1158	8791	1049	88.69	90.17	93.20	82.58
Indonesia	7665	750	4955	502	4399	475	95.93	90.31	90.03	94.33
India	62753	4722	23459	2449	20711	2337	88.11	87.50	86.90	92.73
Japan	60453	4415	48801	3726	30530	2328	91.01	91.31	87.99	91.92
Malaysia	15290	1203	9958	960	8757	915	90.72	91.62	92.61	90.56
Singapore	9535	784	5720	653	4916	611	90.53	88.69	85.55	90.61
South Korea	20067	2191	12553	1609	7880	1052	95.10	94.24	96.46	94.19
Thailand	9730	769	7018	620	6213	587	93.26	93.45	96.26	95.39
Taiwan	31254	2344	21439	1982	18966	1845	89.07	90.43	92.68	91.65
Rest of Asia	38788	3273	20186	2237	17805	2110	92.68	91.09	91.10	88.11
France	8207	861	4853	558	3784	476	92.18	92.71	96.77	95.60
Germany	8594	865	4894	578	3876	492	83.88	80.26	76.19	85.29
Poland	8454	820	3866	478	3358	434	86.91	79.32	86.12	90.59
UK	28987	2804	13213	1700	9926	1387	89.09	87.59	92.76	87.32
Rest of Europe	52311	5012	25043	2968	20448	2591	88.52	88.47	92.68	89.05
Canada	26710	2957	7609	1091	6410	961	93.62	90.89	95.49	86.71
USA	65133	7636	47332	5393	39318	4767	93.71	89.51	93.51	92.19
Rest of Americas	14235	1054	8123	792	7016	752	93.69	88.58	93.86	91.40
Australia	26376	2564	7800	1288	6272	1122	86.15	82.10	89.90	88.87
Africa	7295	689	4715	544	3958	516	86.95	74.88	89.64	85.43

Table OT.2: Statistics of Sample Construction for Other Countries within Regions (Table Continued)

The table below reports the descriptive statistics of listed corporations for individual countries in the region of remaining area of each continent. Column (1) reports the name of the geographic area (region). Column (2) reports the country (or territory). Columns (3) to (12) report the statistics identical with Table OT.2 for each country. Table continues in the next page.

Region	Country	Sample Size						Coverage in 2nd-stage (%)			
		Compustat Sample		Interim Sample		Qualified Sample		Sale	Asset	Physical	Intangible
(1)	(2)	(3) Obs	(4) Firm	(5) Obs	(6) Firm	(7) Obs	(8) Firm	(9)	(10)	(11)	(12)
Africa	Cote Divoire	218	23	145	20	139	19	100.00	100.00	100.00	100.00
	Ghana	111	15	90	13	90	13	100.00	100.00	100.00	100.00
	Kenya	472	41	274	31	257	31	99.19	98.32	98.36	98.95
	Morocco	810	63	583	52	500	50	95.64	95.17	95.51	95.75
	Mauritius	307	43	116	22	91	21	96.71	81.70	82.63	98.45
	Nigeria	1380	114	840	95	731	93	94.43	97.03	97.56	94.13
	Tunisia	608	53	415	45	367	44	82.00	82.45	81.50	80.80
	South Africa	3339	324	2209	255	1746	234	84.67	69.98	87.30	82.55
	Zambia	50	13	43	11	37	11	97.88	41.53	96.76	93.97
Latin America	Argentina	1133	75	755	63	624	59	84.41	81.18	85.44	86.31
	Brazil	5459	409	2601	274	2209	255	93.84	85.76	94.35	88.38
	Chile	2379	149	1544	130	1366	126	93.18	92.01	89.71	97.55
	Colombia	595	44	343	36	322	36	98.71	99.17	99.22	99.37
	Cayman Islands	591	81	312	59	259	55	90.05	77.31	90.07	80.33
	Jamaica	548	61	270	38	253	38	94.60	92.44	94.72	92.92
	Mexico	2010	141	1350	109	1129	102	93.92	88.83	94.62	92.67
	Peru	1520	94	948	83	854	81	97.72	98.28	98.51	98.50
Rest of Asia	UAE	738	83	498	52	427	49	97.38	93.02	90.43	91.79
	Bangladesh	2020	223	788	132	716	130	96.93	97.95	98.51	93.43
	Bahrain	222	18	162	17	158	17	100.00	100.00	100.00	100.00
	Cyprus	1032	91	552	61	474	59	96.68	89.43	85.38	96.48
	Israel	6939	597	2902	365	2401	320	78.91	76.98	68.17	79.12
	Jordan	1824	120	836	91	772	87	98.04	96.58	96.34	96.06
	Kuwait	1209	95	706	83	602	80	94.01	92.56	95.41	96.06
	Sri Lanka	2839	203	1631	155	1462	150	85.08	93.47	95.12	91.51
	Oman	1160	71	727	63	649	61	86.73	92.79	96.80	93.55
	Pakistan	5695	365	2995	274	2690	261	95.70	95.86	95.07	95.24
	Philippines	2714	176	1256	132	1082	125	97.58	95.14	93.43	98.44
	Palestine	124	18	96	17	96	17	100.00	100.00	100.00	100.00
	Qatar	206	23	177	16	175	16	100.00	99.91	99.97	99.95
	Saudi Arabia	1935	215	1322	125	1195	122	97.96	96.93	96.57	97.36
	Turkey	4763	405	3144	298	2765	281	86.90	72.80	63.05	78.92
	Viet Nam	5368	570	2394	356	2141	335	85.45	79.08	86.60	84.84

Table OT.2: Statistics of Sample Construction for Other Countries within Regions (Table Continued)

Region	Country	Sample Size						Coverage in 2nd-stage (%)			
		Compustat Sample		Interim Sample		Qualified Sample		Sale	Asset	Physical	Intangible
(1)	(2)	(3) Obs	(4) Firm	(5) Obs	(6) Firm	(7) Obs	(8) Firm	(9)	(10)	(11)	(12)
	Austria	1126	93	684	68	589	61	75.58	81.95	85.98	70.28
	Belgium	2025	158	976	104	858	95	96.38	98.25	97.48	96.71
	Bulgaria	693	75	350	52	297	45	96.21	81.90	75.15	94.97
	Switzerland	4023	309	2318	219	1955	194	90.67	92.02	90.53	92.38
	Denmark	2619	256	1273	131	1072	115	69.59	76.49	83.56	62.34
	Spain	1849	185	1160	136	987	126	93.45	89.00	87.79	97.48
	Estonia	264	28	165	18	159	18	99.09	99.44	99.44	91.34
	Finland	2711	227	1323	142	1034	118	88.90	87.94	89.60	88.44
	Greece	4059	295	2696	239	2313	229	97.90	92.60	96.86	92.18
	Croatia	1108	98	649	69	563	66	95.05	92.39	88.64	94.84
	Hungary	257	31	130	16	129	16	100.00	100.00	100.00	100.00
	Ireland	1710	152	853	92	646	77	85.98	85.28	86.20	91.69
	Iceland	112	22	67	13	63	13	100.00	100.00	100.00	100.00
Rest of Europe	Italy	3644	470	1993	278	1584	242	85.88	85.22	90.18	89.19
	Lithuania	419	37	302	33	301	33	100.00	100.00	100.00	100.00
	Luxembourg	679	76	346	47	311	42	91.26	90.01	96.62	96.43
	Latvia	361	34	156	19	152	19	100.00	100.00	100.00	100.00
	Malta	109	24	60	15	52	13	69.08	86.61	98.96	60.54
	Netherlands	2819	258	1377	165	1027	141	78.10	73.67	86.11	81.44
	Norway	3102	395	1279	196	979	159	89.39	83.33	88.50	91.18
	Portugal	591	51	443	44	351	43	98.50	93.93	97.03	96.42
	Romania	2853	267	950	153	762	141	86.01	84.76	83.84	94.32
	Russia	2895	226	1465	179	1252	170	95.98	96.44	98.16	94.99
	Serbia	265	47	124	24	124	24	100.00	100.00	100.00	100.00
	Slovenia	354	32	184	21	142	20	99.68	97.04	95.58	99.86
	Sweden	11480	1141	3600	475	2633	352	86.82	84.90	92.95	89.38
	Ukraine	184	25	120	20	113	19	100.00	100.00	100.00	100.00

Table OT.3: Descriptive Firm Statistics for Other Countries within Regions

The table below reports the descriptive statistics of listed corporations for individual countries in the region of remaining area of each continent. Column (1) reports the name of the geographic area (region). Column (2) reports the country (or territory). Column (3) reports the ratio between firm valuation and total amount of capitals $TK = K^P + K^I$. Columns (4) to (11) report the statistics identical with Table 1 for each country. Table continues in the next page.

Region	Country	Median				Standard Deviation				Correlation
		$\frac{Q}{TK}$	$\frac{I^P}{K^P}$	$\frac{I^I}{K^I}$	$\frac{K^I}{TK}$	$\frac{Q}{TK}$	$\frac{I^P}{K^P}$	$\frac{I^I}{K^I}$	$\frac{K^I}{TK}$	$\rho(\frac{I^P}{K^P}, \frac{I^I}{K^I})$
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Africa	Cote Divoire	1.65	0.20	0.22	0.52	1.54	0.22	0.09	0.16	0.08
	Ghana	0.85	-0.04	0.09	0.49	0.93	0.25	0.04	0.22	0.54
	Kenya	1.05	0.05	0.20	0.33	1.83	0.27	0.07	0.23	0.10
	Morocco	2.46	0.11	0.26	0.37	1.80	0.23	0.08	0.20	0.22
	Mauritius	1.24	0.10	0.24	0.28	1.98	0.27	0.09	0.24	0.05
	Nigeria	1.23	0.04	0.17	0.42	1.31	0.32	0.09	0.21	0.24
	Tunisia	2.19	0.06	0.21	0.36	1.57	0.22	0.09	0.14	0.25
	South Africa	1.39	0.11	0.22	0.49	1.56	0.36	0.12	0.28	0.19
	Zambia	0.64	-0.15	0.12	0.49	0.66	0.19	0.07	0.23	0.02
Latin America	Argentina	0.75	-0.06	0.09	0.56	0.96	0.25	0.04	0.24	0.21
	Brazil	1.18	0.10	0.20	0.41	1.64	0.30	0.09	0.24	0.31
	Cayman Islands	1.42	0.09	0.23	0.26	1.16	0.19	0.07	0.19	0.24
	Chile	1.48	0.13	0.25	0.20	5.15	0.48	0.17	0.17	0.37
	Colombia	1.99	0.19	0.31	0.28	4.94	0.34	0.10	0.21	0.34
	Jamaica	1.37	0.08	0.17	0.57	1.92	0.39	0.09	0.22	0.03
	Mexico	1.22	0.07	0.21	0.35	1.66	0.22	0.08	0.21	0.20
	Peru	0.79	0.11	0.23	0.20	1.59	0.26	0.09	0.15	0.21
Rest of Asia	United Arab Emirates	1.54	0.15	0.26	0.12	1.72	0.34	0.10	0.19	0.24
	Bangladesh	2.39	0.05	0.24	0.16	2.06	0.25	0.09	0.20	0.17
	Bahrain	1.57	0.16	0.24	0.26	1.70	0.39	0.08	0.22	-0.03
	Cyprus	0.64	0.06	0.21	0.25	0.51	0.21	0.09	0.22	0.27
	Israel	1.67	0.23	0.27	0.52	2.20	0.35	0.09	0.25	0.31
	Jordan	1.89	0.03	0.22	0.19	1.63	0.19	0.08	0.16	0.23
	Kuwait	2.26	0.18	0.26	0.24	4.63	0.68	0.13	0.19	0.12
	Sri Lanka	1.01	0.05	0.22	0.25	0.86	0.25	0.09	0.16	0.16
	Oman	1.68	0.11	0.25	0.18	1.16	0.38	0.11	0.16	0.19
	Pakistan	1.38	0.03	0.19	0.17	1.44	0.27	0.08	0.19	0.16
	Philippines	1.42	0.12	0.24	0.25	1.97	0.45	0.15	0.21	0.21
	Palestine	1.54	0.10	0.23	0.29	4.47	0.30	0.06	0.18	0.13
	Qatar	2.46	0.16	0.31	0.10	4.02	0.53	0.12	0.19	0.06
	Saudi Arabia	3.35	0.11	0.26	0.14	2.39	0.22	0.09	0.15	0.15
	Turkey	1.42	0.00	0.13	0.44	1.35	0.34	0.06	0.21	0.18
	Viet Nam	1.79	0.10	0.24	0.35	1.59	0.42	0.10	0.22	0.19

Table OT.3: Descriptive Firm Statistics for Other Countries within Regions (Table Continued)

Region	Country	Median				Standard Deviation				Correlation
		$\frac{Q}{TK}$	$\frac{I^P}{K^P}$	$\frac{I^I}{K^I}$	$\frac{K^I}{TK}$	$\frac{Q}{TK}$	$\frac{I^P}{K^P}$	$\frac{I^I}{K^I}$	$\frac{K^I}{TK}$	$\rho(\frac{I^P}{K^P}, \frac{I^I}{K^I})$
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
	Austria	1.39	0.18	0.25	0.43	1.59	0.23	0.09	0.21	0.30
	Belgium	1.56	0.21	0.26	0.44	2.37	0.25	0.09	0.23	0.23
	Bulgaria	1.15	0.06	0.22	0.36	1.00	0.25	0.12	0.18	0.17
	Switzerland	1.69	0.22	0.26	0.57	2.40	0.28	0.10	0.24	0.20
	Denmark	1.30	0.17	0.24	0.55	2.74	0.28	0.10	0.22	0.24
	Spain	1.68	0.15	0.23	0.43	2.27	0.28	0.09	0.24	0.26
	Estonia	1.56	0.17	0.23	0.48	1.27	0.26	0.08	0.21	0.10
	Finland	1.69	0.22	0.25	0.57	2.20	0.29	0.11	0.24	0.29
	Greece	1.23	0.11	0.24	0.29	0.86	0.24	0.08	0.20	0.18
	Croatia	0.91	0.07	0.20	0.30	0.63	0.17	0.09	0.17	0.24
	Hungary	1.07	0.12	0.18	0.40	0.87	0.22	0.11	0.24	0.20
	Ireland	2.41	0.23	0.26	0.54	2.30	0.29	0.11	0.23	0.32
	Iceland	2.18	0.33	0.23	0.39	1.73	0.31	0.05	0.25	0.21
Rest of Europe	Italy	1.60	0.19	0.24	0.53	2.36	0.32	0.12	0.24	0.26
	Lithuania	1.09	0.13	0.23	0.35	0.93	0.38	0.12	0.22	0.34
	Luxembourg	1.42	0.17	0.27	0.22	3.36	0.48	0.20	0.22	0.55
	Latvia	0.85	0.13	0.19	0.27	0.84	0.32	0.11	0.21	0.30
	Malta	2.04	0.17	0.28	0.20	5.47	0.33	0.09	0.25	0.08
	Netherlands	1.72	0.24	0.25	0.56	2.57	0.29	0.10	0.25	0.22
	Norway	1.60	0.22	0.29	0.31	2.48	0.46	0.18	0.30	0.26
	Portugal	1.24	0.13	0.22	0.46	1.14	0.21	0.16	0.23	0.31
	Romania	0.49	0.01	0.17	0.34	0.44	0.24	0.09	0.17	0.21
	Russia	1.41	0.06	0.22	0.25	1.21	0.26	0.16	0.20	0.16
	Serbia	0.70	0.04	0.18	0.36	0.92	0.15	0.13	0.16	0.09
	Slovenia	0.91	0.09	0.19	0.31	0.50	0.12	0.10	0.21	0.20
	Sweden	2.20	0.26	0.27	0.62	2.55	0.35	0.11	0.22	0.27
	Ukraine	0.75	-0.11	0.08	0.36	1.10	0.37	0.07	0.16	0.19

Table OT.4: Capital Accounting: Share of Intangible in Other Countries within Regions

The table below reports the descriptive statistics of listed corporations for individual countries in the region of remaining area of each continent. Column (1) reports the name of the geographic area (region). Column (2) reports the country (or territory). Column (3) reports the contribution of intangible capital in the firm valuation for each country, denoted as market share μ_I, reported in unite of percentage (%). Columns (4) to (7) report the statistics identical with Table 4 for each country. Table continues in the next page. In the panel of summary, country-level standard deviation is reported, calculated for the estimated share and adjustment cost across all individual countries and territories in Table 4 and Table OT.4.

Region	Country	Share	Adjustment Cost		Counterfactual Share	
		Market μ_I(%)	C^I/Y (% sales)	C^P/Y (% sales)	Book $\overline{\mu}_I$(%)	Homo. Est. $\tilde{\mu}_I$(%)
(1)	(2)	(3)	(4)	(5)	(6)	(7)
Africa	Cote Divoire	65.87	8.27	2.39	44.02	63.64
	Ghana	52.50	2.04	1.37	38.46	50.15
	Kenya	48.75	6.56	0.81	25.39	46.07
	Morocco	54.52	6.76	1.32	30.30	51.70
	Mauritius	49.34	8.79	1.57	25.44	46.55
	Nigeria	64.82	3.58	3.34	37.37	62.11
	Tunisia	54.10	4.19	0.73	32.10	51.54
	South Africa	66.99	4.59	1.31	46.68	64.54
	Zambia	71.95	6.54	4.49	38.26	69.11
Latin America	Argentina	75.69	1.05	4.23	65.90	75.01
	Brazil	62.54	3.63	2.09	41.39	61.75
	Cayman Islands	39.31	4.81	1.13	21.77	39.84
	Chile	30.50	2.76	0.89	14.56	29.20
	Colombia	43.71	5.24	2.92	26.67	43.78
	Jamaica	64.17	7.33	1.47	47.36	65.47
	Mexico	48.37	5.02	1.28	27.18	48.15
	Peru	29.00	4.15	0.90	14.94	29.01
Rest of Asia	United Arab Emirates	26.01	4.72	4.69	10.17	25.17
	Bangladesh	24.50	3.43	1.43	9.55	23.75
	Bahrain	29.67	5.08	8.38	23.48	33.57
	Cyprus	43.61	5.91	3.31	27.90	44.62
	Israel	54.42	6.64	7.18	42.02	58.28
	Jordan	31.82	4.43	0.99	16.95	32.67
	Kuwait	37.52	5.13	5.73	22.33	41.15
	Sri Lanka	42.92	5.79	1.48	20.31	40.58
	Oman	36.56	6.75	4.99	17.85	37.92
	Pakistan	34.72	1.61	2.12	12.12	27.26
	Philippines	27.64	5.91	5.30	15.93	29.54
	Palestine	39.26	6.02	2.63	25.86	41.81
	Qatar	22.37	5.91	14.84	9.14	21.45
	Saudi Arabia	27.51	5.21	2.10	12.92	28.32
	Turkey	73.16	1.56	3.11	37.69	63.60
	Viet Nam	48.44	3.71	1.43	30.01	51.01

Table OT.4: Capital Accounting: Share of Intangible in Other Countries within Regions (Table Continued)

Region	Country	Share	Adjustment Cost		Counterfactual Share	
		Market $\mu_I(\%)$	C^I/Y (% sales)	C^P/Y (% sales)	Book $\overline{\mu}_I(\%)$	Homo. Est. $\tilde{\mu}_I(\%)$
(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Austria	56.03	7.16	2.75	39.37	56.64
	Belgium	54.19	6.03	2.67	36.82	55.06
	Bulgaria	59.79	6.59	0.98	37.49	59.84
	Switzerland	66.60	9.57	2.77	52.34	67.45
	Denmark	65.98	9.02	3.52	52.17	66.62
	Spain	53.32	7.05	3.20	36.82	54.18
	Estonia	57.99	4.02	1.35	44.95	58.90
	Finland	68.90	5.87	2.96	57.50	70.10
	Greece	45.32	5.40	1.21	26.58	45.13
	Croatia	46.25	4.07	1.38	28.95	46.84
	Hungary	47.98	5.52	3.44	33.13	49.00
	Ireland	66.08	9.40	4.54	54.43	67.51
	Iceland	46.22	6.65	7.99	33.70	47.64
Rest of Europe	Italy	59.68	8.07	3.84	44.19	60.55
	Lithuania	44.30	4.70	2.03	31.79	44.91
	Luxembourg	38.18	5.76	2.93	21.16	38.33
	Latvia	44.60	5.32	2.70	30.45	45.90
	Malta	31.31	11.00	6.20	15.50	31.48
	Netherlands	63.59	7.04	3.83	49.27	63.96
	Norway	45.73	6.45	6.91	31.74	47.07
	Portugal	56.94	5.80	2.91	40.69	58.24
	Romania	56.68	7.66	1.15	31.60	56.08
	Russia	42.53	2.53	1.97	26.20	42.00
	Serbia	50.14	4.96	1.01	31.48	50.47
	Slovenia	38.72	1.47	2.05	25.77	38.23
	Sweden	69.89	9.20	4.41	60.38	70.98
	Ukraine	50.97	1.23	4.00	36.12	48.31
Summary						
Large countries (or Territories, from Table 4), Other countries in Rest of Regions						
	S.D.	(12.97)	(2.66)	(2.32)	(13.00)	(13.06)

OT.2 Estimation of Counterfactual Models

Table OT.5: Counter-Factual Accounting: Single Capital

Table OT.5 reports the counter-factual outcome where we assume the intangible capital plays no role in the production function nor the adjustment cost function. The point estimate of adjustment cost coefficient in the physical capital, the statistics of model fit, the model-implied adjustment cost are reported. The standard error of parameter is reported in the parenthesis in the row below. Definitions of statistics are identical to Table 2 and 4.

Country/Region	Point Estimate	Model Fit			Cost	Country/Region	Point Estimate	Model Fit			Cost
	θ_P	XS-R^2	TS-R^2	$m.a.e./\overline{VR}$	c_P		θ_P	XS-R^2	TS-R^2	$m.a.e./\overline{VR}$	c_P
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
China	17.91	-1.21	-1.09	0.50	6.48	France	15.29	-0.87	-1.23	0.46	11.65
	(1.53)						(1.90)				
Hong Kong	8.11	-0.88	-0.80	0.40	4.65	Germany	14.71	-0.42	-0.79	0.41	10.82
	(0.48)						(1.56)				
Indonesia	12.22	-0.74	-0.56	0.39	2.93	Poland	6.12	-0.95	-0.10	0.42	1.95
	(0.90)						(0.91)				
India	11.90	-1.71	-1.16	0.54	2.26	UK	15.13	-0.67	-0.81	0.44	10.91
	(1.26)						(1.16)				
Japan	6.66	-2.41	-1.99	0.36	2.74	Rest of Europe	13.93	-0.23	-0.50	0.44	8.03
	(0.66)						(1.05)				
Malaysia	11.27	0.02	-0.87	0.32	3.63						
	(0.76)										
Singapore	6.72	-0.58	-0.88	0.37	3.35	Canada	7.69	-0.87	-0.95	0.45	7.63
	(0.58)						(0.53)				
South Korea	4.27	-3.22	-1.74	0.30	1.21	USA	23.65	-0.91	-0.90	0.45	20.10
	(0.65)						(1.96)				
Thailand	10.19	-1.21	-0.71	0.36	4.94	Latin America	10.50	0.08	-0.08	0.39	3.34
	(0.70)						(0.90)				
Taiwan	11.91	-1.69	-1.65	0.37	4.99						
	(0.90)					Australia	7.71	-0.81	-0.72	0.46	13.28
Rest of Asia	14.50	-0.21	-0.43	0.30	5.59		(0.54)				
	(1.08)										
						Africa	12.98	-4.11	-1.45	0.46	4.60
							(1.50)				

Table OT.6: Counter-Factual Model of Homogeneous Cost Function

Table OT.5 reports the counter-factual outcome for the model of homogeneous adjustment cost function and two capital inputs. We assume the identical adjustment cost function everywhere, $\theta_c \equiv \theta_g$. Panel (A) reports the point estimates of parameters. In Panel (B), the statistics of model fit, the model-implied adjustment cost are reported for the sub-sample of each country or each region. Definitions of statistics are identical to Table 2 and 4.

Panel (A) Point Estimate		
	$\theta_{P,g}$ (1)	$\theta_{I,g}$ (2)
	3.76	10.73
s.e.	(0.21)	(0.35)

Panel (B) Model Fit and Estimated Costs in Sub-sample of Countries and Regions

Country/Region	Counterfactual Model Fit			Cost		Country/Region	Counterfactual Model Fit			Cost	
	XS-R^2	TS-R^2	$m.a.e./\overline{VR}$	c_I	c_P		XS-R^2	TS-R^2	$m.a.e./\overline{VR}$	c_I	c_P
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
China	-2.18	-0.98	0.49	6.00	1.36	France	0.45	0.16	0.28	10.18	2.87
Hong Kong	-0.28	-0.13	0.30	6.75	2.16	Germany	0.73	0.23	0.28	7.56	2.77
Indonesia	0.28	0.24	0.26	3.76	0.90	Poland	-3.47	-0.28	0.49	6.12	1.20
India	-0.34	-0.08	0.33	2.09	0.71	UK	0.81	0.53	0.22	7.87	2.71
Japan	-18.00	-8.05	0.70	6.19	1.55	Rest of Europe	0.77	0.52	0.25	6.37	2.17
Malaysia	0.89	0.38	0.18	4.18	1.21						
Singapore	-3.46	-1.01	0.38	5.31	1.87	Canada	0.84	0.49	0.22	4.43	3.74
South Korea	-6.72	-3.09	0.41	4.99	1.06	USA	-0.32	-0.12	0.33	7.98	3.20
Thailand	0.81	0.30	0.23	5.65	1.82	Latin America	0.75	0.58	0.20	4.00	1.20
Taiwan	0.46	0.11	0.22	4.14	1.58						
Rest of Asia	0.28	0.24	0.21	3.38	1.45	Australia	0.83	0.42	0.25	9.31	6.48
						Africa	0.05	0.26	0.22	3.90	1.33

Table OT.7: Counter-Factual Accounting: Varying Cost for Intangible Capital

Table OT.7 reports the counter-factual outcome where we assume country-specific adjustment cost in intangible capital and homogeneous adjustment cost in physical capital $\theta_{P,c} \equiv \theta_{P,g}$ for all the countries. The point estimate of adjustment cost coefficient in the intangible capital, the statistics of model fit, the model-implied adjustment cost are reported. The standard error of parameter is reported in the parenthesis in the row below. Definitions of statistics are identical to Table 2 and 4.

Country/Region	Point Estimate	Model Fit			Cost	Country/Region	Point Estimate	Model Fit			Cost
	θ_I	XS-R^2	TS-R^2	$m.a.e./\overline{VR}$	c_I		θ_I	XS-R^2	TS-R^2	$m.a.e./\overline{VR}$	c_I
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
China	32.08	0.14	0.10	0.32	17.93	France	9.00	-0.06	-0.09	0.31	8.53
	(2.43)						(0.78)				
Hong Kong	5.88	-1.54	-0.52	0.37	3.70	Germany	10.67	0.25	0.04	0.30	7.52
	(0.68)						(1.19)				
Indonesia	15.79	-0.01	0.11	0.29	5.54	Poland	4.15	-1.29	-0.10	0.35	2.37
	(1.33)						(1.15)				
India	20.82	0.33	0.12	0.31	4.05	UK	10.13	0.21	0.14	0.29	7.43
	(1.80)						(0.66)				
Japan	1.18	-0.53	-0.20	0.20	0.68	Rest of Europe	11.85	0.49	0.31	0.29	7.04
	(0.44)						(0.86)				
Malaysia	10.81	0.11	0.04	0.22	4.21						
	(0.83)										
Singapore	4.90	-1.80	-0.41	0.32	2.42	Canada	11.64	0.20	0.12	0.28	4.81
	(0.71)						(0.79)				
South Korea	1.61	-2.60	-1.13	0.28	0.75	USA	19.29	0.40	0.32	0.26	14.34
	(0.59)						(0.91)				
Thailand	10.63	-1.36	-0.28	0.30	5.60	Latin America	12.00	0.36	0.29	0.26	4.48
	(1.05)						(1.23)				
Taiwan	15.85	-0.10	-0.08	0.24	6.11						
	(1.07)					Australia	9.89	-0.79	-0.15	0.34	8.58
Rest of Asia	15.20	-0.24	-0.05	0.24	4.79		(0.89)				
	(1.12)										
						Africa	13.04	-0.85	0.07	0.26	4.74
							(0.83)				

OT.3 Country Characteristics

Table OT.8: Descriptive Statistics of Economic Status in Countries

This table reports the descriptive statistics for country-level characteristic variables. Panel (a) reports assessment of respect for intellectual property rights relating to trade secrets and industrial patents from Institutional Profiles Database of 2016 version. Countries of strong respect has value 4. Countries of no respect has value 0. Panel (b), the cost of contract enforcement, reports the number of procedures for completing the filing, resolution of dispute, and the enforcement of court decision. These are statistics in the year 2016, from World Bank Doing Business database. Panel (c) reports the status of economic and financial development. The GDP per capita and the population use the log value. Statistics are outcomes of the year 2016, provided from the UN database. Bank profit is the ratio between the operating income and the total operating cost, calculated using World Financial Development database. The statistics are reported as the time-series average outcome during 2011-2020. Statistics of mean, median, cross-section standard deviation, minimal value, maximal value, are reported for countries with assessment from Institutional Profiles Database. In Columns (7) to (10), correlation statistics are reported between the country/region characteristic variables and the cost coefficients in the Benchmark model of country-specific adjustment cost function. Correlation to adjustment cost coefficient of physical capital, cost coefficient of intangible capital, are calculated across 17 countries and 4 regions. Cost coefficients are from the baseline estimation. For region with multiple countries, region-level characteristic uses the simple-average outcomes across countries within.

Variables of Market Feature	Descriptive Stats					Correlation	
	mean	median	s.e.	min	max	θ_P	θ_I
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
(a) **Intellectual Property Rights**							
Secrets and Patents	2.88	3.00	1.01	0.00	4.00	-0.10	-0.71 **
						(0.23)	(0.20)
(b) **Contract Enforcement**							
Procedures	35.55	35.00	6.54	21.00	51.00	0.28 *	0.50 ***
						(0.15)	(0.08)
(c) **Economic and Financial Development**							
GDP per capita	9.56	9.68	1.18	7.18	11.60	-0.07	-0.44 **
						(0.19)	(0.13)
Population	16.72	16.86	1.77	12.71	21.07	0.19	0.63 **
						(0.19)	(0.23)
Bank Profit	1.93	1.83	0.43	1.16	3.68	-0.16	0.57 *
						(0.18)	(0.29)

Table OT.9: Correlation Statistics of Economic Status in Countries and Firm Outcomes

This table reports the correlation statistics for country-level characteristic variables in Table OT.8 and firm outcome characteristics in Table 1. Correlation are calculated across 17 countries and 4 regions. Cost coefficients are from the baseline estimation. For region with multiple countries, region-level characteristic uses the simple-average outcomes across countries within.

Variables of Market Feature	Valuation	Physical Invest	Intangible Invest	Intensity
X	$\rho(X, \frac{Q}{K^I+K^P})$	$\rho(X, \frac{I^P}{K^P})$	$\rho(X, \frac{I^I}{K^I})$	$\rho(X, \frac{K^I}{K^I+K^P})$
(1)	(2)	(3)	(4)	(5)
(a) **Intellectual Property Rights**				
Secrets and Patents	-0.44 *	0.55 **	0.08	0.63 **
	(0.25)	(0.16)	(0.33)	(0.17)
(b) **Contract Enforcement**				
Procedures	0.27 **	-0.52 **	-0.33 *	-0.59 **
	(0.09)	(0.14)	(0.17)	(0.14)
(c) **Economic and Financial Development**				
GDP per capita	-0.11	0.78 ***	0.41 *	0.59 **
	(0.15)	(0.10)	(0.21)	(0.17)
Population	0.44 *	-0.05	0.02	0.03
	(0.24)	(0.21)	(0.31)	(0.25)
Bank Profit	0.51 *	-0.31 *	0.45 *	-0.84 **
	(0.28)	(0.18)	(0.24)	(0.19)

Table OT.10: Descriptive Statistics of Economic Status in Countries

This table reports the classification of countries along the ranking of intensity of using intangible capital for production. The statistic of intensity of using intangible capital is calculated as the time-series average outcome during 2016-2020. Countries are grouped into 4 quartiles, from lowest to the highest. In Panel (A), Column (2) reports the large countries of each quartile. Column (3) reports other countries in the rest of regions. Cayman Islands, Palestine, Zambia. Romania are in parenthesis, not included for estimating the country-characteristic model, due to the incomplete profile of characteristic variables. Panel (B) in this table reports the summary statistics for country-level characteristic variables in Table OT.8. Statistics reported in Column (2) to (3) are calculated using the subset of countries with the lowest quartile of intensity of intangible capital usage. The names of countries are reported in Panel (A). Column (4) to (9) report the statistics for the subset of countries in the 2nd quartile, 3rd quartile and 4th quartile respectively.

Panel (A) Countries Grouped by Intensity of using Intangible Capital		
Intensity (1)	Large Countries (2)	Other Countries (3)
Bottom25%	Canada , Indonesia	UAE , Bangladesh , Bahrain , Chile , Colombia , Jordan , Kuwait , Sri Lanka , Luxembourg , Malta , Oman , Pakistan , Peru , Philippines , Qatar , Saudi Arabia
[25%, 50%)	China , India , South Korea , Malaysia , Thailand , Taiwan	Cyprus , Greece , Croatia , Hungary , Kenya , Lithuania , Latvia , Mexico , Mauritius , Russia , Serbia , Slovenia , Viet Nam
[50%, 75%)	Australia , Hong Kong , Japan , Poland , Singapore	Austria , Belgium , Bulgaria , Spain , Ghana , Hungary , Iceland , Israel , Morocco , Nigeria , Norway , Tunisia , Turkey , Ukraine
Top25%	Germany , France , UK , USA	Argentina , Brazil , Switzerland , Cote Divoire , Denmark , Estonia , Finland , Ireland , Italy , Jamaica , Netherlands, Portugal , Sweden , South Africa

Panel (B) Characteristics of Countries in 4 Groups								
Variables of Market Feature	Bottom25%		[25%, 50%)		[50%, 75%)		Top25%	
	mean	median	mean	median	mean	median	mean	median
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
(a) **Intellectual Property Rights**								
Secrets and Patents	2.67	3.00	2.53	3.00	2.94	3.00	3.39	3.50
(b) **Contract Enforcement**								
Procedures	40.94	40.50	36.32	36.00	32.56	33.50	32.33	32.00
(c) **Economic and Financial Development**								
GDP per capita	9.35	9.60	9.15	9.24	9.67	10.32	10.10	10.58
Population	16.50	16.79	16.87	16.97	16.66	16.62	16.87	16.82
Bank Profit	2.24	2.06	1.92	1.82	1.91	1.88	1.65	1.62

Table OT.11: Composition of Country-Specific Value for Other Countries within Regions

This table reports the composition of characteristic-specific valuation of capitals, for countries and sub-regions within each region. Columns (2a) to (2c), (3a) to (3c) report the statistics identical with Table 8 for each country. In the panel of summary, standard deviation is calculated for the estimated valuation across large countries and territories in Table 8, medium-size countries and other areas .

Country/Area	Intangible Capital			Physical Capital		
	Characteristic-Specific Value (%)			Characteristic-Specific Value (%)		
	IPR	Contract	Devp.	IPR	Contract	Devp.
(1)	(2a)	(2b)	(2c)	(3a)	(3b)	(3c)
[Within Rest. Asia]						
Israrel	-0.60	1.93	-6.89	0.10	1.00	-2.19
Pakistan	7.12	10.78	-11.11	-1.19	5.73	-3.01
Turkey	5.18	-0.88	11.09	-0.22	-0.12	0.21
Viet Nam	14.88	0.97	-9.76	-2.27	0.47	-2.80
Rest of Southern Asia	-0.21	4.24	-15.11	0.04	2.49	-4.66
Rest of Western Asia	-1.22	6.15	14.75	0.48	5.95	4.94
[Within Rest. Europe]						
Greece	-0.63	3.39	-4.49	0.12	2.14	-0.57
Italy	-1.12	-1.35	-9.58	0.17	-0.67	-0.99
Sweden	-1.08	-6.08	-4.83	0.17	-3.13	-1.72
Switzerland	-8.18	-9.00	10.52	0.80	-2.80	1.29
Rest of Eastern Europe	-11.61	-9.97	-19.35	0.81	-2.21	-1.31
Rest of Southern Europe	-0.44	-0.55	-6.01	0.12	-0.49	-3.36
Rest of Northern Europe	-0.78	6.00	-4.31	0.11	2.89	-1.22
Rest of Western Europe	-8.02	-14.17	10.29	0.92	-4.04	2.66
	-9.44	-21.81	1.54	1.05	-7.75	0.61
[Within Rest. Amer.]						
Brazil						
Rest of Latin Amer.	-0.64	11.88	-9.59	0.04	2.51	-1.37
	9.33	2.03	-3.79	-0.74	0.63	-0.84
[Within Africa]						
South Africa	-0.93	-13.88	-16.33	0.15	-3.05	-1.13
Rest of Africa	8.22	5.72	-12.48	-2.68	1.65	0.82
Summary						
Large Countries (Territories), Medium-size Countries , Sub-regions of Remaining Area						
Mean	-1.43	-3.49	-0.19	0.14	-1.24	-0.48
S.D.	6.76	9.79	11.52	0.84	5.07	2.53

OT.4 Robustness of Model Estimation

Table OT.12: Summary of Alternative Estimations

Table / Figure	Difference from Baseline Estimation
(1)	(2)
Country-Specific Model of Section 5	
Evaluation of Model Fitness	
Table OT.13, Panel (A)	The fitness is calculated using all the years. Table 2 reports the 2006-2020 outcome.
Table OT.13, Panel (B)	The estimation uses 20 portfolios sorted based on proxies of the lagged firm-level variables: investment rate in physical capital and investment rate of intangible capital. Table 2 reports the fitness of portfolios used for estimation.
Estimation Method	
Figure OF.1 and OF.2	The parameters are estimated using firm-level outcome in Section 7.2 Baseline estimation uses portfolio-level outcome.
Measure and Data Construction	
Table OT.14	Baseline estimation assumes the same adjustment cost function for firms residing in the same country. Firms with different incorporation location from its headquarter location are excluded from the sample.
Table OT.15	This table adjusts the sector-specific formation rate of intangible capital, formation rate is from (Gulen et al., 2022). Baseline estimation assumes the same formation rate of intangible capital across countries.
Table OT.16	This table adjusts the flow of total investment in intangible capital, based on conjectures for whether firms report R&D expense outside of SGA.
Sector Heterogeneity	
Figure OF.5	The country-sector specific cost parameters are reported for the Country-Sector Specific Model in Section 7.3.
Table OT.17	This table summarizes the average of country-sector specific cost parameter within a country, and reports the fitness of model.
Country-Characteristic Model of Section 6	
Summary of Alternative Estimation	
Table OT.18	This table reports firm-level method, alternative sample, alternative measure of intangible capital alternative direct estimation of intangible capital
High dimensional Model	
Table OT.19	This table summarizes the hypotheses for how adjustment cost of capitals depend on labor market and infrastructure, investor rights protection etc.
Table OT.20	This table reports descriptive statistics of country characteristics. Table OT.8 reports the subset of baseline model.
Table OT.21	This table reports parameter estimates of high-dimensional model. Table 6 reports the simple baseline model.

Table OT.13: Model Fit in Full Sample

This table reports the measures of fit for the base line model specification. In Panel (A), the beginning year for each country is reported in Column (1). In columns (2) to (4), within in each country, we calculate model fit for the entire sample used for estimation. In columns (5) to (7) of Panel (B), within in each country, the fitness of model is calculated for the 20 portfolios sorted based on proxies of the lagged firm-level variables, {investment rate in physical capital, investment rate in intangible capital} (10 portfolios for each input).

	(A) Fitness in Full Sample				(B) Firm-Characteristic Portfolios		
	Start	XS-R^2	TS-R^2	$m.a.e./VR$	XS-R^2	TS-R^2	$m.a.e./VR$
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
China	2001	0.64	0.26	0.31	0.34	0.05	0.30
Hong Kong	2002	0.76	0.25	0.25	0.52	0.18	0.25
Indonesia	2000	0.93	0.54	0.25	0.60	0.29	0.23
India	2002	0.89	0.38	0.28	0.65	0.08	0.27
Japan	2000	0.32	0.13	0.18	0.30	0.11	0.17
Malaysia	2002	0.86	0.37	0.17	0.75	0.15	0.18
Singapore	2003	0.68	0.27	0.22	0.66	0.22	0.22
South Korea	2000	0.74	0.37	0.20	0.43	0.21	0.14
Thailand	2000	0.84	0.38	0.24	0.63	0.18	0.23
Taiwan	2001	0.92	0.37	0.19	0.74	0.09	0.17
Rest of Asia	2000	0.74	0.31	0.21	0.70	0.36	0.16
France	2007	0.67	0.27	0.26	0.72	0.14	0.24
Germany	2006	0.74	0.23	0.28	0.75	0.18	0.25
Poland	2006	0.82	0.35	0.31	0.74	0.30	0.31
UK	2000	0.87	0.53	0.23	0.82	0.40	0.20
Rest of Europe	2000	0.80	0.50	0.25	0.86	0.48	0.20
Canada	2000	0.87	0.51	0.20	0.79	0.31	0.21
USA	2000	0.87	0.60	0.18	0.84	0.52	0.17
Latin America	2000	0.80	0.59	0.25	0.72	0.47	0.22
Australia	2004	0.78	0.39	0.24	0.62	0.37	0.22
Africa	2006	0.25	0.32	0.21	0.12	0.38	0.20
Asia		0.92	0.59	0.24	0.89	0.56	0.22
Europe		0.80	0.43	0.26	0.83	0.35	0.24
Americas		0.91	0.67	0.20	0.89	0.61	0.19
Australia		0.78	0.39	0.24	0.62	0.37	0.22
Africa		0.25	0.32	0.21	0.12	0.38	0.20
World		0.89	0.57	0.24	0.88	0.53	0.22

Table OT.14: Parameter Estimates and Model Fit (Domestic Firms)

This table reports the parameter estimates and measures of fit for the sub-sample of domestic firms. For firms with different incorporation location from its headquarter location, they are excluded from the sample. θ_P and θ_I are, respectively, the physical capital and intangible capital adjustment cost parameters. s.e. stands for Newey-West standard errors with three lags. $XS-R^2$ is the cross-sectional R^2, $TS-R^2$ is the time-series R^2, and $m.a.e./\overline{VR}$ is the mean absolute valuation error scaled by the absolute value of the ratio. We calculate model fit for the 2006-2020 sample for which most of the countries have data. Portfolios in Hong Kong is unavailable because there isn't sufficient size of sample for firms with identical incorporation location and headquarter location. Other specifications of estimation are identical to Table 2.

Country/Region		Point Estimate		Model Fit			Country/Region		Point Estimate		Model Fit		
		θ_P	θ_I	XS-R^2	TS-R^2	$m.a.e./\overline{VR}$			θ_P	θ_I	XS-R^2	TS-R^2	$m.a.e./\overline{VR}$
(1)		(2)	(3)	(4)	(5)	(6)	(7)		(8)	(9)	(10)	(11)	(12)
China		2.77	37.84	0.61	0.29	0.30	France		5.98	7.69	0.67	0.27	0.26
	s.e.	(1.10)	(3.02)					s.e.	(0.94)	(0.89)			
Hong Kong		-	-	-	-	-	Germany		4.27	10.10	0.74	0.24	0.27
	s.e.							s.e.	(1.10)	(1.38)			
Indonesia		4.51	14.82	0.86	0.50	0.22	Poland		3.01	4.88	0.81	0.34	0.31
	s.e.	(0.61)	(1.62)					s.e.	(0.93)	(0.98)			
India		4.38	19.82	0.81	0.32	0.28	UK		5.61	8.98	0.82	0.51	0.22
	s.e.	(0.78)	(2.03)					s.e.	(0.63)	(0.84)			
Japan		0.79	2.91	0.26	0.12	0.19	Rest of Europe		4.40	11.18	0.81	0.53	0.25
	s.e.	(0.36)	(0.39)					s.e.	(0.62)	(1.03)			
Malaysia		2.80	11.82	0.84	0.39	0.17							
	s.e.	(0.50)	(1.10)				Canada		3.71	11.40	0.83	0.47	0.22
Singapore		2.12	6.51	0.52	0.22	0.23		s.e.	(0.28)	(0.71)			
	s.e.	(0.51)	(0.72)				USA		8.09	16.37	0.84	0.61	0.18
South Korea		0.23	5.72	0.68	0.36	0.14		s.e.	(0.85)	(1.07)			
	s.e.	(0.53)	(0.69)				Latin America		4.14	11.34	0.80	0.61	0.20
Thailand		3.83	10.37	0.79	0.29	0.23		s.e.	(0.64)	(1.33)			
	s.e.	(0.61)	(1.31)										
Taiwan		3.95	15.67	0.80	0.24	0.18	Australia		3.26	10.42	0.75	0.42	0.25
	s.e.	(0.51)	(1.29)					s.e.	(0.47)	(0.98)			
Rest of Asia		6.08	12.31	0.76	0.45	0.17							
	s.e.	(1.21)	(1.67)										
							Africa		4.05	12.77	0.37	0.37	0.21
								s.e.	(0.83)	(1.11)			
Summary of Estimation													
							World	Mean	3.78	11.97	0.87	0.56	0.23
								S.D.	(1.78)	(6.98)			

Table OT.15: Parameter Estimates and Model Fit (Measure of Intangible)

This table reports the parameter estimates and measures of fit for the baseline model specification. The estimation procedure adjusts the sector-specific conversion rate of intangible capital for the firms in Consumption, Manufacturing, Hi-tech and Health sector, using parameters in (Gulen et al., 2022). θ_P and θ_I are, respectively, the physical capital and intangible capital adjustment cost parameters. s.e. stands for Newey-West standard errors with three lags. $XS-R^2$ is the cross-sectional R^2, $TS-R^2$ is the time-series R^2, and $m.a.e./\overline{VR}$ is the mean absolute valuation error scaled by the absolute value of the ratio. We calculate model fit for the 2006-2020 sample for which most of the countries have data.

Country/Region		Point Estimate		Model Fit		
		θ_P	θ_I	XS-R^2	TS-R^2	$m.a.e./\overline{VR}$
(1)		(2)	(3)	(4)	(5)	(6)
China		4.08	26.54	0.57	0.18	0.30
	s.e.	(1.07)	(2.33)			
Hong Kong		2.65	6.10	0.65	0.23	0.24
	s.e.	(0.39)	(0.72)			
Indonesia		4.75	13.70	0.83	0.48	0.21
	s.e.	(0.60)	(1.55)			
India		4.18	17.41	0.80	0.31	0.27
	s.e.	(0.70)	(1.90)			
Japan		0.54	2.56	0.23	0.11	0.18
	s.e.	(0.33)	(0.37)			
Malaysia		2.27	11.63	0.84	0.40	0.17
	s.e.	(0.47)	(1.02)			
Singapore		1.95	6.34	0.57	0.23	0.23
	s.e.	(0.53)	(0.67)			
South Korea		0.19	4.64	0.60	0.27	0.14
	s.e.	(0.49)	(0.57)			
Thailand		3.54	10.30	0.81	0.30	0.22
	s.e.	(0.65)	(1.33)			
Taiwan		3.63	11.70	0.78	0.17	0.18
	s.e.	(0.48)	(0.93)			
Rest of Asia		6.83	9.28	0.66	0.37	0.18
	s.e.	(1.22)	(1.56)			
Summary of Estimation						

Country/Region		Point Estimate		Model Fit		
		θ_P	θ_I	XS-R^2	TS-R^2	$m.a.e./\overline{VR}$
(7)		(8)	(9)	(10)	(11)	(12)
France		5.26	6.24	0.65	0.25	0.23
	s.e.	(0.90)	(0.69)			
Germany		3.88	8.18	0.76	0.24	0.25
	s.e.	(0.96)	(1.14)			
Poland		3.25	3.97	0.84	0.36	0.31
	s.e.	(0.96)	(0.86)			
UK		5.43	7.46	0.83	0.53	0.20
	s.e.	(0.53)	(0.68)			
Rest of Europe		4.02	9.51	0.83	0.53	0.23
	s.e.	(0.53)	(0.85)			
Canada		3.89	9.44	0.82	0.44	0.23
	s.e.	(0.27)	(0.67)			
USA		7.66	12.67	0.81	0.57	0.17
	s.e.	(0.84)	(0.80)			
Latin America		4.51	10.03	0.83	0.62	0.20
	s.e.	(0.74)	(1.19)			
Australia		3.24	9.25	0.76	0.43	0.24
	s.e.	(0.46)	(0.85)			
Africa		4.66	11.47	0.25	0.34	0.21
	s.e.	(0.89)	(0.79)			
World	Mean	3.83	9.93	0.87	0.56	0.22
	S.D.	(1.73)	(5.03)			

Table OT.16: Parameter Estimates and Model Fit (Treatment of R&D Expense)

This table reports the parameter estimates and measures of fit for the baseline model specification. The estimation procedure uses alternative measure of investment flow in intangible capital. For countries that include XRD in XSGA, we assume Knowledge capital and SGA-capital are homogeneous, assume 0.3 * (XSGA − XRD) + XRD as the flow of total investment in intangible capital. For countries where firms have high propensity to report XRD separately (Brazil, Germany, Malaysia, Singapore, Taiwan, and South Africa), we consider the flow of total investment as 0.3 * XSGA + XRD. Other specifications of estimation are identical to Table 2.

Country/Region		Point Estimate		Model Fit		
		θ_P	θ_I	XS-R^2	TS-R^2	$m.a.e./\overline{VR}$
(1)		(2)	(3)	(4)	(5)	(6)
China		3.95	25.51	0.72	0.33	0.26
	s.e.	(1.13)	(2.03)			
Hong Kong		2.54	6.30	0.61	0.23	0.25
	s.e.	(0.40)	(0.70)			
Indonesia		4.45	14.66	0.85	0.49	0.22
	s.e.	(0.61)	(1.61)			
India		4.17	19.14	0.83	0.35	0.28
	s.e.	(0.75)	(1.91)			
Japan		0.10	2.23	0.11	0.08	0.19
	s.e.	(0.35)	(0.36)			
Malaysia		2.54	11.38	0.83	0.35	0.18
	s.e.	(0.48)	(1.03)			
Singapore		1.89	6.42	0.58	0.24	0.23
	s.e.	(0.54)	(0.70)			
South Korea		0.04	4.84	0.76	0.33	0.14
	s.e.	(0.49)	(0.53)			
Thailand		3.94	10.10	0.81	0.29	0.22
	s.e.	(0.61)	(1.27)			
Taiwan		3.30	7.44	0.42	-0.07	0.19
	s.e.	(0.47)	(0.72)			
Rest of Asia		7.32	8.19	0.69	0.36	0.19
	s.e.	(1.34)	(1.69)			

Country/Region		Point Estimate		Model Fit		
		θ_P	θ_I	XS-R^2	TS-R^2	$m.a.e./\overline{VR}$
(7)		(8)	(9)	(10)	(11)	(12)
France		4.95	6.45	0.69	0.28	0.23
	s.e.	(0.76)	(0.70)			
Germany		3.65	6.02	0.80	0.24	0.23
	s.e.	(0.74)	(0.69)			
Poland		3.08	4.62	0.82	0.34	0.31
	s.e.	(0.94)	(0.97)			
UK		5.22	7.48	0.83	0.53	0.21
	s.e.	(0.55)	(0.68)			
Rest of Europe		4.10	8.79	0.83	0.53	0.22
	s.e.	(0.51)	(0.77)			
Canada		3.83	8.99	0.81	0.44	0.22
	s.e.	(0.26)	(0.66)			
USA		7.45	11.94	0.81	0.57	0.17
	s.e.	(0.82)	(0.74)			
Latin America		4.60	10.21	0.82	0.64	0.20
	s.e.	(0.68)	(1.21)			
Australia		3.06	9.43	0.70	0.40	0.25
	s.e.	(0.42)	(0.79)			
Africa		6.91	7.31	0.25	0.24	0.23
	s.e.	(1.75)	(2.54)			
Summary of Estimation						
World	Mean	3.86	9.40	0.88	0.57	0.22
	S.D.	(1.90)	(5.08)			

Table OT.17: Estimation Outcome of Country-Sector Model

This table reports the within-country average of parameter estimates for the model of country-sector-specific adjustment cost function. The 89 sets of country-sectors are classified using Fama-French 10 industries in each country (or territory, region). For firms in a country-sector that have less than 60 firms per year 2011-2020, they are classified as the other sector in that country. The model is estimated using the 89 sets of country-sector portfolios, which contains 9 portfolios in each sector of each country (or territory, region). Portfolios are two-way sorted by lagged explanatory variables in the firm valuation equation. Column (2) and Column (3) report the cross-sector average point estimates within each country or territory. Columns (4) to (6) report the fitness statistics using same definition and identical portfolios with Table 2 in each country (or territory, region). The parameter estimates for all country-sectors are reported in Figure OF.5.

Country/Area	Average Point Estimate		Model Fitness		
	$\overline{\theta}_{P,c}$	$\overline{\theta}_{I,c}$	XS-R^2	TS-R^2	$m.a.e./\overline{VR}$
(1)	(2)	(3)	(4)	(5)	(6)
China	3.28	30.71	0.60	0.24	0.31
Hong Kong	1.52	8.55	0.61	0.29	0.24
Indonesia	3.12	17.26	0.79	0.46	0.22
India	4.43	20.16	0.82	0.32	0.29
Japan	0.49	3.40	0.36	0.20	0.20
Malaysia	2.18	12.50	0.84	0.41	0.17
Singapore	1.76	6.62	0.66	0.26	0.23
South Korea	0.39	5.11	0.71	0.37	0.14
Thailand	2.72	11.75	0.76	0.30	0.22
Taiwan	2.86	15.73	0.79	0.28	0.20
Rest of Asia	2.92	17.47	0.64	0.37	0.19
France	4.48	7.61	0.66	0.26	0.26
Germany	4.14	9.60	0.75	0.26	0.27
Poland	2.33	6.18	0.79	0.34	0.31
UK	4.57	8.42	0.85	0.54	0.21
Rest of Europe	3.66	12.67	0.88	0.56	0.25
Canada	3.76	13.48	0.89	0.49	0.22
USA	8.78	15.57	0.90	0.66	0.18
Rest of Americas	3.18	10.67	0.83	0.63	0.19
Australia	2.99	10.24	0.72	0.43	0.25
Africa	3.29	13.57	0.26	0.31	0.21
Asia			0.88	0.60	0.24
Europe			0.84	0.48	0.25
Americas			0.92	0.70	0.19
Australia			0.72	0.43	0.25
Africa			0.26	0.31	0.21
World			0.88	0.60	0.24

Table OT.18: Parameter Estimates of Alternative Firm-level Method and Alternative Sample Specification

This table reports the parameter estimates for the alternative models of country-specific state-contingent adjustment cost function (in abbreviation, country-characteristic model). Column (1) reports the parameter estimates for the estimation specification of firm-level method. Standard error and statistics of fitness are calculated in the same definition of Table 2, using the same portfolios. Column (2) estimates the model using the sub-sample of domestic firms. Column (3) constructs the sample using alternative measure of investment flow in intangible capital with XRD. Column (4) constructs the sample using quantity of intangible capital estimated from the history of operating profit. Column (5) constructs the sample using quantity of intangible capital estimated from operating profit and firm valuation jointly, with parameter restriction over the conversion rate no smaller than 0.30. Column (6) constructs the sample using the sector-specific conversion rate of intangible capital for the firms in Consumption, Manufacturing, Hi-tech and Health sector, referring (Gulen et al., 2022). Global Cost Coefficients and Incremental Cost Coefficient for each dimension of country characteristic variables are reported. P-value of t-stat are indicated using * for p<0.10, ** for p<0.05, *** for p<0.010.

	(1)Firm-level Method		(2)Domestic Firms		(3) R&D		(4) DeepParam		(5) DeepParam (Joint)		(6) Industry	
Panel (A) Global Coefficient												
	$\theta_{P,g}$	$\theta_{I,g}$	$\theta_{P,g}$	$\theta_{I,g}$	$\theta_{P,g}$	$\theta_{I,g}$	$\theta_{P,g}$	$\theta_{I,g}$	$\theta_{P,g}$	$\theta_{I,g}$	$\theta_{P,g}$	$\theta_{I,g}$
	1.39 **	13.38 ***	3.97 ***	11.89 ***	4.44 ***	8.25 ***	3.53 ***	8.06 ***	3.75 ***	11.51 ***	4.13 ***	9.77 ***
s.e.	(0.33)	(0.52)	(0.27)	(0.50)	(0.33)	(0.49)	(0.39)	(0.80)	(0.39)	(0.76)	(0.26)	(0.40)
Panel (B) Incremental Coefficients												
	γ_x^P	γ_x^I	γ_x^P	γ_x^I	γ_x^P	γ_x^I	γ_x^P	γ_x^I	γ_x^P	γ_x^I	γ_x^P	γ_x^I
(a) Intellectual Property												
Secrets and Patents	-0.11	-2.74 **	0.73 *	-3.84 **	0.07	-2.01 **	0.10	-0.89 *	-0.19	-1.52 *	-0.11	-1.66 **
s.e.	(0.43)	(0.72)	(0.37)	(0.75)	(0.33)	(0.51)	(0.41)	(0.52)	(0.41)	(0.80)	(0.34)	(0.57)
(b) Contract Enforcement												
Procedures	0.03	0.55 ***	0.19 **	0.70 ***	0.14 **	0.25 **	0.21 **	0.43 ***	0.21 **	0.57 ***	0.12 **	0.51 ***
s.e.	(0.05)	(0.08)	(0.04)	(0.08)	(0.04)	(0.06)	(0.06)	(0.07)	(0.06)	(0.10)	(0.04)	(0.06)
(c) Economic and Financial Development												
GDP per capita	0.46 *	2.65 **	0.11	4.19 ***	-0.14	1.61 **	0.85	9.01 ***	1.04	14.98 ***	0.29	1.88 **
s.e.	(0.31)	(0.55)	(0.27)	(0.57)	(0.33)	(0.62)	(0.96)	(0.93)	(0.96)	(1.45)	(0.25)	(0.46)
Population	0.49 **	0.65 *	0.05	0.83 **	-0.18	1.12 **	0.44	1.32 **	0.27	3.95 ***	-0.03	0.63 **
s.e.	(0.19)	(0.29)	(0.16)	(0.29)	(0.18)	(0.26)	(0.37)	(0.39)	(0.38)	(0.67)	(0.15)	(0.23)
Bank Profit	-0.08	11.29 ***	1.32 *	15.12 ***	1.06 *	9.66 ***	-0.14	0.56 **	-0.01	0.45	0.83	11.89 ***
s.e.	(0.73)	(1.31)	(0.65)	(1.27)	(0.61)	(0.99)	(0.22)	(0.21)	(0.23)	(0.33)	(0.61)	(1.06)
Intensity of Intangible Capital (X_2)												
1(Top25%)	0.88	7.95 ***	3.37 ***	9.19 ***	3.19 **	3.87 **	3.08 **	5.63 ***	3.37 **	10.28 ***	2.99 **	7.03 ***
s.e.	(0.68)	(0.90)	(0.58)	(0.82)	(0.68)	(0.96)	(0.87)	(0.60)	(0.87)	(0.95)	(0.55)	(0.67)
Panel (C) Statistics												
XS-R^2		0.78		0.86		0.79		0.84		0.80		0.85
TS-R^2		0.52		0.55		0.52		0.56		0.52		0.54
$m.a.e./\sqrt{VR}$		0.25		0.24		0.24		0.25		0.26		0.23

Table OT.19: Explanation of the impact of country-characteristics on adjustment costs

This table reports a summary of the explanation of the impact of country-characteristics on adjustment costs of intangible capital versus physical capital.

(i) Protection of Intellectual Property Rights (IPR) , referring Rempel (2021);Crouzet et al. (2022a) ; Antill et al. (2023);

Intangible Capital: Strong IPR protection lowers adjustment costs significantly by safeguarding returns on innovation, R&D, and other intangible investments. Without IPR, firms are less willing to invest in or adopt intangible assets.
Physical Capital: Minimal impact, as physical assets rely more on direct ownership rights rather than intellectual protections.
Summary: Critical for intangible capital, minimal for physical capital.

(ii) Employment Protection , referring Acharya, Baghai, and Subramanian (2014); Calcagnini, Ferrando, and Giombini (2014); Bena, Ortiz-Molina, and Simintzi (2022)

Intangible Capital: High labor protection increases adjustment costs by limiting flexibility in hiring or restructuring to fit new organizational or technological needs.
Physical Capital: Also affected, but to a lesser extent, as adjustments often involve one-time labor use (e.g., installation or construction) rather than continuous adaptation.
Summary: More impactful for intangible capital, where ongoing workforce adaptation is key.

(iii) Ease of Contract Enforcement , referring Djankov et al. (2003); Acemoglu and Johnson (2005)

Intangible Capital: Critical for reducing adjustment costs, as intangible assets often involve collaborative agreements like licensing, R&D partnerships, or service contracts.
Physical Capital: Important but less critical; physical assets primarily require straightforward procurement or construction contracts.
Summary: Important for both, but more critical for intangible capital due to reliance on complex, trust-intensive agreements.

(iv) Cost of Financing , referring Petersen and Rajan (1994); Hauswald and Marquez (2006);Chemmanur and Yan (2009), Larkin (2013)

Intangible Capital: Strongly affects adjustment costs, as intangible investments often lack collateral value, increasing reliance on affordable, accessible financing.
Physical Capital: Also affected, but physical assets are easier to collateralize, making them less dependent on favorable financing conditions.
Summary: More impactful for intangible capital due to its higher risk and limited collateral.

(v) Protection of Investor Rights , referring La Porta et al. (2002); McLean, Zhang, and Zhao (2012)

Intangible Capital: Strong protection reduces adjustment costs by encouraging funding for risky, high-uncertainty intangible investments.
Physical Capital: Also benefits, but the impact is less pronounced since physical investments are easier to monitor and collateralize.
Summary: Critical for intangible capital, moderately important for physical capital.

(vi) Economic Development , common sense from non-academic discussion

Intangible Capital: Higher development significantly lowers costs by providing skilled labor, robust institutions, advanced infrastructure
Physical Capital: Also benefits, but physical assets mainly depend on basic infrastructure like roads and electricity, especially in moderately developed economies.
Summary: Crucial for both, but more impactful for intangible capital due to its reliance on advanced ecosystems.

(vii) Regulatory Environment and Permitting , common sense from non-academic discussion

Intangible Capital: Overregulation increases costs by stifling innovation and making it harder to adapt new business models or technologies.
Physical Capital: Excessive regulation increases costs by delaying construction or requiring expensive compliance measures.
Summary: Important for both, with comparable impacts.

(viii) Infrastructure Availability , common sense from non-academic discussion

Intangible Capital: Access to digital and technological infrastructure (e.g., broadband, cloud computing) enables adoption of investments.
Physical Capital: Relies on physical infrastructure (e.g., transportation, electricity) for installation and operation, making availability crucial.
Summary: Essential for both, but the type of infrastructure needed differs (digital for intangible, physical for tangible).

Table OT.20: Descriptive Statistics of High-Dimension Economic Status in Countries

This table reports the descriptive statistics for country-level characteristic variables. Panel (a) reports assessment of respect for intellectual property rights relating to trade secrets and industrial patents, the ease of market entry related to the practices of already established competitors, from Institutional Profiles Database of 2016 version. Countries of strong respect has value 4. Countries of no respect has value 0. Countries of no entry barrier has value 4. Countries of major barriers has value 0. Panel (b), the cost of contract enforcement, reports the number of procedures, the years for completing the filing, resolution of dispute, and the enforcement of court decision. These are statistics in the year 2016, from World Bank Doing Business database. Panel (c) reports the status of economic and financial development. In Panel (c-1), the GDP per capita and the population use the log value. Statistics are outcomes of the year 2016, provided from the UN database. Panel (c-2) reports the assessment of provision of tenure contract and collective dismissal in labor market, and infrastructure availability, territorial coverage of electricity grid from Institutional Profiles Database. Panel (c-3), the bank power reports the statistics calculated using World Financial Development database, Bank profit is the ratio between the operating income and the total operating cost. Concentration is the market share of largest three banks in a country. The statistics are reported as the time-series average outcome during 2011-2020. The assessment of competition is from Institutional Profiles Database. Panel (c-4) reports assessment of the protection of minority investor. Information Disclosure describes how much information can be collected from the large shareholder. Director Liability describes to what extent the director can be punished for the misconduct. Shareholder Suits describes how easy it is to launch the lawsuit. These statistics are from Doing Business database. Statistics of mean, median, cross-section standard deviation, minimal value, maximal value, are reported for countries with assessment from Institutional Profiles Database. In Columns (7) to (10), correlation statistics are reported between the country/region characteristic variables and the cost coefficients in the Benchmark model of country-specific adjustment cost function. Correlation to adjustment cost coefficient of physical capital, cost coefficient of intangible capital, are calculated across 17 countries and 4 regions. Cost coefficients are from the baseline estimation. For region with multiple countries, region-level characteristic uses the simple-average outcomes across countries within.

Variables of Market Feature	Descriptive Stats					Correlation			
	mean	median	s.e.	min	max	θ_P	(s.e.)	θ_I	(s.e.)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
(a) **Intellectual Property Rights**									
Secrets and Patents	2.88	3.00	1.01	0.00	4.00	-0.10	(0.23)	-0.71 **	(0.20)
Easy Entry	1.56	1.00	0.97	0.00	4.00	0.48 **	(0.16)	-0.20	(0.28)
(b) **Contract Enforcement**									
Procedures	35.55	35.00	6.54	21.00	51.00	0.28 *	(0.15)	0.50 ***	(0.08)
Years	1.70	1.41	0.81	0.45	4.33	0.28 *	(0.17)	0.32 *	(0.17)
(c) **Economic and Financial Development**									
(c-1) **Income and Demographic**									
GDP per capita	9.56	9.68	1.18	7.18	11.60	-0.07	(0.19)	-0.44 **	(0.13)
Population	16.72	16.86	1.77	12.71	21.07	0.19	(0.19)	0.63 **	(0.23)
(c-2) **Labor and Infrastructure**									
Tenure	2.88	3.00	0.96	1.00	4.00	0.18	(0.19)	-0.34 *	(0.17)
Collective Dismissal	2.26	2.00	1.03	0.00	4.00	-0.35	(0.26)	-0.33 *	(0.18)
Electricity Coverage	3.25	4.00	0.95	1.00	4.00	-0.18	(0.14)	-0.28	(0.20)
(c-3) **Bank Power**									
Bank Profit	1.93	1.83	0.43	1.16	3.68	-0.16	(0.18)	0.57 *	(0.29)
Concentration (%)	60.67	59.73	18.69	25.40	99.36	-0.24	(0.26)	-0.49 **	(0.17)
Competition	2.99	3.00	0.77	1.00	4.00	0.20 **	(0.08)	-0.40	(0.35)
(c-4) **Investor Protection**									
Information Disclosure	6.74	7.00	2.21	0.00	10.00	-0.22	(0.15)	0.15	(0.21)
Director Liability	5.34	5.00	2.21	1.00	9.00	0.03	(0.21)	-0.27	(0.31)
Shareholder Suits	6.44	7.00	1.94	1.00	9.00	-0.25	(0.19)	-0.49 **	(0.20)

Table OT.21: Parameter Estimates of High-Dimension Country-Characteristic Model

This table reports the parameter estimates for the model specification of country-specific state-contingent adjustment cost function (in abbreviation, country-characteristic model) with high-dimensional state variables. Global Cost Coefficients $\theta_\mathbf{g}$ and Incremental Cost Coefficient $\boldsymbol{\gamma}$ for each dimension of country characteristic variables are reported. Definitions of statistics are identical to Table 5. P-value of t-stat are indicated using * for p<0.10, ** for p<0.05, *** for p<0.010.

	Point Estimate		Point Estimate (Normalized)	
	(1)	(2)	(3)	(4)
Panel (A) Global Cost Coefficient				
	$\theta_{P,g}$	$\theta_{I,g}$	$\theta_{P,g}$	$\theta_{I,g}$
	4.80 ***	10.41 ***	4.80 ***	10.41 ***
s.e.	(0.35)	(0.77)	(0.35)	(0.77)
Panel (B) Incremental Cost Coefficients				
	γ^P	γ^I	γ^P	γ^I
(a) Intellectual Property (X_{1a})				
Secrets and Patents	-0.00	-1.62 *	-0.00	-1.64 *
s.e.	(0.48)	(0.98)	(0.49)	(1.00)
Easy Entry	0.25	0.22	0.24	0.21
s.e.	(0.33)	(0.61)	(0.32)	(0.59)
(b) Contract Enforcement (X_{1b})				
Procedures	0.10	0.98 ***	0.67	6.38 ***
s.e.	(0.09)	(0.16)	(0.56)	(1.04)
Years	0.38	-0.27	0.31	-0.22
s.e.	(0.43)	(1.01)	(0.35)	(0.81)
(c) Economic and Financial Development (X_{1c})				
(c-1) Income and Demographic				
GDP per capita	1.04	4.59 **	1.23	5.40 **
s.e.	(0.72)	(1.23)	(0.85)	(1.44)
Population	-0.34 *	0.94 **	-0.60 *	1.67 **
s.e.	(0.21)	(0.39)	(0.37)	(0.69)
(c-2) Labor and Infrastructure				
Tenure Contract	0.23	-1.48 **	0.22	-1.42 **
s.e.	(0.32)	(0.55)	(0.30)	(0.52)
Collective Dismissal	-0.50 *	-0.83 *	-0.52 *	-0.85 *
s.e.	(0.27)	(0.52)	(0.28)	(0.54)
Electricity Coverage	-0.98	-1.46	-0.93	-1.40
s.e.	(0.66)	(1.17)	(0.63)	(1.11)
(c-3) Bank Power				
Bank Profit	2.93 **	9.58 **	1.27 **	4.14 **
s.e.	(1.08)	(2.21)	(0.47)	(0.95)
Concentration (%)	-0.02	0.07	-0.42	1.37
s.e.	(0.03)	(0.05)	(0.49)	(0.94)
Competition	0.32	-1.99 *	0.25	-1.53 *
s.e.	(0.49)	(1.04)	(0.38)	(0.80)
(c-4) Investor Protection				
Information Disclosure	-0.26	0.81 *	-0.57	1.78 *
s.e.	(0.19)	(0.45)	(0.42)	(1.00)
Director Liability	-0.28 *	-0.04	-0.61 *	-0.09
s.e.	(0.12)	(0.21)	(0.27)	(0.46)
Shareholder Suits	0.34 *	0.30	0.65 *	0.58
s.e.	(0.20)	(0.37)	(0.39)	(0.71)
Intensity of Intangible Capital (X_2)				
$\mathbf{1}([25\%, 50\%))$	-1.79 *	1.93	-1.79 *	1.93
s.e.	(1.03)	(2.07)	(1.03)	(2.07)
$\mathbf{1}([50\%, 75\%))$	-2.56 **	1.87	-2.56 **	1.87
s.e.	(0.93)	(2.01)	(0.93)	(2.01)
$\mathbf{1}(\text{Top25\%})$	2.03 *	9.15 **	2.03 *	9.15 **
s.e.	(0.89)	(1.65)	(0.89)	(1.65)
Panel (C) Statistics				
XS-R^2	O.34	0.86		0.86
TS-R^2		0.56		0.56
$m.a.e./\overline{VR}$		0.23		0.23

OF Online Figure Appendix

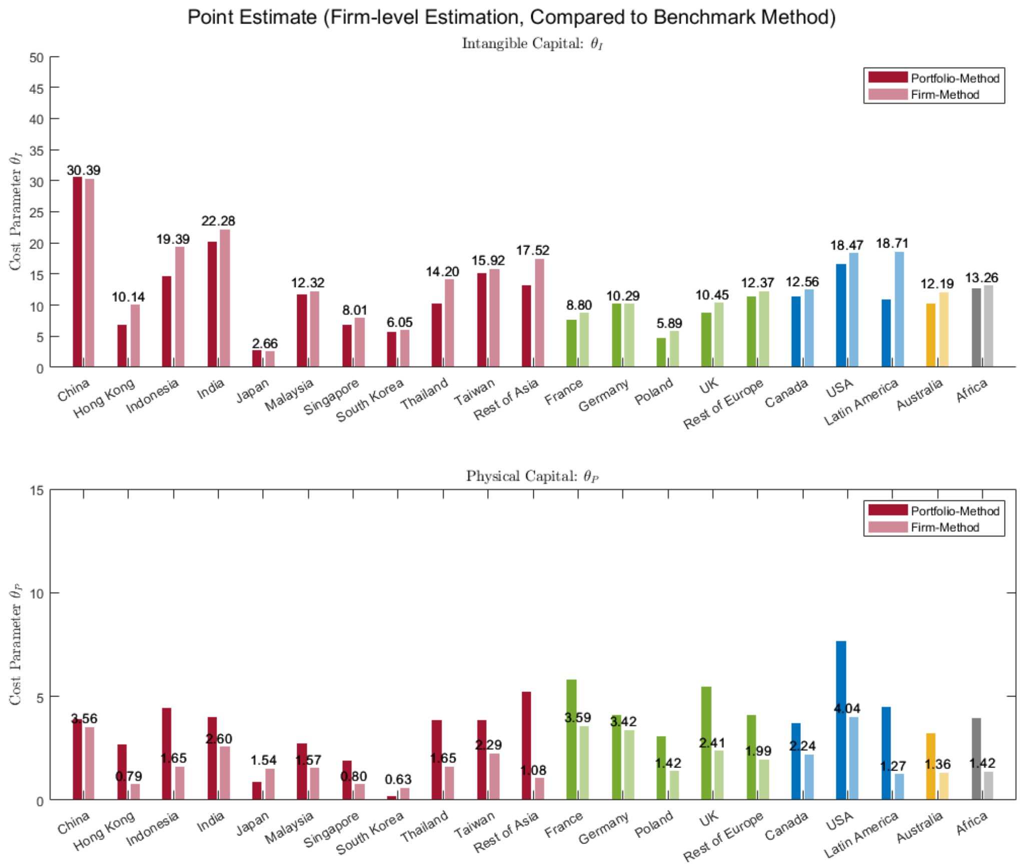

Figure OF.1: Estimates of Cost Coefficients in Firm-level Estimation

This figure compares the parameter estimates in the baseline estimation method of portfolio-level moment, and the parameter estimates in the alternative specification of firm-level moment. The top figure reports the parameters for intangible capital. The bar of yellow color describes the estimation outcome using the portfolio-level moment. The bar of purple color describes the estimation outcome using the firm-level moment. The bottom figure reports the parameters for the physical capital. The bar of blue color, the green color describes the estimation outcomes of the two specifications respectively.

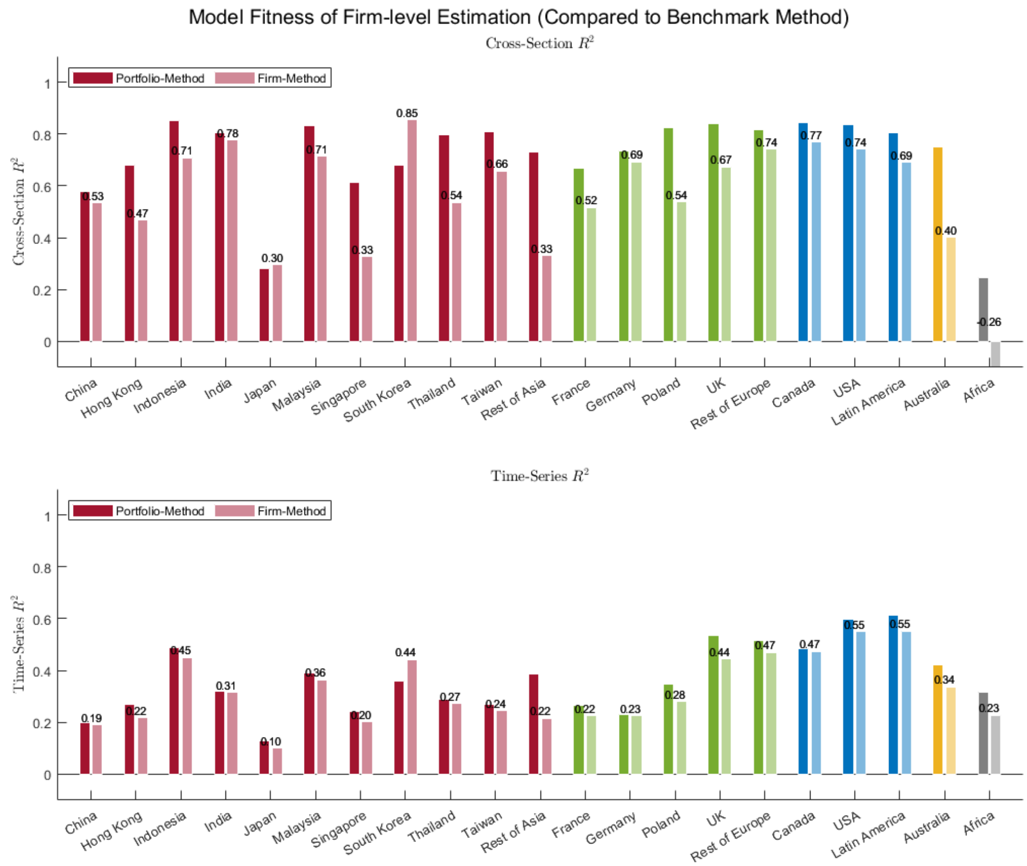

Figure OF.2: Fitness of Model in Firm-level Estimation

This figure compares the fitness of model in the baseline specification of portfolio-level estimation, and the model of firm-level estimation. The top figure reports the cross-section R^2. The bar of yellow color describes the estimation outcome using the portfolio-level moment. The bar of purple color describes the estimation outcome using the firm-level moment. The data label of numbers denotes the cross-section R^2 of firm-level estimation. The bottom figure reports the time-series R^2. The bar of blue color describes the estimation outcome using the portfolio-level moment. The bar of green color describes the estimation outcome using the firm-level moment. The data label of numbers denotes the time-series R^2 of firm-level estimation. These statistics of fitness are calculated using the portfolio-level moments. The construction of portfolios, calculation of statistics are identical with Table 2.

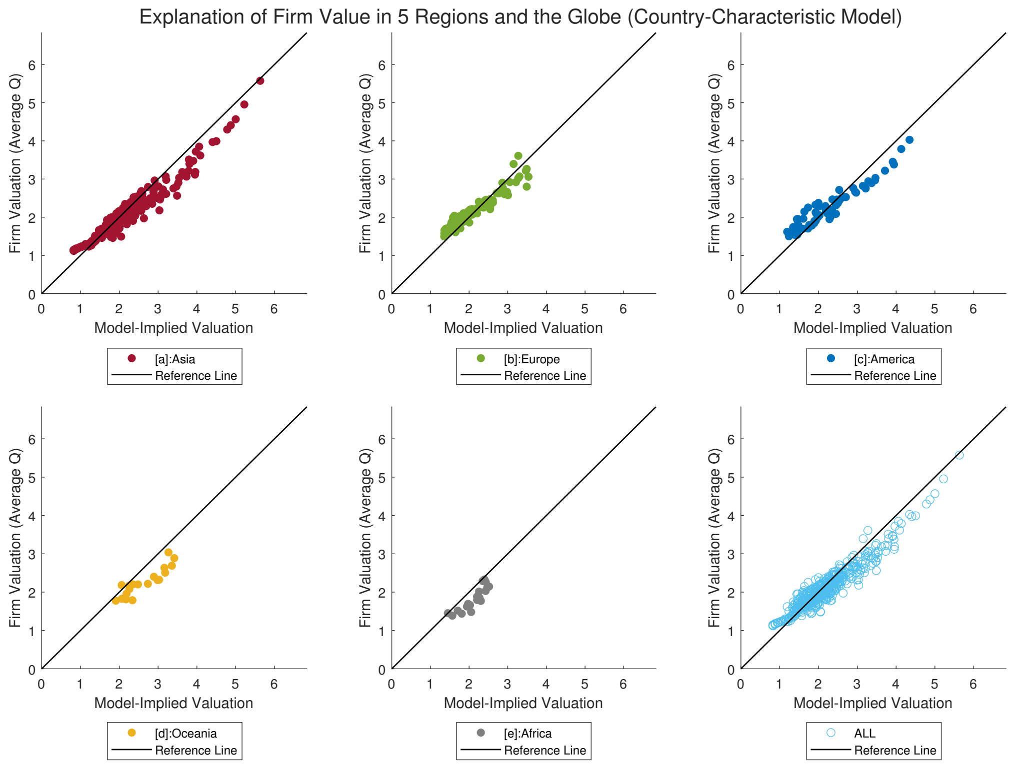

Figure OF.3: Model-Implied Firm Value in Portfolios

This figure reports the model-implied valuation and the firm valuation, estimated from the models of country-specific state-contingent adjustment cost function (in abbreviation, country-characteristic model). The model-implied valuation is the average shadow price of capitals in each portfolio is $\overline{VR} = \frac{1}{N_i}\sum_i \frac{q_i^P K_i^P + q_i^I K_i^I}{K_i^P + K_i^I}$. The firm valuation is $VR = \frac{1}{N_i}\sum_i \frac{P_i + B_i}{K_i^P + K_i^I}$. Each geographic area (of 17 countries, Rest of Asia, Rest of Europe, Africa, Latin America) has 20 out-of-sample portfolios sorted based on lagged firm-level variables: portfolios single-way sorted by investment rate in physical capital and by investment rate of intangible capital respectively. The time-series average during period during 2006-2020 is reported in the figure. Sub-figure (1) with the red dots presents the portfolios of countries, territories, the remaining area in Asia. Sub-figure (2) with the green dots presents the portfolios of countries, the remaining area in Europe. Sub-figure (3) with the blue dots is for the Americas. In sub-figure (4) and (5), the yellow dots and gray dots present the portfolios in Oceania (Australia) and Africa respectively. Sub-figure (6) summarizes all the five regions.

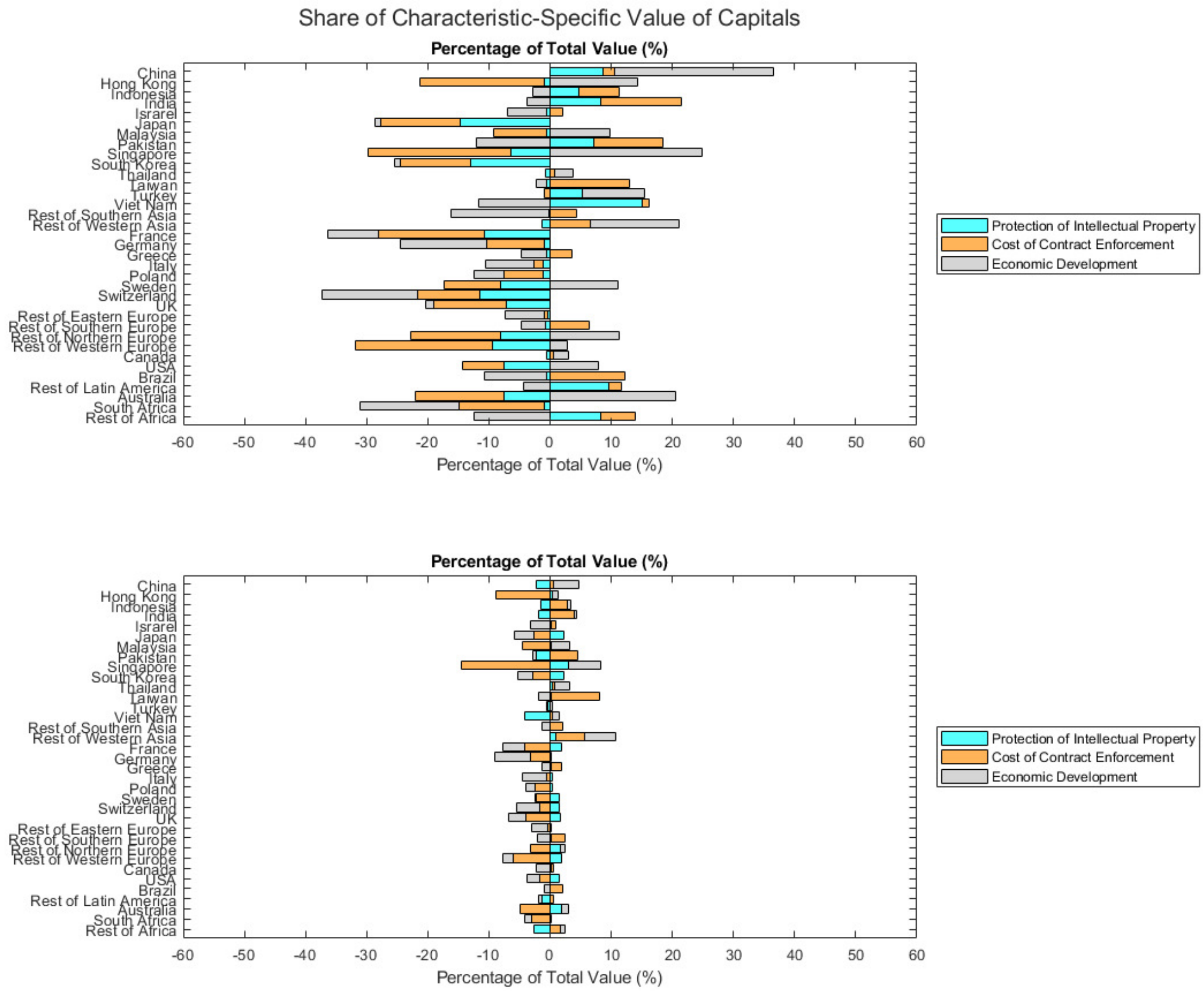

Figure OF.4: Share of Characteristic-Specific Value (in Percentage)

This figure reports the model-implied characteristic-specific valuation for the model of country-specific state-contingent adjustment cost function (in abbreviation, country-characteristic model). The statistics for the 17 large-size countries, 10 medium-size countries, other small-size countries in the remaining area of 8 UN-sub-regions are reported. The valuation of intangible capital from country-characteristic variables in percentage of the total firm value is reported in the first row. For each aspect z of country-characteristic variables, the cost compensation in value of intangible capital is calculated as $\{\gamma_z^I \cdot X_{z,c} \cdot (1-\tau) \cdot i^I \cdot K^I\}_z$, then its contribution to total firm value $\{\frac{\gamma_z^I \cdot X_{z,c} \cdot (1-\tau) \cdot i^I \cdot K^I}{V}\}_z$ is reported. The component $\frac{(1-\tau) \cdot i^I \cdot K^I}{V} = \frac{1}{T}\sum_t \frac{\sum_i (1-\tau_{c,t}) \cdot i^I_{it} K^I_{it+1}}{\sum_i V_{it}}$ is calculated as the aggregate statistic for each geographic area (of 27 countries, 8 sub-regions) and each year during 2016-2020. The similar statistic is reported for physical capital in the second sub-figure.

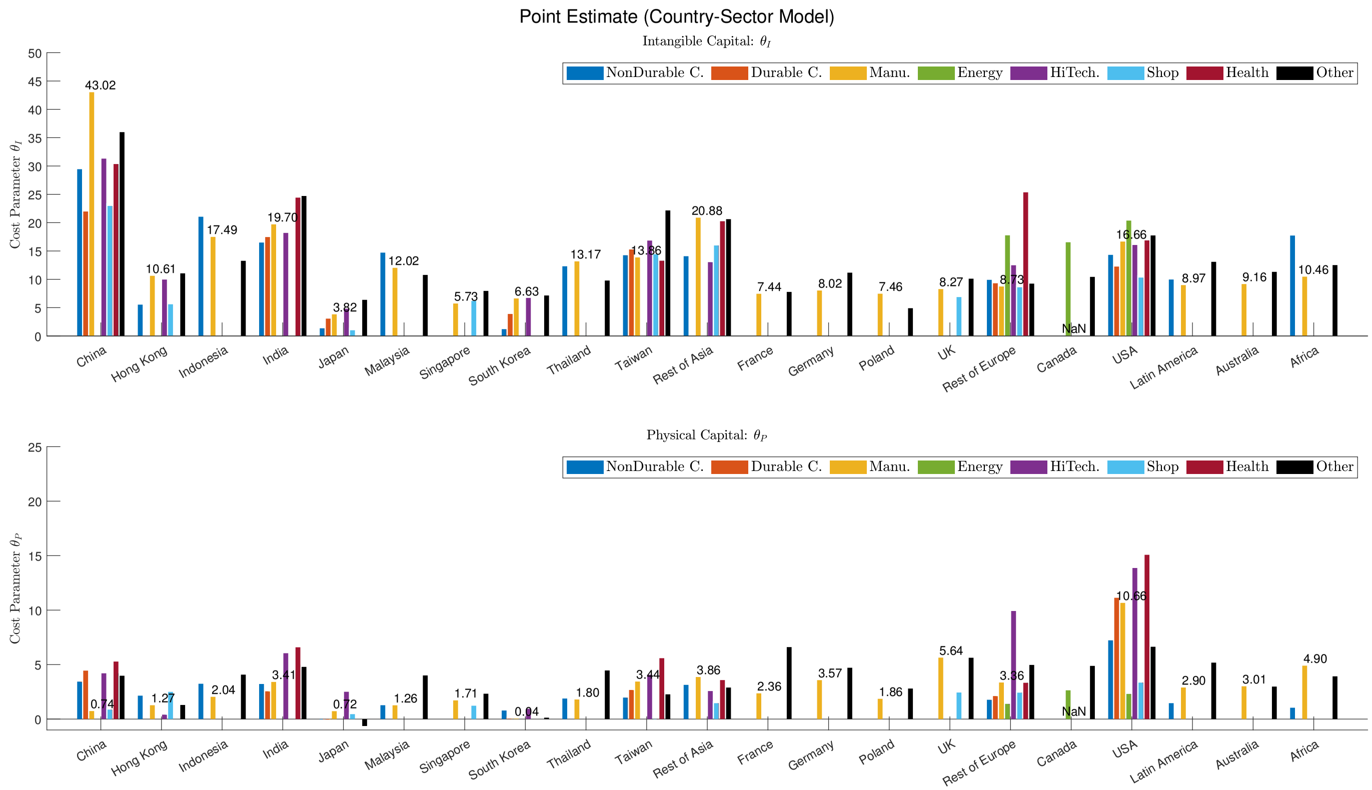

Figure OF.5: Estimates of Cost Coefficients in Country-Sector Model

This table reports the parameter estimates for the model of country-sector-specific adjustment cost function. The model is estimated using the 89 sets of country-sector portfolios, which contains 9 portfolios in each sector of each country (or territory, region). The 89 sets of country-sectors are classified using Fama-French 10 industries in each country (or territory, region). For firms in a country-sector that have less than 60 firms per year 2011-2020, they are classified as the other sector in that country.