ESSAYS IN INTERNATIONAL ECONOMICS USING FIRM-LEVEL DATA

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ABSTRACT

JENNIFER S. RHEE: ESSAYS IN INTERNATIONAL ECONOMICS USING FIRM-LEVEL DATA.
(Under the direction of Anusha Chari)

My dissertation empirically investigates implications of macroeconomic models using firm-level market and accounting data. As Konchitchki and Patatoukas (2014) states, "macroeconomics research has evolved independently from accounting research, which is typically conducted at the firm level" and "the link between accounting earnings and macroeconomy remains relatively unexplored." This paper is part of the growing body of literature that attempts to fill this gap by highlighting macroeconomic insights that can be obtained from the micro-level analysis. The first two chapters of my dissertation investigate Lucas Paradox and the neoclassical model, and the last chapter studies Heckscher-Ohlin model of trade.

Neoclassical theory predicts that if two countries share the same constant return to scale production function, and trade in capital goods is free and competitive, due to the law of diminishing returns (a) new investment will occur only in capital-scarce countries since (b) the marginal product of capital should be higher in economies with less capital. This statement at the heart of Lucas paradox, implicitly assumes that cross-country marginal products of capital mirror cross-country financial investment returns. In the first chapter, I show using firm-level data that although firms in emerging markets enjoy higher marginal products of capital, financial investment returns are roughly equalized across developed and emerging economies. The finding questions the validity of the standard approach that uses differences in marginal products of capital to explain international capital flows. It further suggests that "there is no prima facie support for the view that international credit frictions play a major role in preventing capital flows from rich to poor countries" (Caselli and Feyrer, 2007). The paper also highlights the importance of cross-country differences in capital

efficiency to explain the observed patterns of financial returns. The second chapter further investigates capital efficiency differences across countries and suggests potential modifications to the standard capital accumulation model. It also uses variables that are commonly employed in the macroeconomic growth literature and examine their effect on the capital efficiency of firms.

The third chapter investigates single-cone Heckscher-Ohlin model of specialization, which is one of the most heavily used general equilibrium model of international trade. The theory suggests that if countries share identical technology, then they export goods that intensively use the factors of production that are relatively abundant locally and this leads to a global factor price equalization even in the absence of international factor mobility. In this chapter, I empirically investigate implications of the single-cone Heckscher-Ohlin model using firm-level accounting and market data. I find a systematic relationship between firm return to capital and aggregate relative endowment, which imply a weak link among international factor prices. This finding, which is consistent with Schott (2003, 2004), rejects commonly used single-cone model in favor of the multi-cone model with intra-industry specialization and suggests that trade liberalization can only have a limited effect on the factor price convergence across countries.

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CHAPTER 1

THE LUCAS PARADOX AND THE RETURN TO CAPITAL IN CAPITAL-SCARCE COUNTRIES

1.1 Introduction

Textbook neoclassical theory predicts that if two countries share identical production functions, and trade in capital goods is free and competitive, new investment will only occur in economies with relatively less capital. It follows from the law of diminishing returns that the marginal product of capital ought to be higher in capital-scarce economies. However, since Lucas (1990) a vast literature devotes itself to explain the observation that capital flows from developed to emerging countries fall short of what theory predicts. In fact, in their 2007 paper, Prasad, et al., document an uphill flow of capital from poor to rich countries in the late 1990s-early 2000s. So, why doesn't capital flow from developed to developing countries?

In this essay, I investigate the link between the marginal product of capital and financial rates of return to provide resolution to the paradoxical patterns of observed international capital flows. In the standard neoclassical model, a firm's first order condition states that the marginal product of capital (MPK_t) and the financial return (r_t) should differ only by depreciation rate (δ), which is assumed constant across countries ($r_t = MPK_t - \delta$). Therefore, theory predicts that high financial returns and high marginal products of capital should go hand in hand. If this link breaks down, i.e., if high marginal product of capital does not translate to high financial returns, it is not clear that the capital ought to flow to countries with high marginal products of capital.

Despite the significance of this first order condition that lies at the heart of the Lucas Paradox, there is little attempt to test its validity. In large part, this is due to the limitations of aggregate data. In this paper, I examine the validity of the link between the marginal product of capital and financial returns using firm-level market and accounting data from a set of developed and emerging countries between 1997 and 2014. Konchitchki and Patatoukas (2014) state, "macroeconomics research has

evolved independently from accounting research, which is typically conducted at the firm level" and "the link between accounting earnings and macroeconomy remains relatively unexplored." This essay is part of the growing body of literature that attempts to fill this gap by highlighting macroeconomic insights that can be obtained from the micro-level analysis.

The standard approach in recent work imputes an aggregate marginal product of capital from national income accounts. However, imputed estimates are not the same as computed ones. Imputations rely heavily on underlying assumptions about functional form, raising legitimate questions about the validity of a range of assumptions such as setting parameter values (e.g., technology, capital shares, and elasticities of substitution) equal to those of the US. Specifically, delivering the finding that marginal products of capital are essentially the same across rich and poor countries requires adjustments to the national income accounts for (i) the capital per effective worker and a human capital externality (Lucas, 1990), (ii) non-reproducible capital and the price of capital goods (Caselli and Feyrer, 2007), and (iii) technology catch up and distortions in saving and investment decisions (Gourinchas and Jeanne, 2009).

Imputed estimates are therefore indirect estimates of the aggregate rate of return to capital in developing countries. On the other hand, computed estimates of the return to capital using micro-data may provide a more direct and reliable way forward. Instead of making assumptions about parameters to impute the rate of return to capital from aggregate data, I argue that it is more straightforward to compute firm-level rates of return and to aggregate them to produce estimates of the national rate of return.

The main finding of this paper is that the standard link between the marginal product of capital and the financial return, that is often assumed in the international capital flows literature, does not hold across in a sample of developed and emerging countries between 1997-2014. Consistent with predictions from the neoclassical framework, the results show that firm marginal products of capital are indeed higher in emerging countries relative to their developed-market counterparts. The finding is robust to controlling for firm and industry specific effects and is remarkably consistent across different sample periods and countries.

The neoclassical model implies that the higher marginal product of capital should translate to a

high financial return in emerging-markets. However, contrary to this prediction, I find that despite evidence for a downward sloping marginal product of capital curve, the inflation-adjusted financial return is roughly equal across developed and emerging countries. This core finding is significant as it questions the validity of the standard approach that uses differences in the marginal product of capital to explain international capital flow patterns. The firm-level evidence using computed estimates therefore shows that the marginal product of capital may not be a valid proxy for financial returns expected from the capital investment.

Additionally, the results confirm that "there is no prima facie support for the view that international credit frictions play a major role in preventing capital flows from rich to poor countries" (Caselli and Feyrer, 2007). If a high marginal product of capital in emerging countries correctly translates to high financial returns as implied by the standard model, then the shortfall in the capital flow to these countries points international capital market frictions and investment barriers. However, if financial returns are equalized across developed and emerging countries, an alternative hypothesis may be that there is little incentive for capital to flow to the less-developed countries.

These findings further highlight the importance of cross-country capital efficiency differences to explain the Lucas Paradox. Much of the international macro and growth literature, which uses cross-country marginal product of capital differences to explain international capital flow patterns, focuses on productivity differences across countries and the macroeconomic factors that affect productive efficiency, i.e., the level of output that can be obtained from a unit of the capital input. The findings of this paper highlight the importance of capital efficiency, i.e., the level of future capital input that can be obtained from a unit investment today. This relationship affects the capital accumulation process within the economy and determines the relationship between the marginal product of capital and financial returns.

The firm's first order condition that links the marginal product of capital and financial returns stems from the standard capital accumulation equation, which suggests that the capital stock tomorrow is the sum of capital stock today and the investment net of the depreciation ($K_{t+1} = (1-\delta)K_t + I_t$ such that K_t and I_t are the capital stock, and investment in period t, respectively). However, if a unit investment does not lead to a unit increase in the capital stock, the standard

link between the investment return and marginal product of capital no longer holds, and the cross-country investment return and marginal product of capital patterns can differ.[1]

As Alfaro, et al (2008) states, "theoretical explanations for the Lucas Paradox can be grouped into two categories. The first group includes differences in fundamentals that affect the production structure of the economy, such as technological differences, missing factors of production, government policies, and the institutional structure. The second group of explanations focuses on international capital market imperfections, mainly sovereign risk and asymmetric information." Some of the major works on international capital market frictions include Stulz (2005), which shows that agency problems in emerging countries can lead to a wedge in the investment returns received by the international and domestic investors, and Reinhart and Rogoff (2004), which highlights the default history of emerging market countries. This finding suggest that the credit risk can explain the paucity of capital flow to emerging countries. Montiel (2006) also proposes an information friction as an important determinant in explaining the paucity of capital flows to African countries. On the other hand, much of the international macro and growth literature, which uses cross-country marginal product of capital differences to explain international capital flow patterns, focus on macroeconomic fundamentals and endowments that affect productive efficiency.[2]

In their 2005 paper, Banerjee and Duflo outline an exhaustive list of indirect and direct methods used to calibrate the marginal product of capital in the empirical development literature. An indirect method often employed in the literature proxies for the firm return to capital using the interest rate. Therefore a long line of researchers study of lending market in the emerging countries, and they document the extremely high cost of borrowing in these countries even when one adjusts for the risk. For example, Timberg and Aiyar (1984) document a $21 - 120\%$ interest rate charged by the indigenous-style bankers in India, and Ghate (1992) shows that interest rates in northern Thailand range up to $5 - 7\%$ per month.

However, as stated in Caselli and Feyrer (2007), "in financially repressed/distorted economies, interest rates on financial assets may be very poor proxies for the cost of capital actually borne

[1] See Cochrane (1991), Hayashi (1982), and Abel and Blanchard (1986)

[2] see Lucas(1990) and King and Rebelo (1993)

by firms." More popular and direct estimates of marginal product of capital require one to posit a production function (usually Cobb-Douglas) and derive the expression for marginal product of capital based on the assumed equation. This is the approach employed by Lucas in his 1990 paper, and he shows that marginal product of capital difference across countries fall substantially when one adjust for productivity difference across countries. A more recent paper by Caselli and Feyrer (2007) finds that the return to capital is roughly equal between emerging and developed countries when one adjusts for the relative price of capital, and the complementary factors of production.

Within this extensive literature on Lucas Paradox, there has been a relatively little discussion about the link between the marginal product of capital and the investment return. In large part, this is because in aggregate data, capital is not observed and therefore estimated from aggregate investment using the perpetual inventory method, which requires one to posit a capital accumulation process. Since this process is typically assumed to follow a standard model where a unit increase in investment lead to a unit increase in capital stock[3], the aggregate capital stock estimate itself implicitly relies on the assumption that the standard link between marginal product of capital and the investment return holds. This makes it virtually impossible to test the validity of the link using aggregate data. The key advantage of a firm-level data is that unlike aggregate estimates, capital can be directly observed from the accounting and market values. This allows for direct computation of the marginal product of capital and investment returns, which can then be used to empirically test the validity of the standard link between the two variables.

Despite the advantages of firm-level data, there are some drawbacks. For example, firm-level data do not provide any insight into the productivity of self-employed workers or informal sector firms. This is a significant drawback as these types of households and firms constitute a large part of the economy in developing countries. Unlike aggregate data, firm-level market variables are also susceptible to market volatility. Since the period of analysis includes the global financial crisis (2007-2008), I control for year-specific effects in my analysis and also run a robustness test

[3]Cochrane (1991) is an exception in that he uses non-standard capital accumulation process with adjustment cost to estimate capital stock. However, he also sets the adjustment parameter so that the mean aggregate investment and stock returns equate.

excluding these years. Despite these shortcomings, the firm-level data provide useful insights as they utilize detailed information on the relationship between financial returns and productivity of the firms. This paper therefore provides an alternative lens to complement existing literature that primarily uses macroeconomic data to perform aggregate analysis.

The paper limits the analysis to listed-firms in MSCI emerging and developed countries that have relatively well established stock markets. Although this substantially reduces the number of countries in the sample, as Reinhart and Rogoff (2004) write "roughly twenty five 'emerging markets' account for the bulk of international financial flows." Therefore, the analysis of the firms in these countries ought to provide useful insights into the factors that drive the international capital flows. I also restrict the period of analysis to the post-1996 period due to the limited availability of reliable firm-level data from emerging countries in the early 1990s.

An important concern with using cross-country firm-level data is the difference in the accounting standards used to report data from different countries. For example, the definition of "assets" in the US Generally Accepted Accounting Principles (US GAAP) may differ from the definition in the International Financial Reporting Standard (IFRS). To minimize the effects of the cross-country accounting standard differences, I use the financial and accounting data from the Worldscope Datastream. Datastream not only provides extensive accounting and market data on listed firms across countries, but also aims to "provide the data in a manner that allows maximum comparability between one company and another, and between various reporting regimes" (Worldscope/Disclosure Partners, 1992). Thus, the numbers reported in the firm's annual/quarterly audit reports could differ from the numbers provided by the Worldscope as they make "several adjustments to the data to make the definitions more comparable to their U.S. counterparts." (Wald, 1999) Although extensive measures are taken by Datastream to increase the firm comparability across countries, I further check for the effects of cross-country differences in accounting standards that may remain in the data, by running a robustness test exclusively restricted to firms from countries that adopt the International Financial Accounting Standards (IFRS). I find that the main results remain robust.

The findings in this paper are closely related to Gourinchas and Jeanne (2009), Banerjee and Duflo (2005), and Chirinko and Mallik (2008). Although the approaches differ, these papers all

investigate the effect of domestic capital friction on the cross-country marginal product of capital differences. Gourinchas and Jeanne (2009) show that one can reconcile the observed difference between aggregate capital return and the international capital flow using the saving and investment wedge, and Chirinko and Mallik (2008) investigate the role of capital adjustment cost at an aggregate level using a stock market return. Banerjee and Duflo (2005) show that one can partially explain the cross-country difference in marginal product of capital by adjusting for the intra-country heterogeneity in the firm productivity.[4] However, this paper differs from others in that it studies the effect of domestic capital frictions on the relationship between the marginal product of capital and the investment returns rather than the marginal product of capital itself.

The paper proceeds as follows. In section 2, I introduce the basic neoclassical model and its predictions about the relationship between the marginal product of capital and financial investment returns and explain the empirical methodology. Section 3 describes the firm-level data used in the analysis and the summary statistics. Section 4 present the empirical results; I analyze the cross-country marginal product of capital and investment return patterns in the section. I also perform a robustness test by using only the firms in countries with IFRS accounting standards. Section 5 provides additional robustness test results for labor input and tax adjustments, and section 6 concludes.

1.2 Benchmark model and Empirical Methodology

In this section, I introduce the benchmark neoclassical model to motive Lucas Paradox, and describe the empirical methodology used to calibrate the marginal product of capital and investment return using the firm-level data.

1.2.1 Benchmark: Neoclassical model

In this subsection, I introduce a standard neoclassical model with perfectly competitive factor markets. This simple, benchmark model delivers useful predictions and illustrates the first order condition that I use to motivate the empirical analysis.

[4] Hsieh & Klenow (2009) and Alfaro, et al (2008) also study the domestic capital market imperfection (misallocation of capital within countries), but their analysis focus on TFP and income difference across countries rather than return differences.

Consider a standard neoclassical economy where the representative firm faces competitive factor and goods markets. The firm chooses a capital, investment, and labor ($\{K_t, I_t, L_t\}_{t_0}^{\infty}$) to maximize the net present value of the future cash flows, taking the interest rate as given:

$$\max_{\{K_t, I_t, L_t\}_{t_0}^{\infty}} \sum_{t \geq t_0} \frac{1}{R_t}(Y_t - I_t - w_t L_t) \tag{1.1}$$

subject to:

$$\text{Production function:} \quad Y_t = F(K_t, L_t) \tag{1.2}$$

$$\text{Capital accumulation:} \quad K_{t+1} = G(K_t, I_t) = (1-\delta)K_t + I_t \tag{1.3}$$

$$\text{Definition:} \quad R_t = (1+r_t)(1+r_{t-1})...(1+r_{t_0}) \tag{1.4}$$

Y_t is the period output of the representative firm which is a function of capital and labor input, and the w_t is the exogenously determined wage. Note that in a standard model, period $t+1$ capital stock (K_{t+1}) is sum of period t capital stock(K_t) and investment (I_t) net of depreciation (δK_t); therefore, a unit increase in investment lead to a unit increase in future capital stock. There is no capital rental market in this economy as the firms own the capital used in the production. R_t is the aggregate compounded investment return from period t_0 to t and δ is the depreciation rate of the physical capital, which is assumed constant. The first order conditions yield:

$$\begin{aligned} 1 + r_t &= \left(F_1(K_t, L_t) + \frac{G_1(K_t, I_t)}{G_2(K_t, I_t)} \right) G_2(K_{t-1}, I_{t-1}) \\ &= F_1(K_t, L_t) + 1 - \delta \end{aligned} \tag{1.5}$$

$$F_2(K_t, L_t) = w_t \tag{1.6}$$

for all periods $t > t_0$.[5] It is evident from equation (1.5) that the key determinant of the relationship

[5]Note that equation (1.5) can also be written as $1 + r_t = \frac{F_1(K_t, L_t)}{p_{t-1}^{k_t}} + (1-\delta)\frac{p_t^{k_{t+1}}}{p_{t-1}^{k_t}}$ such that $p_t^{k_{t+1}}$ is the relative price of installed capital in period $t+1$ in period t output. This follows from the fact that $G_2(K_t, I_t)$ is the marginal rate of transformation of a consumption good in period t to installed capital in period $t+1$ (Cochrane, 1991). Therefore

between the period marginal product of capital ($F_1(K_t, L_t)$) and the investment return (r_t) is the capital accumulation equation($G_(K_t, I_t)$). Thus, if there exists any friction in the capital accumulation process, then the cross-country investment return and marginal product of capital patterns may diverge.

Assuming a constant return to scale Cobb-Douglas production function($Y = AK^{\alpha}L^{1-\alpha}$),

$$\begin{aligned} F_1(K_t, L_t) &= A\alpha K_t^{\alpha-1} L_t^{1-\alpha} \\ &= \alpha A^{\frac{1}{\alpha}} y_t^{\frac{\alpha-1}{\alpha}} \end{aligned} \tag{1.8}$$

such that $y_t = \frac{Y_t}{L_t}$ and A is total factor of productivity or productive efficiency. The capital share of output (α) is assumed less than unity.

Since I assume that all firms in the economy share an identical production function, the output per unit labor should be identical across all entities. It follows from equations (1.5) and (1.8) that both the period investment return and marginal product of capital should decline with increases in output per unit labor. With these simplifying assumptions, the model predicts that firm-level marginal products of capital and investment returns should on average slope downwards when plotted against the aggregate output per unit labor. In this paper, I test these implications of the model using firm level data.

1.2.2 Empirical Methodology

In this subsection, I describe the methodology to estimate marginal products of capital and investment returns used in the empirical analysis. To proxy for the two variables of interest, I use accounting and finance measures of profitability with some modifications to better align them with the economic definitions described in the standard model.

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in equilibrium, the price of an installed capital in period $t+1$ in period t output is

$$p_t^{K_{t+1}} = \frac{1}{G_2(K_t, I_t)} \tag{1.7}$$

and $\frac{F_1(K_t, L_t)}{p_{t-1}^{k_t}}$ is a price corrected measure of marginal product of capital that is consistent with Caselli and Feyrer (2007). With a standard capital accumulation equation, $p_t^{k_{t+1}} = 1$ for all t, which suggests that buying a unit of capital at time t costs a unit of consumption good. However, the relative price can diverge from a unity if there exists any friction in the capital accumulation process.

From equation (1.8), one can easily derive the following expression for marginal product of capital.

$$F_1(K_t, L_t) \quad = \quad \alpha \frac{y}{k} \tag{1.9}$$

Since α is the capital share in output, this expression suggests that the marginal product of capital is the ratio between the portion of earnings that accrue to capital holders (in the model these is simply the firm), and the firm's assets.[6] The empirical estimations use the return on assets(ROA) as a measure of the marginal product of capital as follows:

$$ROA_{c,t,i,f} \quad = \frac{EBITDA_{c,t,i,f}}{(MVA_{c,t1,i,f})(1+infl_{c,t})} \tag{1.10}$$

$EBITDA_{c,t,i,f}$ is the earnings before interest, tax, depreciation and amortization, and measures the income that accrues to capital holders or the firm f in industry i in period t in country c. I use this measure of earning rather than net income since the model assumes that, the firm owns all of its capital assets, and therefore there are no interest costs. In the analysis, and following accounting practice, I further adjust this measure of income for extraordinary gains/costs. The adjustment is necessary as these costs/gains are often unrelated to everyday business operations which is of interest in the model, and can increase the volatility of earnings by inflating or deflating the income from the operations.[7] $MVA_{c,t,i,f}$ is the current market value of the firm's assets[8], and is defined as $MVA_{c,t,i,f} = Debt_{c,t,i,f} + MV_{c,t,i,f}$. $Debt_{c,t,i,f}$ is the book value of debt and the $MV_{c,t,i,f}$ is the market value of equity for the firm f in industry i in period t in country c. Poterba(1998) uses a similar measure to estimate the return to tangible capital at an aggregate level.

This measure differs from the standard accounting ROA, which uses the book value of the

[6]Note that this general expression of the marginal product of capital should hold even if the firms have increasing/decreasing return to scale Cobb-Douglas type production function

[7]The main empirical result of the analysis, however, remains robust even with the extraordinary costs/gains

[8]note that this is also the replacement value of the asset based on the q-theory of investment and is similar to the measure used in Fama and French (1999)

assets in the denominator as the measure of capital. Although this ratio is widely used in finance and accounting[9], assets on the balance sheet are measured at the acquisition cost. As the market value of an asset can change over time (e.g., the value of buildings or land may appreciate as urban centers develop), the value of assets on financial statements may not correctly reflect current values and may even lead to a misleading result. Therefore, I replace the denominator of the indicator with the sum of the book value of debt and market value of equity. As total assets necessarily equal the sum of liabilities and equity, this ought to provide a more accurate estimate of the replacement value of an asset in period $t-1$ under perfect capital markets.[10] The value of assets at the end of period $t-1$ is used in the denominator as a measure of what the firm owns entering period t. This is the capital that is employed during period t to generate the income $EBITDA_{c,t,i,f}$. Due to the time discrepancy between the measurement of the capital stock and income, assets are adjusted for inflation using $infl_{c,t}$, which is consumer price inflation in country c during period t.

To derive a testable expression for the investment return, I use equation (3), which can be rewritten as:

$$1-\delta = \frac{K_{t+1}-I_t}{K_t} \tag{1.3a}$$

If the equation (5) holds true,

$$r_t \quad = \quad \frac{\alpha Y_t - I_t + K_{t+1} - K_t}{K_t} \tag{1.11}$$

Note that this is the internal rate of return equation commonly used in finance to assess the profitability of an investment [11]. It measures the investment return that capital owners can receive by purchasing one unit of capital at time t, and selling it at period t+1.

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[9]See Eisenberg, et al (1998), Guenther and Young (2000), Chaney, et al (2004), Bowen, et al (2008)

[10]Debt also enters financial statements at a historical cost, and the interest rate on debt may differ across time. However, the income used in the analysis is income before the interest, and therefore, even if debt is refinanced at a "current" rate of interest, it should not affect the ROA measure used in the analysis.

[11]see Gordon (1974), Salamon(1985), Fama and French(1999), Graham and Harvey(2001)

Using equation (11) as the benchmark, I derive the following expression to measure the investment return:

$$IRR_{c,t,i,f} = \frac{EBITDA_{c,t,i,f} + [-Adj\Delta Asset_{c,t,i,f} + MVA_{c,t,i,f} - MVA_{c,t-1,i,f}]}{MVA_{c,t-1,i,f}} - infl_{c,t} \quad (1.12)$$

This definition is similar to a period investment return measure employed by Fama and French (1999) for the US stock market. In their paper, this estimate is termed "internal rate of return on value" and is used as the measure of "the return required by investors," or more precisely, "an estimate of what an investor would have earned during our sample period by passively investing in all corporate securities as they enter the sample." $Adj\Delta Asset_{c,t,i,f}$ is a measure of period investment, which is defined as $Adj\Delta Asset_{c,t,i,f} = \Delta Asset_{c,t,i,f} + Depreciation_{c,t,i,f}$. $\Delta Asset_{c,t,i,f}$ is the change in the book value of assets. This measures the current value of tangible asset investments by firms as financial statements are filed using the historical basis approach, i.e., assets are valued at the acquisition price. I note that this measure of investment does not include a significant portion of the R&D spending by the firm. Due to accounting conservatism and uncertainty about the success of the R&D activity, R& D spending is considered as a cost rather than an asset, and is thus, expensed. These R&D spending, however, should be captured in $EBITDA_{c,t,i,f}$, and therefore the overall measure of investment return remains unaffected.

If the capital accumulation process outlined in equation (3) accurately describes the data, the values inside the square bracket equals $-\delta MVA_{c,t-1,i,f}$, and $IRR_{c,t,i,f} = ROA_{c,t,i,f} - \delta$, as implied by the model. I further adjust the investment return for inflation in the respective countries to estimate the real return.

1.3 Data and Summary Statistics

Financial and market data used to calculate the firm-level marginal product of capital and investment return are from Worldscope Datastream. Datastream is a preferred source of data for the cross-country comparison because it not only provides an extensive accounting and market data on listed firms across countries, but also aims to "provide the data in a manner that allows maximum comparability between one company and another, and between various reporting regimes"

(Worldscope/Disclosure Partners, 1992). These adjustments by the Worldscope help minimize the potential bias from the cross-country differences in accounting standards.

Although Datastream takes extensive measures to increase the accounting comparability across countries, I further check for the effects of cross-country differences in accounting standards by running robustness test restricting the analysis to the countries that adopted IFRS. Since the mid-2000s there has been increasing attempt led by Euro-zone countries to unify the accounting standards across countries. This has led to a formation of International Accounting Standards Boards (IASB), with the explicit goal "to develop an internationally acceptable set of high quality financial reporting standards." (Barth, et al 2008) Although the United States is yet to adopt IFRS, the standard has been adopted in EU countries by 2005, and majority of MSCI developed and emerging countries by 2011–a list is available in the Appendix. Many other countries that are yet to adopt IFRS have announced their plans for convergence in the near future. For example, India's Ministry of Corporate Affairs released a roadmap for the convergence with the IFRS, and all Indian companies whose securities traded in a public market other than the SME Exchange, will be required to use IFRS by 2017. These efforts may lead to even greater data comparability going forward facilitating firm-level research. In this paper, I find that the main results remain robust to the cross-country differences in accounting standards.

The countries used in the analysis are MSCI emerging and developed countries that have relatively well established stock markets.[12] Exchange floor in developing countries are often very new (e.g., Laos opened its stock exchange in 2011, Syria in 2009, and Somalia in 2012), and in many cases Datastream does not carry data on the firms traded on these exchanges as the market capitalization of these countries is very small (e.g., the Maldives Stock Exchange had only five firms listed as of 2008). Some developing countries do not have a national stock exchange (e.g., Angola, Brunei). Restricting the analysis to MSCI emerging and developed countries reduces the countries in the sample, but as Reinhart and Rogoff (2004) point out "roughly 25 'emerging markets' account for the bulk of the financial flows". Therefore, analyzing the marginal product of capital and

[12]Saudi Arabia is dropped from the sample due to the limited availability of the firm-level data in early-2000s.

the investment return of the firms in MSCI developed and emerging countries can provide useful insights into factors that drive international capital flows.

The period of analysis is $1997 - 2014$. A long period is preferred for the analysis as it provides more reliable estimates of ROA and IRR patterns, but unlike macroeconomic aggregate data, which date back to mid-1900s, firm level data for emerging countries are often unavailable before 1995. Even though the estimation period used in the paper is relatively short compared to papers that use macroeconomic data, the period after 1995 is characterized by a large volume of international capital investment following "a series of trade and financial liberalization programs undertaken since the mid-1980s." (Kose, Prasad, and Terrones (2006)). Therefore, the period post-1990 is especially relevant for answering questions related to the marginal product of capital, investment returns and the observed patterns of international capital flows. A major drawback, however, is that the sample period includes the Global Financial Crisis, characterized by high levels of volatility in both earnings and market values. Thus, in the empirical analysis, I control for the time specific effect and also run a robustness check excluding the crisis period.

Within the Worldscope dataset, I exclude firm-years with missing market value, assets, liabilities, depreciation, EBITDA or extraordinary gains/cost. I also drop balance-sheet insolvent firm-years when total liabilities exceed total assets. As period $t-1$ asset values are used to calculate the period t ROA and IRR, firm-years without debt and market value from the previous year are also excluded from the sample.

The remaining data are winsorized at 1% and 99% by country to control for the outliers, following the accounting practice.[13] I repeat the analysis without the winsorization, and the results remain unchanged. To adjust for the industry-specific effects, I sort the firms into the Fama-French 48 industries.[14]. Firms in the financial sector are dropped from the analysis as the paper focuses on the real economy. To test for the robustness of the empirical results to changes in the industry

[13]Some of the major outliers in the sample are due to merger/acquisitions. Consider a listed firm that merged with another (listed or unlisted) firm in January 2000. The ROA_{2000} will be the ratio between the post-merger EBITDA, and the pre-merger asset value, and the indicator will be highly inflated. Major mergers are highly uncommon, but they can upwardly bias the results.

[14]The actual number of industries used in the analysis is 44, as 4 financial industries are dropped from the sample

classification schemes, I repeat the exercise using the 2-digit SIC (Standard Industry Classification) codes. After these exclusions, the main analysis uses 334,608 firm-years across 42 countries. Table 1 provides summary statistics for the raw data.

Table 1 shows that there is a large variation in the sample size across countries. The US has the largest sample size with 69,400 firm-years, closely followed by Japan with 52,501 firm-years. The sample size is the smallest for Colombia, which has only 365 firm-years. Industry diversity also differs across countries; all 44 Fama-French (FF) industries are observed in Australia, China, Canada, India, United Kingdom and the United States. On the other hand, only 23 FF industries are observed in Hungary. Purchasing power parity (PPP) adjusted real GDP[15], population, employment, and average hours worked per employed are from the Penn World Tables 9.0. As data on average hours worked is not available for China, I use GDP per capita as the baseline measure of output per unit labor in this paper; I later check the robustness of the result using the GDP per hour worked and find that the result remain unchanged. Consumer price indices are from the World Bank database.

Table 2 provides summary statistics for the return on assets (ROA) and internal rate of return (IRR) estimates across countries. The data show two idiosyncrasies. First, the mean ROA for Australia is negative during the analysis period (1997-2014). This is due to the significant underperformance of the metal mining industry during and after the financial crisis, and excluding the metal mining companies (SIC 2-digit code: 10), Australia's mean ROA turns positive.

Second, across the MSCI developed and emerging countries the average IRR is greater than the average ROA, a finding which seems at odds with the implications of the standard model ($r = MPK - \delta$). The mean IRR across MSCI developed and emerging countries between 1997 and 2014 is 9.2% and the mean ROA is 7.6%. However, upon further examination this pattern is due to a large rightward skewness in the distribution of IRR, illustrated in Figure 1. The graph shows that compared to the ROA distribution (Figure 1a), which is almost perfectly symmetric across the mean, the IRR distribution (Figure 1b) is skewed to the right.

[15]A detailed discussion about the construction of the PPP adjusted GDP is available on Feestra, et al (2015)

This pattern is also seen in the difference between the means and the medians in Table 2. The mean and the median ROA almost perfectly align with each other with a less than 1% difference between the two values. On the other hand, the mean and the median IRR differ by 6.4%! Due to the right skewness, even when the mean IRR is higher than the mean ROA, the median IRR is substantially lower than the median ROA. Thus, in the following section, I analyze not only the average cross-country patterns, but also the median trend across countries, to check for the effects of the skewness. The IRR is also substantially more volatile relative to ROA. The aggregate standard deviation for the ROA is 10%, but it is 49% for the IRR.

Figure 2 shows the two-way scatter plot between the median firm level ROA and IRR against the mean log(PCGDP) between 1997 and 2014. The figure also include the best fit line for the mean trend. Figure 2a is the two-way plot for the median ROA and the mean log(PCGDP); it shows a clear negative correlation between the two variables and a steep downward sloping best-fit line. On the other hand, the figure 2b, which is the two-way plot for the median IRR and the mean log(PCGDP), shows a positive correlation between the two variables and an upward sloping best-fit line suggesting a potential deviation between the cross-country marginal product of capital and the financial return patterns. While this positive financial return trend contradicts the predictions of the neoclassical model, it is consistent with the international capital flow pattern documented in Prasad, et al (2007). In the paper, they show that "the relative income of [current account] surplus countries has fallen below that of deficit countries. Not only is capital not flowing from rich to poor countries, in quantities the neoclassical model would predict–a paradox pointed out by Lucas (1990)– but, in the last few years it has been flowing from poor to rich countries".

Although the scatter plots are highly revealing, the trend may be driven by firm-specific factors; the firms in emerging countries may engage in more risky business, and may face greater financial constraints relative to their peers in the developed markets. Therefore, in the following section, I conduct empirical analysis controlling for the firm and industry specific factors that could have led to the observed results.

1.4 Cross Country Marginal Products of Capital and Investment Return Patterns

The standard neoclassical model predicts that both firm-level marginal product of capital and investment return will correlate negatively with per capital GDP. In this section, I conduct empirical analysis to test the implications of the standard model using firm-level data.

1.4.1 Firm-Level Return on Assets and Per Capita GDP

To formally assess the relationship between aggregate output per unit labor and the firm level profitability (return on assets), I estimate the following benchmark specification:

$$MPK_{c,t,i,f} = \alpha + \beta_1 log(PCGDP_{c,t}) + \beta_2 D_t + \beta_3 F_i + \boldsymbol{\gamma} \boldsymbol{X_{c,t,i,f}} + \epsilon_{c,t,i,f} \tag{1.13}$$

$MPK_{c,t,i,f}$ is the return on assets (ROA) for a firm f in industry i in country c in period t, and $PCGDP_{c,t}$ is the purchasing power parity adjusted real per capita GDP in country c in period t in 2011 US dollars that I use as a proxy for output per unit labor. D_t and F_i are time and industry dummies that are added to control for global macroeconomic shocks that occurred during the period of analysis, or an industry specific trend. $\boldsymbol{X_{c,t,i,f}}$ is the vector of firm specific factors, which includes the log size (the book value of assets denominated in USD; the value is adjusted for the inflation using the CPI index), leverage (book debt to equity ratio), and the equity price-to-book ratio. This vector adjusts for firm-specific risk, which are absent in the standard model. This vector of firm specific factors is motivated by Fama and French (1992); in the paper authors write that "if assets are priced rationally, our results suggest that stock risks are multidimensional. One dimension of risk is proxied by size, ME. Another dimension of risk is proxied by BE/ME, the ratio of the book value of common equity to its market value." Leverage is added for completeness although the effect of leverage on the return is debated in the literature.[16] Note that the riskiness of the firm is expected to rise with a decrease in size and an increase in leverage and the price to book ratio. Errors are clustered in country-year to control for the firm-level error correlation within the country-year groups. As stated in their heavily cited paper, Cameron and Miller

[16] see Fama and French (1992), Penman, et al (2007)

(2015) write, "[f]ailure to control for within-cluster error correlation can lead to very misleadingly small standard errors, and consequent misleadingly narrow confidence intervals, large t-statistics and low p-values." Therefore clustering of errors should enhance the precision of the coefficient estimates.[17]

I do not include the country fixed effect in the benchmark regression due to the relatively moderate time dimension of the dataset (less than 20 years). Although country fixed effect is an attractive way to control for unobserved non-time varying country characteristics, "[i]nclusion of country fixed effects also affects the estimated coefficients of explanatory variables... Coefficients on country variables that are constant (such as geographical features and colonial history) cannot be estimated at all, and variables that have little within-country time variation cannot be estimated with precision."(Barro, 2012). Considering the relatively small change in PPP adjusted PCGDP in 1997-2014 period especially among developed countries, the bias from the inclusion of country fixed effect is unlikely to be negligible. However, in appendix I do present the regression result with country fixed effect for periods 1997-2014 for robustness, and I find that the main result remain unchanged.[18]

Table 3 reports the results from the regression model. Column (1) shows the results for the MSCI developed and emerging countries between 1997 and 2014. Size has a statistically significant positive effect on the return on assets, and the price to book ratio and leverage have a negative and significant effect confirming the prediction that firm-level ROA rises with the increase in the firm specific risk. The statistically significant negative relationship between per capital GDP and the firm ROA shows that the implication of the standard neoclassical model holds during the period across firms in MSCI developed and emerging countries and controlling for the firm, industry, and time specific effects. In other words, as the model predicts the firm ROA falls with increases in the

[17]The errors are clustered by country-year rather than country due to limited number of country clusters. Camerona and Miler (2015) state "we note that there is no specific point at which we need to worry about few clusters. Instead, 'more is better'. Current consensus appears to be that $G = 50$ is enough for state-year panel data." The authors also add that more clusters are needed in case of the unbalanced panel. Since the maximum possible number of country cluster is 42, which is arguably too few even for the balanced panel, I use country-year cluster for the main analysis. Regression result with country clusters however, are also presented in the appendix and the findings of the paper do remain robust.

[18]Appendix also presents regression results with firm-fixed effect and find that the main findings remain unchanged.

proxy for labor productivity. This finding also suggests that if, on average, the first order condition that equates the marginal product of capital and the investment return holds, then investment returns should also be inversely correlated with per capita GDP.

Column (1) shows that, on average, the firm-level ROA declines with increases in per capita GDP, but does not provide any insight on how the pattern differs within the sample. For example, what is the relationship between firm ROA and per capita GDP when we examine high productivity firms with an above average return on assets. Quantile regressions make up for this shortcoming of the OLS regression by modeling the relationship between the specified percentile of the response variable and the control variables, i.e., the median quantile regression portrays the relationship between the median marginal product of capital and the predictor variables, etc. For a more comprehensive analysis, I run a quantile regression for the 25th, 50th (median), and the 75th percentile firms. Also note that this question is particularly important in analyzing the differences between internal rates of return (IRR) and the return on assets, due to the high level of skewness observed in the distribution of the internal rates of return in Table 2.

Columns $(2) - (4)$ show that the coefficient on per capita GDP is consistently statistically significant across the 25th, 50th, and the 75th percentiles. The negative slope is the steepest for the firms in the 75th percentile of ROA, and there is a little difference in the slope between the 25th and the 50th percentile. The finding suggests that the effect of the changes in the aggregate output per unit labor is most acutely felt by the "most productive" firms in the economy.

As the data section mentions, the period of analysis includes the global financial crisis, during which financial systems went through substantial stresses.[19] Therefore, I repeat the exercise in column (1) for the 2011-2014 post-financial crisis period. Due to the short period of analysis, the values are susceptible to skewness from the market volatility, but the regression results presented in column (5) confirm the findings in column (1). Columns (6) and (7) check for the effect of the cross-country differences in the accounting standards. Column (6) repeats the regression in column (5) using firms from the countries that adopted the International Financial Reporting Standards

[19] see Hanson, et al (2011)

(IFRS) during the post-financial crisis period, and the column (7) shows the results using firms in MSCI EU countries during 2006-2014– the European Union officially adopted IFRS starting 2005.[20] This result is particularly insightful as the area enjoys a relative low capital flow barriers across countries within the Eurozone[21] which is consistent with the free-capital flow assumption within the standard neoclassical model. The results presented in columns (5)-(7) of Table 3 show that the inverse correlation between per capita GDP and firm-level ROA is surprisingly consistent across time, and is robust to cross-country differences in accounting standards.

Table 4 examines the relationship between ROA and per capita GDP with industry-level controls. I estimate the following industry by industry regression for each of the 48-Fama French industry (44 excluding financial industries) using the base sample of firms in the MSCI developed and emerging countries between 1997 and 2014. Table 4 presents the results.:

$$MPK_{c,t,f} = \alpha + \beta_1 log(PCGDP_{c,t}) + \beta_2 D_t + \boldsymbol{\gamma X_{c,t,f}} + \epsilon_{c,t,f} \tag{1.14}$$

Table 4 confirms that the cross-country pattern observed in the Table 3 is not industry-specific. Firm ROAs decline with increases in per capita GDP in almost all 44 non-financial Fama-French industries. Thirty six industries have statistically significant negative coefficients for per capita GDP, and only one industry (aircraft manufacturing) has a statistically significant positive coefficient. The negative coefficient is steepest in the medical and the defense industries, which require high-levels of human capital. The Appendix presents a similar analysis using SIC 2-digit industries and the results remain unchanged. A majority of industries have a statistically significant negative coefficient for per capita GDP, and only a few industries have an insignificant or positive coefficient.

Table 5 further shows that the observed results are not time-specific. It shows the results for

[20] see Guggiola (2010)

[21] "In the EUs single market (sometimes also called the internal market) people , goods , services , and money can move around the EU as freely as within a single country. "(European Union, n.d.)

the following estimating equation using the base sample:

$$MPK_{c,i,f} = \alpha + \beta_1 log(PCGDP_c) + \beta_2 F_i + \boldsymbol{\gamma X_{c,i,f}} + \epsilon_{c,i,f} \tag{1.15}$$

Between 1997 and 2014, we observe a statistically significant negative coefficient for all years. The coefficient is most negative during the financial crisis (2007 and 2009). The negative coefficient slowly flattens post-2010, as the developed countries recover. Conversely, the negative slope is relatively flat during the Asian Financial Crisis (1998) and slowly steepens as the Asian tigers move out of their deep recessions.

The results presented in this section show that consistent with the neoclassical model, the marginal product of capital is higher in countries with low per capita GDP. In the following subsection, I repeat the exercises using the investment return (IRR).

1.4.2 Investment Returns and Per Capita GDP

In order to test for the validity of the firm first order condition described in equation (6), I use the following regression specification:

$$r_{c,t,i,f} = \alpha + \beta_1 log(PCGDP_{c,t}) + \beta_2 D_t + \beta_3 F_i + \boldsymbol{\gamma X_{c,t,i,f}} + \epsilon_{c,t,i,f} \tag{1.16}$$

The predictor variables in the equation are identical to those in equation (13), but the dependent variable is now the internal rate of return ($IRR_{c,t,i,f}$). As in the equation (13), firm-level factors such as size, leverage, and the price to book ratio control for the firm-specific characteristics, and industry and time dummies control for industry and time specific effects. Errors are also clustered in country-year groups as in the previous subsection. If the standard relationship between the firm investment return and marginal product of capital holds, then the internal rate of return should also be inversely correlated with per capita GDP.

Table 6 presents the results. Column (1) reports the results for the MSCI developed and emerging countries between 1997 and 2014. Despite the statistically significant negative relationship with marginal product of capital observed in the previous subsection, the coefficient on per capita

GDP is not statistically significant when one controls for firm and industry specific factors. This result implies that the cross-country marginal product of capital and investment return patterns do not necessarily mirror each other– as the neoclassical model predicts. This finding questions the validity of the standard approach which uses aggregate marginal product of capital to explain the pattern of international capital flows. The finding also suggests that even accurate measures of marginals product of capital may not explain patterns of international capital flows as the marginal product of capital may be an inaccurate proxy for investment returns.

The finding therefore suggests that "there is no prima facie support for the view that international credit frictions play a major role in preventing capital flows from rich to poor countries." (Caselli and Feyrer, 2007). As Lucas suggests, if investment returns are inversely correlated with per capita GDP, capital ought to flow rapidly from developed to emerging market countries and any deficiencies in these flows imply international financial market frictions. However, the results in Column (1) suggest that the investment returns are relatively equal across developed and emerging countries and therefore there may not be an incentive for the capital to flow to the emerging markets since opportunities with similar investment returns also exist within developed economies. This empirical evidence does not appear consistent with the claim that international investment barriers play a major role in explaining the lack of capital flow to emerging countries. A potential resolution to the Lucas paradox may therefore lie in the cross-firm or cross-industry variation in internal rates of return within countries.

As in the previous subsection, I run a quantile regression to identify the within sample heterogeneity in response to the changes in the per capita GDP. Given the large rightward skewness in the data from the summary statistics in Table 2, this analysis is particularly important for the internal rates of return. Compared to the results in Table 3, the quantile regression results in Table 6 display a greater variation across percentiles. The regression results presented in Columns (2),(3) and (4) show that the coefficient on per capita GDP is positive and statistically significant at 1% level for the bottom 25th percentile and the median. On the other hand, it is negative and statistically significant for the firms in the 75th percentile. The estimates suggest that although the best performing firms within the emerging countries can successfully translate higher marginal product of capital

to higher investment returns, this is not necessarily true for the less-productive firms in the country. One should also note that the counter-intuitive positive coefficient is steeper for the bottom 25th percentile versus the median. This strengthens the argument by Banerjee and Duflo (2005) which suggests that the key to Lucas Paradox may not lie so much with 'international' factors, but 'domestic' factors.

Column (5) presents the results for the post-financial crisis period and reaffirms the divergence between the marginal product of capital and the investment return patterns observed in column (1). The coefficient on $PCGDP$ is positive and statistically significant, which implies that the investment return in developed countries is in fact higher than that in emerging countries during the sample period. Column (6) repeats the regression in column (5) using only the firms that adopted IFRS accounting standards during the period, and documents that the cross-country pattern observed in column (5) is robust to cross-country differences in the accounting standards. Column (7) also repeats the exercise in column (1) using the MSCI EU countries that share the streamlined IFRS accounting standard since 2005 and finds that $PCGDP$ is statistically insignificant.

Table 7 shows the results for the following specification to check for any variation in cross-country IRR patterns across industries:

$$r_{c,t,f} = \alpha + \beta_1 log(PCGDP_{c,t}) + \beta_2 D_t + \boldsymbol{\gamma X_{c,t,f}} + \epsilon_{c,t,f} \tag{1.17}$$

The results confirm the aggregate pattern observed in Table 6. The coefficient on per capita GDP is statistically insignificant or positive and significant in 35 out of 44 industries. Only nine industries have a statistically significant negative coefficient, and the slope is barely significant at the 10% level in the four among the nine industries. This result contrasts sharply with Table 4, in which 36 industries have a statistically significant negative coefficient. It further confirms the finding that the cross-country marginal product of capital pattern does not appear to match the investment return pattern.

Table 8 displays the results of estimating the following regression specification to check for

annual variation in the cross-country internal rate of return pattern:

$$r_{c,i,f} = \alpha + \beta_1 log(PCGDP_c) + \beta_2 F_i + \boldsymbol{\gamma X_{c,i,f}} + \epsilon_{c,i,f} \tag{1.18}$$

Between 1997 and 2014, the coefficient on $PCGDP$ is statistically insignificant or positively significant for 10 years. The negatively significant coefficient is observed for eight years, and four of the eight years occur around the financial crisis (2006-2008, and 2010). The negative slope is also the steepest during this period (2006 and 2010). The finding again confirms that the inverse correlation between the marginal product of capital and per capita GDP does not necessarily translate to an inverse correlation with investment returns as the neoclassical model predicts.

The empirical result in this section documents a divergence between the cross-country investment return and the marginal product of capital patterns, and show that this finding is surprisingly robust across different sets of countries and time periods. This result questions the validity of the traditional approach which uses marginal product of capital to explain the international capital flow patterns, and further suggests that the standard link between marginal product of capital and the financial return does not hold in a sample of developed and emerging countries between 1997-2014. As this standard link between the two variables stems from the frictionless capital accumulation equation, this empirical finding highlights the importance of cross-country capital efficiency (i.e. the level of future capital input that can be obtained from a unit investment today) difference in explaining the Lucas Paradox.

In the following subsection, I check the effect of cross-country difference in the employment and taxes, to further confirm the robustness of the result documented thus far.

1.5 Additional Test and Robustness Checks

In this subection, I test the robustness of the findings presented in the previous subsection by adjusting for the cross-country heterogeneity in hourly labor input and corporate tax rate. I find that the main result presented in the previous subsection remain unchanged.

1.5.1 Robustness Check: Hourly labor input

In the previous two subsections, I use per capita GDP as the measure of output per unit labor. While this is a widely used measure of economic performance[22], in this subsection, I check the robustness of the results using output per hours worked.

Output per hours worked is estimated using the following equation:

$$PHGDP_{c,t} = \frac{GDP_{c,t}}{AHW_{c,t} * Emp_{c,t}} \tag{1.19}$$

$AHW_{c,t}$ is the average annual hours worked by person employed, and $Emp_{c,t}$ is the employed population in country c, in time t. $PHGDP_{c,t}$ is a commonly used measure of labor productivity in the macroeconomics literature[23] and is more precise measure of the output per unit labor input relative to $PCGDP_{c,t}$, as it measures the labor input by hour. Another commonly used measure of productivity is GDP per person employed. However, this ratio tend to over-estimate the productivity of workers in emerging countries as it fails to account for the longer working hours in emerging countries. Even in 2014, the average annual hours worked by person employed in Thailand was almost 1.7 times that in Germany. Therefore, ignoring cross-country differences in the average hours worked can bias the results over-estimating the labor efficiency of the workers in emerging countries. One drawback of the output per hours worked measure is that China has to be dropped from the sample due to a lack of data. However, the regression result using the 315,373 firm-years across 41 countries should still provide a reliable estimate of the cross-country return patterns.

To check the robustness of the results presented in sections 4.1 and 4.2, I use the following equations, which replace $log(PCGDP_{c,t})$ with $log(PHGDP_{c,t})$:

$$MPK_{c,t,i,f} = \alpha + \beta_1 log(PHGDP_{c,t}) + \beta_2 D_t + \beta_3 F_i + \boldsymbol{\gamma X_{c,t,i,f}} + \epsilon_{c,t,i,f} \tag{1.13'}$$

[22] see Caselli and Feyrer (2007), Banerjee and Duflo (2005), Gourinchas and Jeanne(2009)

[23] see Freeman(1988), O'Mahony and Boer (2002), Prescott (2004)

$$r_{c,t,i,f} = \alpha + \beta_1 log(PHGDP_{c,t}) + \beta_2 D_t + \beta_3 F_i + \boldsymbol{\gamma X_{c,t,i,f}} + \epsilon_{c,t,i,f} \qquad (1.16')$$

Table 9 presents the results. Columns (1)-(4) reports results for the equation (13'), and columns (5)-(8) report results for equation (16'). The columns (1)-(4) show that the findings about the marginal product of capital from section 4.1 remain robust. The coefficient on per capita GDP is negative and significant for the base sample excluding China (Column 1), post-financial crisis period (Column 2), and in Euro-zone post-2005 (Column 4). The coefficient on per capita GDP is statistically insignificant for post-financial crisis period IFRS countries (Column 3), which may be due to the small sample size. Columns (5)-(8) further highlight the findings on internal rates of return in section 4.2. The coefficient on per capita GDP is positive and significant for the base sample excluding China (Column 5), post-financial crisis period (Column 6), and post-financial crisis period IFRS countries (Column 7). Per capita GDP has a statistically insignificant impact on internal rates of return in Euro-zone countries post-2005 (Column 8).

The empirical results presented in this section confirm the findings of section 4.1 and 4.2, and questions the validity of the standard approach which use marginal product of capital to explain the international capital flow.

1.5.2 Robustness Check: Tax adjusted income

In the previous two sections, I use EBITDA as a measure of the capital owner's earnings to calibrate firm ROAs and investment returns. Although EBITDA is a consistent with the standard model, it does not take into account government taxes, which reduce the actual income received by the capital holders. Therefore, in this section, I check the robustness of the main results using the following tax-adjusted estimates of MPK and the investment return, following the example of Fama and French (1999)[24]:

[24] I do note that this is not the most accurate measure of the tax-adjustment due to deferred taxes within most firms, but should nevertheless provide a quick check for the effect of tax. More complete robustness check is beyond the scope of this paper, but should be conducted in a future work.

$$ROA_{c,t,i,f} = \frac{EBITDA_{c,t,i,f}(1-tr_{c,t,i,f})}{(MVA_{c,t-1,i,f})(1+infl_{c,t})} \tag{1.20}$$

$$IRR_{c,t,i,f} = \frac{EBITDA_{c,t,i,f}(1-tr_{c,t,i,f})+[-adj\Delta Asset_{c,t,i,f}+MVA_{c,t,i,f}-MVA_{c,t-1,i,f}]}{MVA_{c,t-1,i,f}} - infl_{c,t} \tag{1.21}$$

$tr_{c,t,i,f}$ is the income tax rate on firm f, in industry i in time t, in country c. An alternative expression for tax-adjusted income is $EBITDA_{c,t,i,f} - Tax_{c,t,i,f}$, where $Tax_{c,t,i,f}$ is the actual income tax on firm f. However, $EBITDA_{c,t,i,f}(1-tr_{c,t,i,f})$ should provide a tax-adjusted income estimate that is more consistent with the model, as the amount of tax imposed on the firm is based on the income after deduction of interest income and expense. Therefore, $EBITDA_{c,t,i,f} - Tax_{c,t,i,f}$, where $Tax_{c,t,i,f}$ is the actual income tax on firm f, and should lead to large variation on the post-tax income based on the capital structure of the specific firm. On the other hand, the estimate based on the tax rate is less affected by the capital structure of the firm, reducing potential bias from the capital structure differences across the firms.

The tax-adjusted measures of ROA and IRR reduce the size of the sample, as they exclude firm-years without tax-rate data. Therefore, the cross-country pattern is estimated using 211,407 firm-years across 42 countries, rather than 315,373 firm-years. Table 10 presrnts the empirical results from equations (13) and (16), using the tax-adjusted ROA and IRR. Columns (1)-(4) report the results from the equation (13), and columns (5)-(8) report the results from the equation (16). Columns (1)-(4) confirm the original finding that $log(PCGDP_{c,t})$ and the marginal product of capital are inversely correlated. The coefficient for $log(PCGDP_{c,t})$ is significantly negative in the base sample (Column 1), post-financial crisis period (Column 2), IFRS countries post financial period (Column 3), and Euro-zone countries post 2006 (Column 4). On the other hand, column (5) shows that the $log(PCGDP_{c,t})$ is a positive and significant predictor of IRR in the base sample. These findings corroborate the evidence about the the differences between the cross-country marginal product of capital patterns and the investment return patterns observed in sections 4.1 and 4.2. These differences are also observed in columns (6) and (7), which document positively significant coefficient for $log(PCGDP_{c,t})$ in post-financial crisis period, IFRS countries post-financial

crisis period. $log(PCGDP_{c,t})$ is statistically insignificant in Euro-zone countries post-2006.

These finding shows that the empirical result documented in sections 4.1 and 4.2 are extremely robust across different specifications and samples. There seems to be a non-negligible gap between the cross-country marginal product of capital pattern and the investment return pattern, which suggests that the question "why the capital doesn't flow to emerging countries?" is intricately tied to this gap between the two variables. Based on this finding, in the following section I propose a modification to the traditional neoclassical model, which can potentially model the gap between marginal product of capital and investment return documented in this section. I also investigate alternative macroeconomic variables often used in the Lucas Paradox literature, to find the factors that can potentially affect the size of the observed gap between the marginal product of capital and the investment return.

1.6 Conclusion

According to the textbook neoclassical theory, if two countries share the identical production function, and the trade in capital good is free and competitive, new investment will only occur in the poorer country since the marginal return to capital should be higher in economies with less capital (due to the law of diminishing return). However, as Lucas pointed out in his seminal paper in 1990, observed capital flow from developed to developing countries fall short of what should be observed according to the theory. This phenomena has been named "Lucas Paradox" and has been one of the major puzzles in the macroeconomic literature.

In this paper, I show using the firm-level data that despite the higher marginal product of capital in emerging countries, financial return are equalized across developed and emerging countries. This finding is significant as it questions the validity of using marginal product of capital in explaining the international capital flow. The empirical result suggest that marginal product of capital trend does not mirror the investment return trend due to the cross-country difference in the capital efficiency, i.e., the level of future capital input that can be obtained from a unit investment today. The effect of the capital adjustment cost can be sufficiently large that it can divorce the cross-country financial return pattern from the marginal product of capital pattern. Therefore, the answer to "Lucas Paradox" may simply be that the investment return is equalized across countries,

despite the international difference in marginal product of capital. This finding also suggests that the key issues in explaining the international capital flow is not an ”international” credit frictions but rather a ”domestic” credit frictions which affects the capital accumulation process. Thus, the future research on Lucas Paradox should focus not only on factors that affect productive efficiency, but also those that affect the capital efficiency.

This paper differs methodologically from most others in the literature in that it uses the firm level data instead of an aggregate data to explain the cross country differences in return and marginal product of capital. The firm level data has an advantage over macroeconomic data in that it allows direct computation of marginal product of capital and the financial return. This allows one to test the validity of the firm first order condition that is at the heart of the Lucas Paradox. Despite this major benefits of the firm-level data, it also has some major drawbacks. It restricts the analysis to mid-to large-size firms that are listed in the stock market. One may argue that the return found using only the firm level data is biased upward as it doesn't include self-employed workers, or mom-and-pop stores. This is a plausible argument, and the future research, based on a larger dataset that encompasses both the unlisted firms and the self-employed workers should help increase the understanding of the capital market frictions.

Table 1.1: Data Summary Statistics (1997-2014)

The sample includes all non-financial (all SIC codes except 6000∼6999) balance sheet solvent firm-years in the Worldscope database with 1) market value(WC08001), assets(WC02999), liabilities(WC03351), depreciation(WC01151), EBITDA(WC18198), extraordinary credit(WC01253) and extraordinary charge(WC01254) data for the year and; 2) debt and market value data for the previous year in the MSCI developed and emerging countries (excluding Saudi Arabia, Qatar and UAE) between 1997 and 2014. Purchasing Power Parity (PPP) adjusted per capita GDP (PCGDP) is calibrated using the PPP adjusted GDP(rgdpo) and the population (pop) estimate from the Penn World Table 9.0. Employed population (emp), and average hours worked per employed (avh) are also from the Penn World Table 9.0. CPI inflation is from the World Bank

Country	wbcode	Firm-years	Fama French Industries	PPP adjusted PCGDP (2014)	CPI Inflation (2014)	Population (2014, millions)	Employed (2014, millions)	Average Hours Worked per Employed (2014)
Australia	AUS	14,838	44	44,241	0.025	23.6	12.0	1,803
Austria	AUT	1,147	28	45,705	0.016	8.5	4.4	1,629
Brazil	BRA	1,450	35	14,811	0.063	206.1	105.9	1,711
Belgium	BEL	3,250	38	39,950	0.003	11.2	4.9	1,575
Canada	CAN	12,632	44	43,368	0.019	35.6	18.8	1,688
Chile	CHL	2,080	30	21,317	0.044	17.8	7.8	1,990
China	CHN	20,092	44	12,513	0.020	1,369.4	798.4	NA
Colombia	COL	365	24	12,858	0.029	47.8	24.6	1,772
Czech Republic	CZE	436	24	29,187	0.003	10.5	5.1	1,771
Denmark	DNK	1,890	37	44,423	0.006	5.6	2.8	1,438
Finland	FIN	1,929	36	38,343	0.010	5.5	2.6	1,643
France	FRA	8,637	43	38,584	0.005	66.1	27.3	1,473
Germany	DEU	9,037	43	46,507	0.009	80.6	42.5	1,371
Greece	GRC	3,643	37	24,685	-0.013	11.0	4.0	2,042
Hong Kong	HKG	11,342	42	45,134	0.044	7.2	3.7	2,234
Hungary	HUN	423	23	22,750	-0.002	9.9	4.2	1,860
India	IND	17,621	44	5,452	0.064	1,295.3	510.3	2,162
Indonesia	IDN	3,826	37	9,798	0.064	254.5	113.0	2,027
Ireland	IRL	782	26	51,927	0.002	4.7	1.9	1,821
Israel	ISR	3,187	40	31,606	0.005	7.9	3.9	1,880
Italy	ITA	3,141	36	35,324	0.002	59.8	23.6	1,734
Japan	JPN	52,501	44	35,566	0.027	126.8	65.0	1,729
Malaysia	MYS	11,427	42	21,650	0.031	29.9	13.8	2,268
Mexico	MEX	1,470	35	15,520	0.040	125.4	51.4	2,137
Netherlands	NLD	2,120	39	48,178	0.010	16.9	8.7	1,420
New Zealand	NZL	1,385	36	34,066	0.009	4.5	2.4	1,762
Norway	NOR	2,260	33	78,293	0.020	5.1	2.7	1,427
Peru	PER	986	26	10,931	0.032	31.0	14.7	1,790
Philippines	PHL	1,706	33	6,638	0.041	99.1	34.9	2,115
Poland	POL	3,053	40	24,450	0.001	38.6	15.8	2,039
Portugal	PRT	812	30	27,047	-0.003	10.4	4.3	1,857
Russia	RUS	1,869	35	24,056	0.078	143.4	71.9	1,985
Singapore	SGP	7,146	43	66,482	0.010	5.5	3.4	2,263
South Africa	ZAF	3,621	41	12,067	0.064	54.0	18.3	2,215
South Korea	KOR	16,906	43	34,955	0.013	50.1	26.1	2,124
Spain	ESP	1,883	36	32,858	-0.001	46.3	17.6	1,689
Sweden	SWE	4,761	42	42,605	-0.002	9.7	4.8	1,609
Switzerland	CHE	2,936	34	62,637	0.000	8.2	5.0	1,568
Thailand	THA	5,740	41	13,725	0.019	67.7	38.9	2,284
Turkey	TUR	2,907	36	19,675	0.089	77.5	24.6	1,832
United Kingdom	GBR	18,827	44	38,757	0.015	64.3	31.0	1,675
United States	USA	69,400	44	51,959	0.016	319.4	148.5	1,765
Total		335,464	44					

Table 1.2: Summary Statistics: ROA vs. IRR (1997-2014)

$$ROA_{c,t,i,f} = \frac{EBITDA_{c,t,i,f}}{(PV_{c,t1,i,f})(1+infl_{c,t})}$$

$$IRR_{c,t,i,f} = \frac{EBITDA_{c,t,i,f} + [-Adj\Delta Asset_{c,t,i,f} + PV_{c,t,i,f} - PV_{c,t-1,i,f}]}{PV_{c,t-1,i,f}} - infl_{c,t}$$

$ROA_{c,t,i,f}$ is the ratio between the firm EBITDA before extraordinary items (sum of EBITDA after extraordinary items (WC18198) and extraordinary cost (WC01254) minus extraordinary credit(WC01253)) and the market value of asset (sum of market value of equity(WC08001)and the book value of liabilities(WC03351)) from the previous year adjusted for CPI inflation. $IRR_{c,t,i,f}$ is the ratio between the sum of EBITDA before extraordinary item, change in the market value of asset less the change in the book value of asset and the market value of asset from the previous year adjusted for CPI inflation

		ROA			IRR		
		Mean	Median	SD	Mean	Median	SD
Australia	AUS	-0.001	0.020	0.183	0.184	0.007	0.920
Austria	AUT	0.098	0.098	0.069	0.065	0.042	0.275
Brazil	BRA	0.093	0.097	0.072	0.060	0.042	0.278
Belgium	BEL	0.139	0.124	0.108	0.102	0.052	0.354
Canada	CAN	0.065	0.084	0.139	0.132	0.037	0.626
Chile	CHL	0.107	0.099	0.085	0.062	0.025	0.303
China	CHN	0.062	0.052	0.061	0.146	0.011	0.577
Colombia	COL	0.132	0.119	0.093	0.062	0.007	0.365
Czech Republic	CZE	0.145	0.134	0.098	0.040	0.021	0.254
Denmark	DNK	0.085	0.092	0.087	0.071	0.032	0.342
Finland	FIN	0.094	0.097	0.070	0.088	0.061	0.313
France	FRA	0.087	0.087	0.076	0.067	0.042	0.303
Germany	DEU	0.080	0.088	0.095	0.063	0.040	0.345
Greece	GRC	0.072	0.069	0.075	0.120	-0.015	0.823
Hong Kong	HKG	0.063	0.064	0.118	0.150	0.011	0.749
Hungary	HUN	0.104	0.109	0.094	0.002	-0.025	0.333
India	IND	0.113	0.104	0.087	0.058	-0.029	0.459
Indonesia	IDN	0.111	0.099	0.105	0.072	-0.019	0.489
Ireland	IRL	0.075	0.084	0.079	0.137	0.065	0.551
Israel	ISR	0.069	0.076	0.102	0.083	0.034	0.424
Italy	ITA	0.079	0.082	0.064	0.030	0.020	0.229
Japan	JPN	0.081	0.077	0.059	0.055	0.027	0.244
Malaysia	MYS	0.090	0.088	0.085	0.044	0.015	0.317
Mexico	MEX	0.107	0.102	0.071	0.066	0.040	0.292
Netherlands	NLD	0.095	0.097	0.063	0.084	0.063	0.305
New Zealand	NZL	0.087	0.100	0.100	0.082	0.060	0.330
Norway	NOR	0.075	0.086	0.108	0.087	0.039	0.454
Peru	PER	0.155	0.137	0.127	0.157	0.074	0.510
Philippines	PHL	0.095	0.089	0.101	0.110	0.022	0.527
Poland	POL	0.085	0.084	0.094	0.073	0.011	0.473
Portugal	PRT	0.090	0.086	0.063	0.037	0.018	0.194
Russia	RUS	0.148	0.123	0.137	0.040	-0.014	0.476
Singapore	SGP	0.085	0.082	0.090	0.068	0.013	0.407
South Africa	ZAF	0.126	0.123	0.118	0.105	0.058	0.422
South Korea	KOR	0.091	0.093	0.113	0.068	0.018	0.391
Spain	ESP	0.090	0.087	0.062	0.077	0.049	0.268
Sweden	SWE	0.040	0.072	0.130	0.092	0.037	0.500
Switzerland	CHE	0.084	0.087	0.064	0.096	0.070	0.302
Thailand	THA	0.116	0.109	0.095	0.125	0.055	0.386
Turkey	TUR	0.108	0.091	0.106	0.016	-0.047	0.566
United Kingdom	GBR	0.066	0.086	0.106	0.085	0.037	0.490
United States	USA	0.063	0.081	0.111	0.110	0.048	0.534
Total		0.076	0.082	0.105	0.092	0.028	0.493

Table 1.3: MSCI Developed and Emerging Countries: Firm ROA and PCGDP

Purchasing Power Parity (PPP) adjusted per capita GDP (PCGDP) is calibrated using the PPP adjusted GDP(rgdpo) and the population (pop) estimate from the Penn World Table 9.0. Size is the inflation adjusted book value of the firm's asset in US dollar, and leverage is the ratio between the book value of liability and the assets. Price-to-Book measures the ratio between the market and the book value of the firm equity. Time dummies and industry dummies for the 48 Fama-French Industries are included in all regressions. Standard deviation is reported in the parenthesis.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Variables	ROA	ROA	ROA	ROA	ROA	ROA	ROA
Years	97-14	97-14 (25th)	97-14 (50th)	97-14 (75th)	11-14	11-14 (IFRS)	06-14 (EU)
log(PCGDP)	-0.0197***	-0.00897***	-0.00808***	-0.0140***	-0.0165***	-0.00968**	-0.00936**
	(0.00193)	(0.000250)	(0.000207)	(0.000248)	(0.00369)	(0.00379)	(0.00451)
log(size)	0.00990***	0.00960***	0.00604***	0.00308***	0.00855***	0.00906***	0.0139***
	(0.000796)	(7.11e-05)	(5.87e-05)	(7.03e-05)	(0.00172)	(0.00185)	(0.000601)
Leverage	-0.0338***	-0.0131***	-0.0294***	-0.0615***	-0.0333***	-0.0104	-0.0259***
	(0.00367)	(0.000808)	(0.000667)	(0.000799)	(0.00635)	(0.00878)	(0.00595)
Price-to-Book	-2.04e-05**	-0.000304***	-0.000122***	-2.25e-05***	-2.31e-05*	-7.71e-05***	-5.56e-05***
	(8.19e-06)	(2.45e-06)	(2.02e-06)	(2.42e-06)	(1.35e-05)	(2.93e-05)	(1.92e-05)
Constant	0.189***	0.0347***	0.119***	0.272***	0.166***	0.0597	0.0545
	(0.0227)	(0.00438)	(0.00361)	(0.00432)	(0.0411)	(0.0469)	(0.0466)
Observations	334,608	334,608	334,608	334,608	88,527	44,640	34,031
R-squared	0.127				0.119	0.136	0.116
Time Dummies	Y	Y	Y	Y	Y	Y	Y
Industry Dummies	Y	Y	Y	Y	Y	Y	Y

Robust standard errors in parentheses

*** p< 0.01, ** p< 0.05, * p< 0.1

Table 1.4: Non-Financial 48 Fama French Industries: Firm ROA and PCGDP

Purchasing Power Parity (PPP) adjusted per capita GDP (PCGDP) is calibrated using the PPP adjusted real GDP(rgdpo) and the population (pop) estimate from the Penn World Table 9.0. Size is the inflation adjusted book value of the firm's asset in US dollar, and leverage is the ratio between the book value of liability and the assets. Price-to-Book measures the ratio between the market and the book value of the firm equity. Time dummies are included in the regression but are not reported. Financial industries are excluded from the list of 48 Fama-French Industries, leaving 44 industries for the analysis.

Industries	log(PCGDP)	log(size)	Leverage	Price-to-Book	Observations	R-squared
Agriculture	-0.0320***	0.0165**	-0.123**	-0.000202	4,145	0.024
Food Products	-0.128	2.63e-05	0.0168	-0.000608	9,753	0.003
Candy & Soda	-0.0177***	0.00895***	-0.0325	-0.000240**	2,141	0.062
Beer & Liquor	-0.0361**	0.00540***	-0.0766	-0.000840	2,775	0.017
Tobacco Products	-0.0191	0.00472**	-0.00236	-0.000991	481	0.040
Recreation	0.00377	0.00421***	-0.0705***	-0.000108**	2,990	0.009
Entertainment	-0.0169**	0.0117***	0.0102	-0.000122	5,187	0.012
Printing and Publishing	-0.0104***	0.00784***	-0.0542***	-0.000464***	3,758	0.054
Consumer Goods	-0.0200***	0.00743***	-0.0799***	-0.00112**	7,320	0.014
Apparel	-0.0144***	0.00351**	-0.123***	0.000103	4,111	0.024
Healthcare	-0.0177***	0.00964***	0.0735	-0.00172**	3,156	0.015
Medical Equipment	-0.0764***	0.0480**	0.0641	-9.29e-05***	5,607	0.004
Pharmaceutical Products	-0.0601***	0.0217***	-0.0437***	-1.89e-05	10,932	0.158
Chemicals	-0.0361**	0.00742***	-0.0455	-5.67e-05	12,415	0.004
Rubber and Plastic Products	-0.0198***	0.00455***	-0.0891***	-0.000526**	3,569	0.065
Textiles	-0.0248***	0.00310***	-0.0740***	-0.00390***	5,260	0.112
Construction Materials	-0.0144***	0.00577***	-0.0906***	-0.000377***	13,180	0.065
Construction	-0.00404***	0.00357***	-0.0634***	-3.39e-05	17,807	0.020
Steel Works	-0.0156***	0.00482***	-0.0965***	-0.000582***	10,231	0.082
Fabricated Products	-0.0118***	0.00517***	-0.0939***	-0.00526***	1,530	0.119
Machinery	-0.0168***	0.00573***	-0.0553***	-0.000873*	14,795	0.055
Electrical Equipment	-0.0148***	0.00720***	-0.0453***	-0.000988*	5,427	0.054
Automobiles	-0.0196***	0.00631***	-0.0714***	-0.000180***	8,991	0.044
Aircraft	0.0161***	0.000331	-0.00602	-0.000183	1,190	0.056
Shipbuilding, Railroad Equipment	-0.00827	-0.00108	-0.0125	-0.00900	867	0.027
Defense	-0.0768***	0.00725*	-0.0991***	-0.00519*	343	0.136
Precious Metals	-0.0167***	0.0396***	-0.0139	3.52e-05***	5,036	0.127
Non-Metallic and Industrial Mining	-0.0527***	0.0344***	-0.0491	-0.000104*	5,854	0.141
Coal	-0.0377***	0.0268***	0.0158	-9.83e-07	1,902	0.145
Petroleum and Natural Gas	-0.00235	0.0206***	-0.00271	-0.000313	11,788	0.099
Utilities	-0.0197***	0.0126***	-0.0513***	-1.33e-05	9,876	0.006
Communication	-0.0262***	0.0185***	-0.0335**	-1.13e-05	9,327	0.011
Personal Services	-0.0201***	0.0122***	0.000667	-0.000788**	3,388	0.062
Business Services	0.026	0.0190***	0.0582*	-1.35e-05	36,745	0.001
Computers	-0.0231***	0.00925***	-0.0316***	-9.05e-05	8,793	0.053
Electronic Equipment	-0.0141***	0.0106***	-0.0317***	-4.73e-05	15,818	0.028
Measuring and Control Equipment	-0.00854**	0.00985***	-0.0444***	-0.000184*	4,437	0.049
Business Supplies	-0.0177***	0.00354***	-0.103***	-1.83e-05***	5,242	0.105
Shipping Containers	-0.00553*	0.00457***	-0.0791***	-0.000361	1,665	0.091
Transportation	-0.0199	0.00622***	-0.0176	-7.78e-07	12,407	0.003
Wholesale	-0.0144***	0.00779***	-0.0595**	-2.48e-05	17,709	0.004
Retail	-0.00362**	0.00755***	-0.0720***	-4.16e-05	17,315	0.006
Restaurants, Hotels	-0.0141**	0.000117	-0.0378**	-1.87e-05	7,931	0.005
Other	-0.0043	0.0159***	-0.0311*	-0.000246*	1,365	0.109

Robust standard errors in parentheses

*** p$<$ 0.01, ** p$<$ 0.05, * p$<$ 0.1

Table 1.5: Annual Analysis: Firm ROA and PCGDP

Purchasing Power Parity (PPP) adjusted per capita GDP (PCGDP) is calibrated using the PPP adjusted GDP(rgdpo) and the population (pop) estimate from the Penn World Table 9.0. Size is the inflation adjusted book value of the firm's asset in US dollar, and leverage is the ratio between the book value of liability and the assets. Price-to-Book measures the ratio between the market and the book value of the firm equity. Industry dummies are included in the regression but are not reported.

	log(PCGDP)	log(size)	Leverage	Price-to-Book
1997	-0.00813***	0.00500***	-0.0380***	-1.26e-05*
1998	-0.0102***	0.00703***	-0.0375***	-9.80e-05***
1999	-0.0235***	0.00953***	-0.0517***	-3.00e-05**
2000	-0.0157***	0.00960***	-0.0331***	-6.91e-05
2001	-0.0217***	0.0113***	-0.0350***	-0.000256***
2002	-0.0283***	0.0124***	-0.0387***	-6.44e-06
2003	-0.0169***	0.0128***	-0.0426***	-2.68e-05
2004	-0.0157***	0.0115***	-0.0410***	-1.54e-06
2005	-0.0147***	0.0120***	-0.0340***	-0.000266***
2006	-0.0177***	0.0103***	-0.0159***	-4.59e-05
2007	-0.0235***	0.00976***	-0.0197***	-3.22e-05
2008	-0.0196***	0.00776***	-0.0239***	-2.72e-05**
2009	-0.0257***	0.0129***	-0.0639***	-0.000767***
2010	-0.0273***	0.00968***	-0.0222*	-0.000142***
2011	-0.0160***	0.00872***	-0.0273***	-2.74e-05**
2012	-0.0158***	0.00909***	-0.0384***	-4.93e-05***
2013	-0.0155***	0.00833***	-0.0407***	-1.01e-05
2014	-0.0189***	0.00801***	-0.0251***	-7.43e-05*

Robust standard errors in parentheses

*** p$<$ 0.01, ** p$<$ 0.05, * p$<$ 0.1

Table 1.6: MSCI Developed and Emerging Countries: Firm Investment Return and PCGDP

Purchasing Power Parity (PPP) adjusted per capita GDP (PCGDP) is calibrated using the PPP adjusted GDP(rgdpo) and the population (pop) estimate from the Penn World Table 9.0. Size is the inflation adjusted book value of the firm's asset in US dollar, and leverage is the ratio between the book value of liability and the assets. Price-to-Book measures the ratio between the market and the book value of the firm equity. Time dummies and industry dummies for the 48 Fama-French Industries are included in all regressions. Standard deviation is reported in the parenthesis.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Variables	IRR	IRR	IRR	IRR	IRR	IRR	IRR
Years	97-14	97-14 (25th)	97-14 (50th)	97-14 (75th)	11-14	11-14 (IFRS)	06-14 (EU)
log(PCGDP)	-0.00209	0.0287***	0.0150***	-0.0144***	0.0303	0.0163	-0.00116
	(0.0181)	(0.000858)	(0.000769)	(0.00147)	(0.0206)	(0.0405)	(0.0415)
log(size)	0.000712	0.0123***	0.00633***	-1.55e-05	1.45e-05	-0.00146	0.0117***
	(0.00213)	(0.000243)	(0.000218)	(0.000418)	(0.00263)	(0.00334)	(0.00221)
Leverage	-0.121***	0.141***	-0.0333***	-0.279***	-0.0897***	-0.106**	-0.0882***
	(0.0187)	(0.00277)	(0.00248)	(0.00476)	(0.0306)	(0.0492)	(0.0214)
Price-to-Book	0.000212**	1.65e-05**	0.000490***	0.0209***	0.000103	0.000470**	0.000266***
	(8.39e-05)	(8.38e-06)	(7.51e-06)	(1.44e-05)	(8.64e-05)	(0.000194)	(6.86e-05)
Constant	0.154	-0.652***	-0.187***	0.466***	-0.271	-0.0906	0.0694
	(0.192)	(0.0150)	(0.0134)	(0.0258)	(0.215)	(0.468)	(0.453)
Observations	334,608	334,608	334,608	334,608	88,527	44,640	34,031
R-squared	0.064				0.037	0.036	0.142
Time Dummies	Y	Y	Y	Y	Y	Y	Y
Industry Dummies	Y	Y	Y	Y	Y	Y	Y

Robust standard errors in parentheses

*** p< 0.01, ** p< 0.05, * p< 0.1

Table 1.7: Non-Financial 48 Fama French Industries: Firm IRR and PCGDP

Purchasing Power Parity (PPP) adjusted per capita GDP (PCGDP) is calibrated using the PPP adjusted GDP(rgdpo) and the population (pop) estimate from the Penn World Table 9.0. Size is the inflation adjusted book value of the firm's asset in US dollar, and leverage is the ratio between the book value of liability and the assets. Price-to-Book measures the ratio between the market and the book value of the firm equity. Time dummies are included in the regression, but not reported. Financial industries are excluded from the list of 48 Fama-French Industries, leaving 44 industries for the analysis.

Industries	log(PCGDP)	log(size)	Leverage	Price-to-Book	Observations	R-squared
Agriculture	-0.0172**	0.0110***	-0.104***	0.00124	4,145	0.093
Food Products	-0.00415	0.00250*	-0.157***	0.00190	9,753	0.064
Candy & Soda	-0.0113	-0.00434	-0.0610	-0.000295	2,141	0.092
Beer & Liquor	-0.0375***	0.00625**	-0.198***	0.0204***	2,775	0.142
Tobacco Products	-0.0383	0.0120	-0.00228	0.00355**	481	0.107
Recreation	0.0187	-0.00318	-0.156***	7.76e-05	2,990	0.063
Entertainment	0.000105	0.00265	-0.118***	0.000719	5,187	0.042
Printing and Publishing	0.00829	0.00190	-0.133***	0.000987	3,758	0.096
Consumer Goods	-0.0121*	0.00728***	-0.198***	0.00806**	7,320	0.093
Apparel	0.0152	0.000410	-0.201***	0.00820***	4,111	0.108
Healthcare	-0.00092	0.00866*	-0.188***	0.00849***	3,156	0.078
Medical Equipment	-0.0288	0.00995***	-0.148***	0.000340***	5,607	0.102
Pharmaceutical Products	-0.0183***	0.00686***	-0.158***	0.000364	10,932	0.090
Chemicals	-0.00826*	0.00394***	-0.101***	0.000133	12,415	0.083
Rubber and Plastic Products	0.0113	0.00130	-0.155***	0.00267	3,569	0.091
Textiles	0.0167***	-0.000736	-0.0999***	0.00474*	5,260	0.071
Construction Materials	0.000967	0.00342***	-0.120***	0.00760***	13,180	0.115
Construction	-0.00254	-0.00524***	-0.0769***	0.000518*	17,807	0.088
Steel Works	0.00177	0.000873	-0.103***	0.00627***	10,231	0.120
Fabricated Products	-0.0291**	0.00653***	-0.272***	0.0469***	1,530	0.207
Machinery	-0.0181***	0.00299**	-0.0989***	0.00555**	14,795	0.124
Electrical Equipment	-0.0155*	0.00469**	-0.118***	0.00378	5,427	0.095
Automobiles	-0.00718	0.000143	-0.105***	0.000566**	8,991	0.101
Aircraft	-0.0233	-0.0135***	-0.0547	0.000528	1,190	0.164
Shipbuilding, Railroad Equipment	0.0372**	0.00419	-0.353***	0.0654***	867	0.324
Defense	-0.106*	0.0126	-0.295***	0.0593***	343	0.211
Precious Metals	-0.0251	0.00246	-0.156***	0.000288***	5,036	0.120
Non-Metallic and Industrial Mining	-0.0035	0.00546	-0.330***	0.000881	5,854	0.120
Coal	-0.027	-0.00552	-0.247***	-1.39e-05	1,902	0.110
Petroleum and Natural Gas	0.0105	0.00151	-0.287***	0.00331***	11,788	0.109
Utilities	0.00869	-0.00358*	-0.0825***	0.000178	9,876	0.081
Communication	0.0150**	-0.00246	-0.0697**	6.88e-05**	9,327	0.128
Personal Services	0.00207	0.000821	-0.145***	0.0106**	3,388	0.079
Business Services	-0.00194	0.00488***	-0.0987***	7.51e-05	36,745	0.080
Computers	-0.00299	0.000476	-0.129***	0.00163***	8,793	0.114
Electronic Equipment	0.0103	-0.00122	-0.161***	0.000327	15,818	0.136
Measuring and Control Equipment	0.0122	0.00151	-0.0977***	0.000724	4,437	0.118
Business Supplies	0.0058	0.000816	-0.128***	0.000473***	5,242	0.121
Shipping Containers	0.0247**	0.00307	-0.0878*	0.00512	1,665	0.106
Transportation	0.002	-0.000145	-0.126***	0.000244***	12,407	0.091
Wholesale	-0.00206	0.000249	-0.108***	0.000234	17,709	0.051
Retail	-0.00134	0.00306**	-0.126***	0.00107**	17,315	0.066
Restaurants, Hotels	0.0210***	-0.00471*	-0.0839***	0.000387*	7,931	0.069
Other	-0.0194	0.000250	-0.169**	0.000494**	1,365	0.094

Robust standard errors in parentheses

*** p< 0.01, ** p< 0.05, * p< 0.1

Table 1.8: Annual Analysis: Firm IRR and PCGDP

Purchasing Power Parity (PPP) adjusted per capita GDP (PCGDP) is calibrated using the PPP adjusted GDP(rgdpo) and the population (pop) estimate from the Penn World Table 9.0. Size is the inflation adjusted book value of the firm's asset in US dollar, and leverage is the ratio between the book value of liability and the assets. Price-to-Book measures the ratio between the market and the book value of the firm equity. Industry dummies are included in the regression but are not reported.

	log(PCGDP)	log(size)	Leverage	Price-to-Book
1997	0.0786***	-0.00267	-0.0655***	8.87e-05*
1998	0.0553***	0.0118***	0.0258	0.00171***
1999	-0.0431***	-0.0202***	-0.442***	0.000586***
2000	-0.0239***	0.00242	-0.0526**	0.000447
2001	0.0223***	0.0154***	-0.0334**	0.00101***
2002	-0.0194***	0.00202	0.0131	0.000163*
2003	0.0840***	-0.00765***	-0.308***	0.000238
2004	0.0494***	-0.0164***	-0.202***	2.64e-05
2005	0.00699	0.0225***	-0.129***	0.000885
2006	-0.0764***	-0.00294**	-0.144***	0.000880***
2007	-0.108***	0.00313*	-0.269***	0.000539**
2008	-0.0244***	-0.00520***	0.156***	5.30e-05
2009	0.00671	0.0273***	-0.334***	0.00956***
2010	-0.0658***	-0.0106***	-0.136**	0.00119**
2011	0.0496***	-0.00447***	0.000452	9.99e-05
2012	0.0234***	0.0111***	-0.0470***	0.000270***
2013	0.0856***	-0.00529***	-0.140***	3.27e-05
2014	-0.0441***	-0.000912	-0.171***	0.000502

Robust standard errors in parentheses

*** p$<$ 0.01, ** p$<$ 0.05, * p$<$ 0.1

Table 1.9: Robustness Check: log(PHGDP) vs. ROA and IRR

Purchasing Power Parity (PPP) adjusted per hour GDP (PHGDP) is calibrated using the PPP adjusted GDP(rgdpo), employment (emp) and the average hours worked (avh) estimate from the Penn World Table 9.0. Size is the inflation adjusted book value of the firm's asset in US dollar, and leverage is the ratio between the book value of liability and the assets. Price-to-Book measures the ratio between the market and the book value of the firm equity. Time dummies and industry dummies for the 48 Fama-French Industries are included in all regressions. Standard deviation is reported in the parenthesis.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	ROA	ROA	ROA	ROA	IRR	IRR	IRR	IRR
	97-14	11-14	11-14 (IFRS)	06-14 (EU)	97-14	11-14	11-14 (IFRS)	06-14 (EU)
log(PHGDP)	-0.0225***	-0.0192***	-0.00116	-0.00460**	0.00405***	0.0320***	0.0256***	-0.00713
	(0.000256)	(0.000479)	(0.00133)	(0.00189)	(0.00122)	(0.00199)	(0.00560)	(0.00808)
log(size)	0.00951***	0.00827***	0.00876***	0.0137***	0.000703**	0.000599	-0.000498	0.0117***
	(8.54e-05)	(0.000152)	(0.000206)	(0.000268)	(0.000352)	(0.000553)	(0.000771)	(0.000935)
Leverage	-0.0313***	-0.0330***	-0.00667**	-0.0223***	-0.121***	-0.0969***	-0.121***	-0.0865***
	(0.00184)	(0.00191)	(0.00332)	(0.00322)	(0.00770)	(0.00755)	(0.0129)	(0.0108)
Price-to-Book	-1.97e-05**	-2.11e-05*	-7.50e-05**	-5.69e-05***	0.000198**	8.93e-05	0.000420***	0.000265***
	(7.95e-06)	(1.25e-05)	(3.01e-05)	(1.98e-05)	(8.07e-05)	(7.75e-05)	(0.000160)	(6.86e-05)
Constant	0.0686***	0.0697***	-0.0336*	-0.0269*	0.121***	-0.0430	0.0804	0.0802*
	(0.00357)	(0.00689)	(0.0185)	(0.0148)	(0.0161)	(0.0322)	(0.101)	(0.0474)
Observations	315,373	80,077	35,935	32,130	315,373	80,077	35,935	32,130
R-squared	0.132	0.126	0.140	0.119	0.059	0.028	0.019	0.141
Time Dummies	Y	Y	Y	Y	Y	Y	Y	Y
Industry Dummies	Y	Y	Y	Y	Y	Y	Y	Y

Robust standard errors in parentheses

*** p$<$ 0.01, ** p$<$ 0.05, * p$<$ 0.1

Table 1.10: Robustness Check: Tax Adjustment

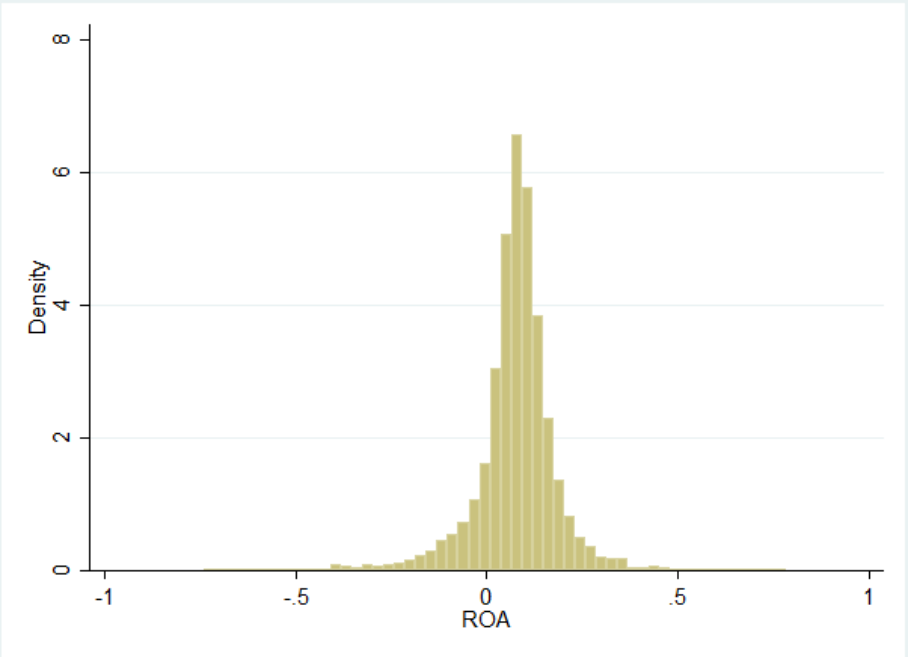
Purchasing Power Parity (PPP) adjusted per capita GDP (PCGDP) is calibrated using the PPP adjusted GDP(rgdpo) and the population (pop) estimate from the Penn World Table 9.0. Size is the inflation adjusted book value of the firm's asset in US dollar, and leverage is the ratio between the book value of liability and the assets. Price-to-Book measures the ratio between the market and the book value of the firm equity. Time dummies and industry dummies for the 48 Fama-French Industries are included in all regressions. Standard deviation is reported in the parenthesis.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	ROA	ROA	ROA	ROA	IRR	IRR	IRR	IRR
	97-14	11-14	11-14 (IFRS)	06-14 (EU)	97-14	11-14	11-14 (IFRS)	06-14 (EU)
log(PCGDP)	-0.0129***	-0.00667***	-0.00262**	-0.00388**	0.00252*	0.0322***	0.0119*	-0.0174
	(0.000211)	(0.000381)	(0.00103)	(0.00196)	(0.00144)	(0.00226)	(0.00617)	(0.0114)
log(size)	0.000452***	-0.000223**	-0.000437***	-0.000628***	-0.00387***	-0.00292***	-0.00335***	-0.000911
	(6.00e-05)	(0.000105)	(0.000144)	(0.000199)	(0.000348)	(0.000562)	(0.000923)	(0.00103)
Leverage	-0.0503***	-0.0506***	-0.0525***	-0.0401***	-0.115***	-0.101***	-0.123***	-0.101***
	(0.000736)	(0.00142)	(0.00264)	(0.00266)	(0.00472)	(0.00870)	(0.0172)	(0.0131)
Price-to-Book	-8.42e-05***	-0.000251***	-0.000391*	-1.81e-05	0.00198***	0.00585***	0.00992**	0.000703
	(2.94e-05)	(9.05e-05)	(0.000220)	(2.52e-05)	(0.000542)	(0.00183)	(0.00498)	(0.000568)
Constant	0.226***	0.176***	0.124***	0.154***	0.138***	-0.267***	-0.0476	0.396***
	(0.00319)	(0.00609)	(0.0152)	(0.0223)	(0.0203)	(0.0304)	(0.0879)	(0.127)
Observations	211,407	54,075	21,260	20,556	211,407	54,075	21,260	20,556
R-squared	0.088	0.071	0.062	0.045	0.081	0.071	0.079	0.185
Time Dummies	Y	Y	Y	Y	Y	Y	Y	Y
Industry Dummies	Y	Y	Y	Y	Y	Y	Y	Y

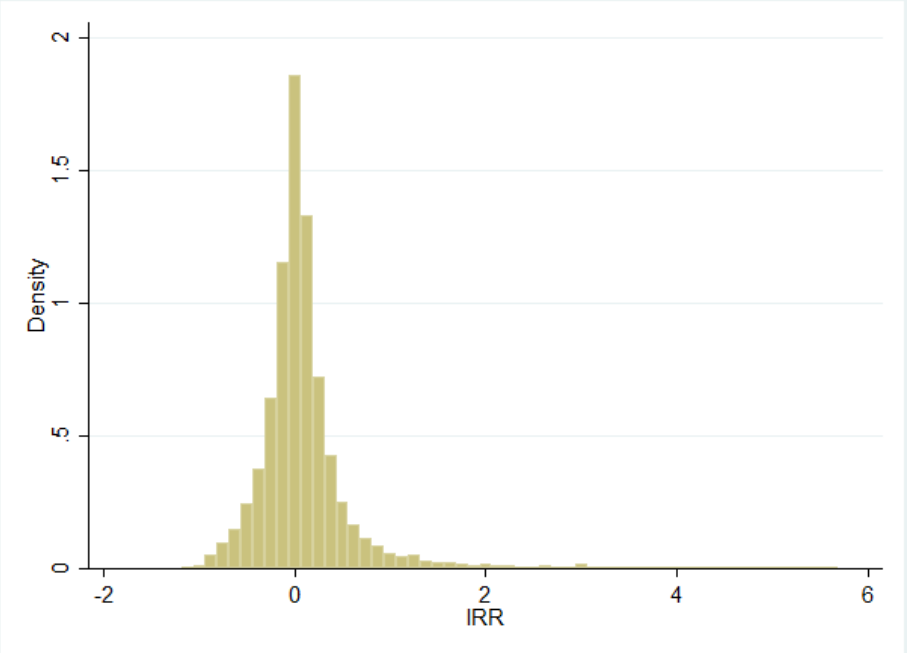
Robust standard errors in parentheses

*** p< 0.01, ** p< 0.05, * p< 0.1

Figure 1.1: ROA and IRR distribution plot

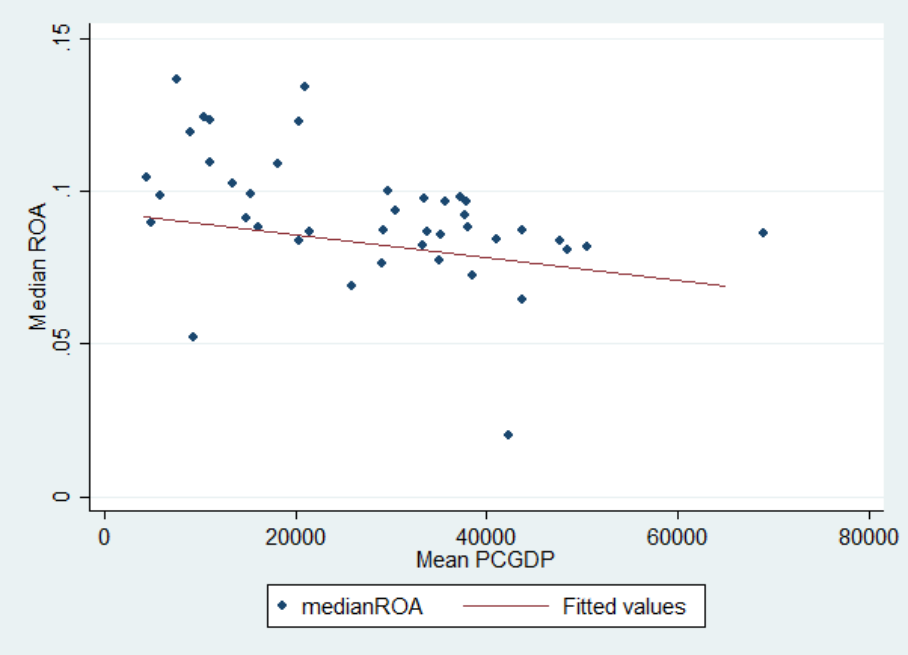


(a) ROA distribution

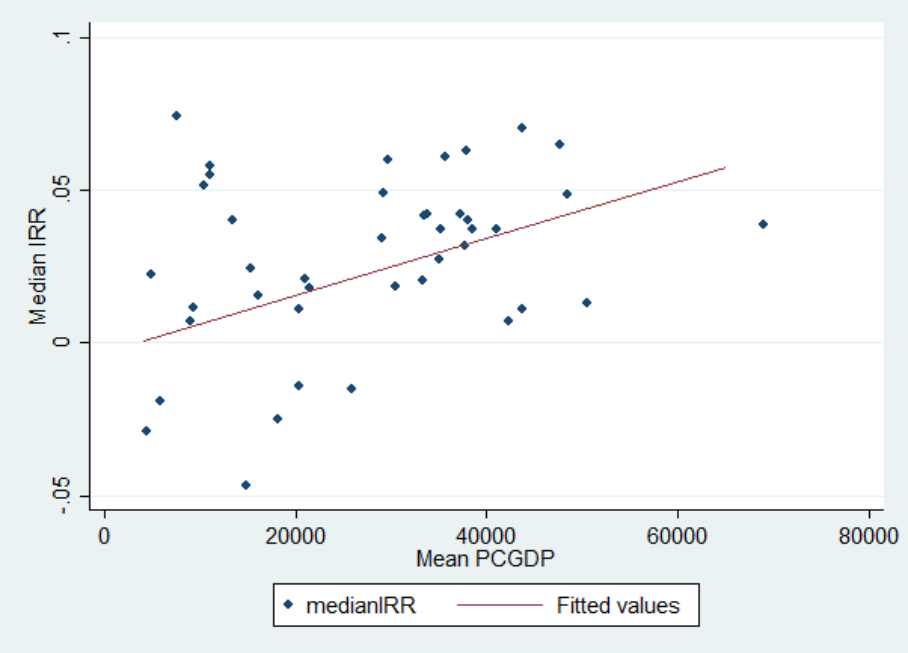


(b) IRR distribution

Figure 1.2: ROA and IRR scatter plot



(a) median ROA and mean log(PCGDP) two-way plot



(b) median IRR and mean log(PCGDP) two-way plot

CHAPTER 2

THE LUCAS PARADOX AND THE CAPITAL ACCUMULATION IN CAPITAL-SCARCE COUNTRIES

2.1 Introduction

In his seminal paper in 1990, Lucas brings into spotlight the lack of capital flow from US to India despite the large difference in marginal product of capital between the two countries. This seminal paper by Lucas led to an extensive literature on international capital market friction and productive efficiency differences across developed and emerging market countries. However, the empirical patterns in the previous chapters show that while there exists a statistically significant inverse relationship between per capita GDP and the marginal product of capital, no such relationship exists between per capita GDP and investment returns. This finding suggests that differences in the marginal product of capital across countries do not necessarily translate into corresponding differences in investment returns and the standard link assumed between productivity and investment returns appears not to hold.

This has a major implication for extensive literature on Lucas Paradox, which has been one of the major puzzles in the macroeconomics, as the finding suggest that key issues in explaining the lack of capital flow may be the domestic factors that affect the capital accumulation process. Therefore, in this chapter, I further expand the findings of the previous chapter and investigate capital accumulation path and macroeconomic factors that affect this process within an economy using the firm-level market and accounting data from MSCI developed and emerging market countries.

The key equation that dictates the relationship between the marginal product of capital and the investment return is the capital accumulation formula. The standard model assumes a costless adjustment of the capital stock, where a unit increase in investment leads to a unit increase in capital stock. This relationship implies that the investment return differs from the marginal product of capital only by the constant depreciation rate (δ). However, the empirical findings from the

previous chapter questions the validity of this standard assumption. Thus, in this chapter, I propose a modified capital accumulation equation with an adjustment factor which account for the installation/dismantling cost, or potential synergistic gains with the existing capital stock.

Through empirical analysis, I find that the quadratic capital adjustment factor introduced in Chirinko(1993) can help model the divergence between the investment return and marginal product of capital observed in the data between 1997-2014. This finding is significant as it suggests that 1) the aggregate capital estimates, which rely on a standard capital accumulation process, need modification, and 2) cross-country marginal product of capital and investment return pattern may differ. This finding of the paper is also consistent with Able and Blanchard (1986), which empirically documents that "the cost of capital component of q and the marginal profit component to be highly positively correlated, that is, that the cost of capital and marginal profit move, in general, in opposite directions. This result is also at variance with what we would expect, if adjustment with costs were unimportant. If there were no adjustment cost at all, the cost of capital and marginal profit would always be equal."

The paper also uses variables that are commonly employed in the empirical literature investigating the Lucas Paradox to examine macroeconomic factors that may affect the capital efficiency of firms. Despite an extensive effort has been devoted to identify the macroeconomic factors that affect the aggregate productivity[1], there has been relatively little interest in the factors that affect capital efficiency, i.e., the level of future capital input that can be obtained from a unit investment today. I find that controlling for per capita output, technology, human capital, financial development, and government efficiency all have a positively significant effect on the capital efficiency of firms. This finding imply that current macroeconomic variables not only affect financial returns today, but also affect future returns by influencing future levels of the capital input. The exact mechanism by which these macroeconomic factors affect the firm productivity and the capital accumulation process is beyond the scope of this paper, but can be a subject for future research.

Although models with capital adjustment factors are widely used in the investment literature,

[1] see Banerjee and Duflo (2005)

they have been largely ignored in the Lucas Paradox literature.[2] Some of the major papers within the investment literature that discusses the capital adjustment factors include Hayashi (1982). In his 1982 paper, Hayashi showss "Tobin's conjecture that investment is a function of marginal q is equivalent to the firm's optimal capital accumulation problem with adjustment costs." Similarly, Yoshikawa (1980) shows that "q theory can be derived from a choice theoretic framework which explicitly takes account of adjustment costs associated with investment." Cochrane (1991) uses a neoclassical investment model with cubic adjustment cost to create a production based asset pricing model and empirically tests the validity of the modified model using the US investment-to-capital ratio and the CRSP value weighted portfolio return. On the other hand, Chirinko (1993) uses a quadratic adjustment cost to model when he introduces the investment models with explicit dynamics.

Modified neoclassical model with capital adjustment is also quite popular in the growth literature. Uzawa (1969) introduces a capital accumulation equation with friction in his model of economic growth, and Jorgenson (1963) also endorses these models with modifications saying "A derivation of this model incorporating installation costs explicitly with constant returns to scale in both production and installation is obviously much more satisfactory than the original derivation." More recent paper, Aoki and Yoshikawa (2002) also introduce capital adjustment factor in their product demand based model of growth. The finding of this paper is closely related to Onitsuka (1974), which introduces model with both international capital flows and capital accumulation frictions into his model to explain long-run growth.

The paper proceed in the following order. In section 2, I explain the model and the empirical methodology used to examine the capital efficiency. Section 3 describes the firm-level data and section 4 presents empirical results. Section 5 concludes.

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[2]Keyu Jin (2012) is an exception as she employs a non-standard capital accumulation equation from Abel (2003). However, her analysis focuses on the effect of comparative advantage rather than the effects of within-country distortions.

2.2 Benchmark Model and Empirical Methodology

In this section, I introduce the benchmark neoclassical model to define the relationship between marginal product of capital and investment return. I also describe the empirical methodology used to test the standard capital accumulation model using the firm-level data.

2.2.1 Benchmark Model and Modifications

Consider a standard neoclassical economy where the representative firm choose capital, investment, and labor ($\{K_t, I_t, L_t\}_{t_0}^{\infty}$) to maximize the net present value of the future cash flows, in a competitive factor and goods market:

$$\max_{\{K_t, I_t, L_t\}_{t_0}^{\infty}} \sum_{t \geq t_0} \frac{1}{R_t}(Y_t - I_t - w_t L_t) \tag{2.1}$$

subject to:

$$\text{Production function:} \quad Y_t = F(K_t, L_t) \tag{2.2}$$

$$\text{Capital accumulation:} \quad K_{t+1} = G(K_t, I_t) \tag{2.3}$$

$$\text{Definition:} \quad R_t = (1 + r_t)(1 + r_{t-1})...(1 + r_{t_0}) \tag{2.4}$$

Y_t is the period output, and the w_t and r_t is the exogenously determined wage and real interest rate. The first order conditions yield:

$$1 + r_t = \left(F_1(K_t, L_t) + \frac{G_1(K_t, I_t)}{G_2(K_t, I_t)} \right) G_2(K_{t-1}, I_{t-1}) \tag{2.5}$$

$$F_2(K_t, L_t) = w_t \tag{2.6}$$

for all periods $t > t_0$. Note that equation (2.5) can also be written as :

$$1 + r_t = \frac{F_1(K_t, L_t)}{p_{t-1}^{K_t}} + G_1(K_t, I_t) \frac{p_t^{K_{t+1}}}{p_{t-1}^{K_t}} \tag{2.7}$$

such that $p_t^{K_{t+1}}$ is the relative price of installed capital in period $t + 1$ in period t output. This follows from the fact that $G_2(K_t, I_t)$ is the marginal rate of transformation of a consumption good

in period t to installed capital in period $t+1$ (Cochrane, 1991). Therefore in equilibrium, the price of an installed capital in period $t+1$ in period t output is

$$p_t^{K_{t+1}} = \frac{1}{G_2(K_t, I_t)} \tag{2.8}$$

and $\frac{F_1(K_t,L_t)}{p_{t-1}^{K_t}}$ is a price corrected measure of marginal product of capital that is consistent with Caselli and Feyrer (2007). [3] It is evident from equation (2.5) that the key determinant of the relationship between the period marginal product of capital ($F_1(K_t, L_t)$) and the investment return (r_t) is the capital accumulation equation($G_(K_t, I_t)$).

The standard neoclassical model assumes a frictionless capital accumulation over time in which a unit investment leads to a unit increase in capital stock.

$$\text{Capital accumulation:} \quad K_{t+1} = G(K_t, I_t) = (1-\delta)K_t + I_t \tag{2.9}$$

This relationship implies that the investment return differs from the marginal product of capital only by the constant depreciation rate (δ). However, the empirical findings from the previous chapter questions the validity of this standard assumption. Thus, in this section, I introduce modified capital accumulation equation with an adjustment factor which account for the installation/dismantling cost, or potential synergistic gains with the existing capital stock.

Consider the following modified capital accumulation conditions:

$$K_{t+1} = G(K_t, I_t) = (1-\delta)K_t + I_t + \beta I_t \tag{2.9 a}$$

$$K_{t+1} = G(K_t, I_t) = (1-\delta)K_t + I_t + \beta\frac{I_t^2}{K_t} \tag{2.9 b}$$

$$K_{t+1} = G(K_t, I_t) = (1-\delta)K_t + I_t + \beta\frac{I_t^3}{K_t^2} \tag{2.9 c}$$

[3] With a standard capital accumulation equation, $p_t^{K_{t+1}} = 1$ for all t, which suggests that buying a unit of capital at time t costs a unit of consumption good. However, the relative price can diverge from a unity if there exists any friction in the capital accumulation process.

These equations are commonly employed in the investment literature and yields the traditional capital accumulation equation if we set $\beta = 0$. In this model, capital cannot be used in production until it has been installed. The adjustment term, which may be linear, quadratic or cubic in investment, accounts for the costs incurred in the installation process. This assumption implies, for example that large investments will increase installation costs firms need to set aside more resources for the installation. Moreover, in equation (2.9b) and (2.9c), the adjustment costs are inversely proportional to the size of the existing capital stock as firms are less affected by the reallocation of resources when they have a large capital base. Chirinko(1993), Gilchrist & Himmelberg (1995), and Keyu Jin (2012)) assume quadratic adjustment costs while Chocrane (1991) assumes a cubic adjustment cost. In this paper, I test all three equations for the best fit.

The investment theory literature assumes that β is negative, as it is the cost incurred in the installation process. However, there also exists an extensive research in the finance literature that studies potential synergies in corporate mergers. [4] Here, the fact that the value of the combined firm can exceed the sum of assets in the individual firms suggests that a unit investment can lead to a more than one unit increase in the aggregate capital stock. Therefore, I do not place any restrictions on the sign of β. If $\beta < 0$ then a unit of investment leads to a less than one unit increase in the aggregate capital stock (a friction) and if $\beta > 0$ a unit of investment leads to a greater than one unit increase in the aggregate capital stock (a synergy). Note that with $\beta \neq 0$ cross-country investment return pattern may deviate from marginal product of capital pattern depending on the sign and the magnitude of β.[5]

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[4] see Brigham (1983), Horne (1983), Chang (1988)

[5] For example, replacing (2.9) with (2.9b), the firm's FOC yields:

$$\begin{aligned} 1 + r_t &= \frac{F_1(K_t, L_t)}{p_{t-1}^{k_t}} + \left(1 - \delta + \beta \left(\frac{I_t}{K_t}\right)^2\right) \frac{p_t^{k_{t+1}}}{p_{t-1}^{k_t}} \\ &= \frac{F_1(K_t, L_t)}{p_{t-1}^{k_t}} + \left(\frac{K_t - I_t}{K_t}\right) \frac{p_t^{k_{t+1}}}{p_{t-1}^{k_t}} \end{aligned}$$

With the additional quadratic adjustment term, investment return now depends not only on the marginal product of capital but also the investment-capital ratio.

2.2.2 Empirical Methodology

In this subsection, I describe the empirical methods used to test the capital accumulation equation using the firm-level market and accounting data. Note that equation (2.9a)-(2.9c) can also be written as

$$\frac{K_{t+1} - K_t - I_t}{K_t} = -\delta + \beta \left(\frac{I_t}{K_t} \right) \tag{2.9 a}$$

$$\frac{K_{t+1} - K_t - I_t}{K_t} = -\delta + \beta \left(\frac{I_t}{K_t} \right)^2 \tag{2.9 b}$$

$$\frac{K_{t+1} - K_t - I_t}{K_t} = -\delta + \beta \left(\frac{I_t}{K_t} \right)^3 \tag{2.9 c}$$

Using above equations as the benchmark, I define the following variables to test the validity of the standard capital accumulation equation:

$$IKRatio_{c,t,i,f} = \left(\frac{Adj\Delta Asset_{c,t,i,f}}{(MVA_{c,t-1,i,f})(1 + infl_{c,t})} \right) \tag{2.10}$$

$$DK_{c,t,i,f} = \frac{-Adj\Delta Asset_{c,t,i,f} + MVA_{c,t,i,f} - MVA_{c,t-1,i,f}}{MVA_{c,t-1,i,f}} - infl_{c,t} \tag{2.11}$$

$IKRatio_{c,t,i,f}$ is investment to capital ratio($\frac{I_t}{K_t}$) of firm f in industry i in country c in year t. $MVA_{c,t,i,f}$ is the current market value of the firm's assets, which is calibrated as the sum of book value of debt and market value of equity. This market measure of capital stock is more accurate than the book value of asset, which is measured at the acquisition cost. Note that period t capital stock (K_t) is estimated as the market value of asset at the end of period $t-1$ as it is an input that is used to produce output (Y_t) at the end of period t. Therefore, the ratio is adjusted for period t inflation ($infl_{c,t}$). $Adj\Delta Asset_{c,t,i,f}$ is a measure of period investment, which is defined as $Adj\Delta Asset_{c,t,i,f} = \Delta Asset_{c,t,i,f} + Depreciation_{c,t,i,f}$. $\Delta Asset_{c,t,i,f}$ is the change in the book value of assets. This measures the current value of tangible asset investments by firms as financial statements are filed using the historical basis approach, i.e., assets are valued at the acquisition price. This definition of a firm-level capital stock and investment-to-capital ratio is consistent with the previous chapter and Fama and French (1999). $DK_{c,t,i,f}$ is change in capital stock that remains unexplained in the standard capital accumulation process $\left(\frac{K_{t+1} - K_t - I_t}{K_t} \right)$. If the standard model is

correct, then $DK_{c,t,i,f}$ should have no dependence on $IKRatio_{c,t,i,f}$.

As stated in the previous chapter, $adj\Delta Asset_{c,t,i,f}$ does not include most of the investment in Research and development (R&D), as R&D costs are taken as expenses on financial statements due to the accounting conservatism. This may downwardly bias the estimate of $IKRatio_{c,t,i,f}$ by underestimating the level of investment in R&D heavy industries or countries. The market value of assets, $MVA_{c,t-1,i,f}$, on the other hand, does include the value of the intangible assets in the firm as the market observes the outcome of R&D activities. However, if omitted R&D investment is the sole driver of the observed gap, then higher-order investment-to-capital ratio ($IKRatio^2_{c,t,i,f}$ or$IKRatio^3_{c,t,i,f}$) should not be statistically significant in the regression analysis as the effect of omission on $DK_{c,t,i,f}$ should be linear; i.e. omitted R&D investment may affect the level of $IKRatio_{c,t,i,f}$, but it should not affect the curvature of the capital accumulation process.

2.3 Data

Financial and market data used to calculate the $IKRatio_{c,t,i,f}$ and $DK_{c,t,i,f}$ are from Worldscope Datastream. Datastream is a commonly used source of data for the cross-country comparison at the firm-level because it not only provides an extensive accounting and market data on listed firms across countries, but also aims to "provide the data in a manner that allows maximum comparability between one company and another, and between various reporting regimes" (Worldscope/Disclosure Partners, 1992). These adjustments by the Worldscope help minimize the potential bias from the cross-country differences in accounting standards, and make it a preferred source for firm-level accounting data.

The countries used in the analysis are MSCI emerging and developed countries; Saudi Arabia is dropped from the sample due to the limited availability of firm-level data before mid-2000s. As in the previous chapter, within the Worldscope dataset, I exclude firm-years with missing market value, assets, liabilities, depreciation, EBITDA, or extraordinary gains/cost. I also drop balance-sheet insolvent firm-years when total liabilities exceed total assets. As period $t-1$ asset values are used to calculate $IKRatio_{c,t,i,f}$ and $DK_{c,t,i,f}$, firm-years without debt and market value from the previous year are also excluded from the sample.

As in the previous chapter, both $IKRatio_{c,t,i,f}$ and $DK_{c,t,i,f}$ are winsorized at 1% and 99% by

country to control for the outliers, following the accounting practice.[6] Table 2.1 provides summary statistics for the two variables. It shows that the mean and the median for $DK_{c,t,i,f}$ are smaller in emerging-market countries relative to the developed countries, suggesting a greater deviation from the standard capital accumulation path in the emerging market countries. Mean and the median for $IKRatop_{c,t,i,f}$, on the other hand are higher in the emerging market countries, which suggest that the effect of adjustment costs on the capital accumulation process may depend on the relative level of aggregate development within the economy. Based on this summary statistics, in the following section, I investigate the effect of not only the capital adjustment factor, but also macroeconomic indicators on $DK_{c,t,i,f}$.

2.4 Modified Capital Accumulation Model

2.4.1 Testing Modified Capital Accumulation Model

Using the two variables described in the previous section, I test the validity of the standard capital accumulation by using the following two specifications:

$$DK_{c,t,i,f} = \alpha + \beta_1 D_t + \beta_2 F_i + \eta_1 Adj_{c,t,i,f} + \boldsymbol{\gamma X_{c,t,i,f}} + \epsilon_{c,t,i,f} \tag{2.12}$$

Equation (2.12) analyses the effects of adjustment costs, $Adj_{c,t,i,f}$, on the capital accumulation process, $DK_{c,t,i,f}$, to test the validity of the capital adjustment factor. $Adj_{c,t,i,f}$ may be $IKRatio_{c,t,i,f}$, $IKRatio^2_{c,t,i,f}$ or $IKRatio^3_{c,t,i,f}$ and measures adjustment cost/gain for firm f in industry i in country c in period t. $PCGDP_{c,t}$ is the purchasing power parity adjusted real per capita GDP in country c in period t in 2011 US dollars that I use as a proxy for output per unit labor. D_t and F_i are time and industry dummies that are added to control for global macroeconomic shocks that occurred during the period of analysis, or an industry specific trend. $\boldsymbol{X_{c,t,i,f}}$ is the vector of firm specific factors, which includes the log size (the book value of assets denominated in USD; the value is adjusted for the inflation using the CPI index), leverage (book debt to equity ratio), and the equity price-to-book ratio. The errors are also clustered in country-year groups as in Chapter 1. If the standard capital accumulation equation is correct, then the $Adj_{c,t,i,f}$ ought to be statistically

[6] see Konchitchki (2013), Barth, Landsman and Lang (2008), and Barth, Konchitchki, Landsman (2013)

insignificant.

Column 1-3 of Table 2.2 shows that $IKRatio_{c,t,i,f}$, $IKRatio^2_{c,t,i,f}$, $IKRatio^3_{c,t,i,f}$ are positive and statistically significant between 1997 and 2014. This finding implies that modified capital accumulation equation describes the capital accumulation more accurately than the standard model, and suggests that the aggregate capital estimates, which rely on a standard capital accumulation process need modification. The adjusted R-squared value is highest for the model with quadratic adjustment factor, so for the future empirical analysis I use the quadratic adjustment factor following Chirinko(1993).

2.4.2 Macroeconomic factors

As stated earlier, summary statistics of $DK_{c,t,i,f}$ and $IKRatio_{c,t,i,f}$ suggest that the effect of adjustment factor on capital accumulation process depends on the relative level of aggregate development. Numerous macroeconomic factors have been discussed in the Lucas Paradox literature as the sources of inefficiency in emerging market countries but most of the analysis focused on their effect on the aggregate productive efficiency, and the effect on the capital efficiency remain relatively unexplored. Higher level of capital efficiency should increase the investment return as higher level of future capital stock can be obtained from a unit investment today. Therefore in this section, I study macroeconomic variables commonly used in the development literature and investigate potential macroeconomic factors that could lead to frictions/synergies in the capital accumulation process.

Table 2.3 summarizes some of the factors that has been discussed in the development literature. The variables used in the analysis include human capital, institutional quality, financial development, and technology.

Human Capital: Consider the following modified Cobb-Douglas function with human capital:

$$Y = AK^{\alpha}(hL)^{1-\alpha}$$

where h is the level of human capital. This modified production function yields the following

expression for the marginal product of capital:

$$\frac{\partial Y}{\partial K} = \alpha A^{\frac{1}{\alpha}} h^{1-\alpha+\frac{1}{\alpha}} y^{\frac{\alpha-1}{\alpha}}$$

If the level of total factor of productivity (A) and human capital(h) is identical across countries, then the marginal product of capital should be completely determined by the relative level of per capita output as predicted in the neoclassical model. However, if the assumption is violated cross-country difference in the marginal product of capital may deviate from the predicted values based on the model. Therefore an extensive effort has been devoted to identify the macroeconomic factors that affect the aggregate productivity.

Human capital is one of the most commonly employed predictor variable in the development literature, and has been suggested as a potential solution to Lucas paradox by Lucas himself. Table 2.3 shows that human capital based on education is highest in the US (3.63) and the lowest in India(1.76). All MSCI developed countries except Spain and Portugal have human capital index greater than 3, but only a few emerging countries (Czech Republic, Hungary, Poland, Russia, and South Korea) tops this threshold number.[7] For the empirical analysis, I use percent population with tertiary (or secondary) education as the measure of human capital.

Government Institutions: As stated in Alfaro, et al (2008) " 'cluster of institutions,' including constraints on government expropriation, independent judiciary, property rights enforcement, and institutions providing equal rights and ensuring civil liberties, are important to encourage investment and growth." Thus, in this paper I construct institution quality measure using the World Governance Indicators by World Bank. The World Governance Indicator measures: Control of Corruption, Government Effectiveness, Regulatory Quality, Rule of Law, Political Stability and Voice and Accountability. I take the average of the five indexes, linearly interpolating the missing values in each index. Within the MSCI developed and emerging countries, the rating is the highest in Finland and the Nordic countries, and the lowest in Russia and China.

[7]One major drawback of this index is that it does not account for the on-the-job learning, highlighted by Lucas (1990).

Financial Development: The measure of financial development is from the International Monetary Fund (IMF). The financial development index summarizes the accessibility, efficiency and the depth of the financial market and institutions within the economy.[8] Limited access to financial institutions has been discussed as a source of inefficiency in emerging countries by Banerjee and Duflo (2005), where they document a large within-country variance in the interest rate. Hsieh and Klenow (2009) further argues that financial system can lead to a more efficient allocation of capital within the economy, increasing the aggregate productivity. As shown in Table 13, within the MSCI developed and emerging countries, Switzerland (0.97) has the highest level of financial development, and Peru has the lowest level of development.

Patents/Technology: The number of triadic patent families is used to proxy for the country's ability to innovate. Triadic patents families is a series of corresponding patents filed at the European Patent Office (EPO), the United States Patent and Trademark Office (USPTO) and the Japan Patent Office (JPO), for the same invention, by the same applicant or inventor. It is a better proxy for the R&D level of the firms than the total number of patent applications as triadic patent families is the "database of 'high-quality' inventions" (Popp, 2007) which excludes inventions/innovations with zero commercial value. The average number of triadic patents over the analysis period is the highest in Japan (15,135), and is the lowest in Peru (0.4).

Although literature thus far remained relatively silent on the effect of the macroeconomic factors on the capital efficiency, these factors are likely to have a significant effect on the capital installation process. As loss and damage of goods in the capital transportation/allocation process has often been cited as one of the major sources of the capital frictions in emerging countries, better institutions, and financial development can help minimize the capital adjustment cost through efficient allocation of resources. Technological innovation should increase the possibility of capital synergy as countries with greater innovative power are likely to generate more value from the unit investment.

To test the effect of the macroeconomic variables on the capital efficiency, I use the following

[8] See Svirydzenka (2016)

equation:

$$DK_{c,t,i,f} = \alpha + \beta_1 D_t + \beta_2 F_i + \eta IKRatio^2_{c,t,i,f} * Macro_{c,t} + \boldsymbol{\gamma X_{c,t,i,f}} + \epsilon_{c,t,i,f} \tag{2.13}$$

This is a modified version of equation (2.12), and includes $IKRatio^2_{c,t,i,f} * Macro_{c,t}$ to measure the effect of the macroeconomic factors discussed above. If the discussed factors affect installation process, then the effect should be most acutely felt by the firms that engage in intensive capital investment, and therefore $IKRatio^2_{c,t,i,f} * Macro_{c,t}$ should be statistically significant.

Table 2.4 summarizes the regression result for equation (2.13), which measures the effect of the macroeconomic variables on the capital efficiency of the firms. The table shows that triadic patents, government efficiency, financial development index, and human capital all have a positively significant effect on the capital efficiency of firms. This finding suggests better utilization of resources, and higher level of education can help minimize the capital adjustment friction and help create synergies. The result presented in this subsection implies that the macroeconomic factors of production discussed in the development literature affect not only the production today, but also the production in the future by increasing 1) the level of output for a given input, and 2) the future capital input that can be obtained from a unit investment today. The exact mechanism behind this effect is beyond the scope of this paper, but should be a subject of the future research.

2.5 Conclusion

Standard capital accumulation equation, which suggests that the capital stock tomorrow is the sum of capital stock today and the investment net of depreciation ($K_{t+1} = (1-\delta)K_t + I_t$), imply that investment return and marginal product of capital differ only by a constant depreciation rate (δ). Therefore, marginal product of capital has been extensively used in the Lucas Paradox literature to explain the lack of cross-country capital flow from rich country to poor countries. However, the empirical findings of the previous chapter show that while there exists a statistically significant relationship between per capita GDP and the marginal product of capital, no such relationship exists between per capita GDP and investment returns.

In this chapter, I investigate the capital accumulation path, the key equation that link marginal

product of capital and investment returns. I show using the firm-level data that the standard capital accumulation does not hold empirically; i.e. a unit investment does not lead to a unit increase in capital stock. This result is significant as it 1) questions the accuracy of the aggregate capital stock estimate, which rely on the standard capital accumulation process, and 2) implies that cross-country investment and marginal product of capital patterns can differ as investment return depends not only on the marginal product of capital, but also investment-to-capital ratio. This finding suggests that a potential solution to Lucas Paradox may be the domestic factors that affect the capital accumulation process within the economy. Therefore, I use commonly employed macroeconomic variables and test their effect of the capital accumulation process. The empirical results of the paper suggests that technology, human capital, financial development and government efficiency, all have a significant effect in improving the capital efficiency of the firms.

However, this paper does not describe the channels by which these macroeconomic factors affect the firm productivity and the capital accumulation process, and the macroeconomic indicators used in the macroeconomic factor analysis are likely to be highly correlated. Therefore, for the further analysis on the subject should employ micro-level data on financial development and institutional quality to provide a more insightful results regarding the cross-country difference in the capital efficiency of the firms.

Table 2.1: Summary Statistics: Capital Friction and Investment-Capital Ratio

$$DK_{c,t,i,f} = \frac{-adj\Delta Asset_{c,t,i,f} + \Delta MVA_{c,t,i,f}}{MVA_{c,t-1,i,f}} - infl_{c,t}$$

$$IKRatio_{c,t,i,f} = \left(\frac{adj\Delta Asset_{c,t,i,f}}{(MVA_{c,t-1,i,f})(1+infl_{c,t})}\right)$$

$DK_{c,t,i,f}$ is the ratio between the sum of change in the market value of asset less the change in the book value of asset and the market value of asset from the previous year adjusted for the CPI inflation. $IKRatio_{c,t,i,f}$ is the ratio between the change in the book value of asset market value of asset adjusted for the CPI inflation.

		DK			IKRatio		
		Mean	Median	SD	Mean	Median	SD
Australia	AUS	0.180	-0.043	0.922	0.139	0.057	0.487
Austria	AUT	-0.032	-0.050	0.254	0.093	0.070	0.190
Brazil	BRA	-0.033	-0.057	0.262	0.087	0.067	0.179
Belgium	BEL	-0.044	-0.092	0.305	0.147	0.104	0.220
Canada	CAN	0.064	-0.049	0.613	0.155	0.081	0.385
Chile	CHL	-0.045	-0.076	0.271	0.118	0.089	0.206
China	CHN	0.085	-0.050	0.548	0.112	0.071	0.181
Colombia	COL	-0.068	-0.106	0.325	0.187	0.126	0.265
Czech Republic	CZE	-0.101	-0.110	0.234	0.104	0.089	0.171
Denmark	DNK	-0.015	-0.059	0.318	0.087	0.059	0.202
Finland	FIN	-0.007	-0.043	0.288	0.079	0.054	0.185
France	FRA	-0.021	-0.050	0.281	0.096	0.067	0.181
Germany	DEU	-0.018	-0.046	0.319	0.079	0.058	0.212
Greece	GRC	0.046	-0.074	0.775	0.095	0.062	0.225
Hong Kong	HKG	0.085	-0.062	0.730	0.175	0.091	0.507
Hungary	HUN	-0.105	-0.123	0.283	0.117	0.095	0.246
India	IND	-0.059	-0.131	0.397	0.163	0.110	0.250
Indonesia	IDN	-0.039	-0.109	0.418	0.172	0.103	0.324
Ireland	IRL	0.056	-0.025	0.514	0.104	0.071	0.254
Israel	ISR	0.012	-0.046	0.396	0.082	0.056	0.236
Italy	ITA	-0.049	-0.060	0.212	0.092	0.059	0.212
Japan	JPN	-0.025	-0.046	0.229	0.049	0.043	0.124
Malaysia	MYS	-0.045	-0.072	0.291	0.096	0.070	0.211
Mexico	MEX	-0.042	-0.063	0.254	0.113	0.099	0.178
Netherlands	NLD	-0.010	-0.041	0.288	0.089	0.064	0.197
New Zealand	NZL	-0.003	-0.042	0.312	0.086	0.055	0.240
Norway	NOR	0.012	-0.049	0.437	0.134	0.081	0.320
Peru	PER	0.003	-0.066	0.466	0.148	0.093	0.259
Philippines	PHL	0.014	-0.069	0.496	0.121	0.075	0.284
Poland	POL	-0.011	-0.067	0.438	0.133	0.085	0.307
Portugal	PRT	-0.053	-0.069	0.180	0.109	0.068	0.214
Russia	RUS	-0.111	-0.141	0.377	0.192	0.147	0.261
Singapore	SGP	-0.015	-0.069	0.383	0.110	0.074	0.250
South Africa	ZAF	-0.025	-0.070	0.364	0.139	0.095	0.345
South Korea	KOR	-0.023	-0.075	0.364	0.138	0.094	0.284
Spain	ESP	-0.015	-0.044	0.250	0.110	0.069	0.227
Sweden	SWE	0.052	-0.022	0.471	0.100	0.056	0.277
Switzerland	CHE	0.012	-0.021	0.285	0.057	0.044	0.168
Thailand	THA	0.007	-0.056	0.352	0.106	0.078	0.191
Turkey	TUR	-0.085	-0.133	0.423	0.187	0.131	0.257
United Kingdom	GBR	0.018	-0.046	0.468	0.107	0.060	0.296
United States	USA	0.045	-0.036	0.518	0.089	0.059	0.230
MSCI		0.015	-0.055	0.472	0.105	0.065	0.265
MSCI Developed		0.007	-0.048	0.375	0.100	0.064	0.241
MSCI Emerging		-0.034	-0.087	0.386	0.133	0.094	0.243

Table 2.2: Testing Capital Accumulation Path

$IKratio$ is the ratio between the change in the book value of asset and the market value of asset adjusted for the CPI inflation. Purchasing Power Parity (PPP) adjusted per hour GDP (PHGDP) is calibrated using the PPP adjusted GDP(rgdpo), and population (pop) estimates from the Penn World Table 9.0. Size is the inflation adjusted book value of the firm's asset in US dollar, and leverage is the ratio between the book value of liability and the assets. Price-to-Book measures the ratio between the market and the book value of the firm equity. Time dummies and industry dummies for the 48 Fama-French Industries are included in all regressions. Standard deviation is reported in the parenthesis.

	(1)	(2)	(3)	(4)
	DK	DK	DK	DK
	97-14	97-14	97-14	97-14
IKRatio		0.283***		
		(0.0267)		
IKRatioˆ2			0.213***	
			(0.0194)	
IKRatioˆ3				0.0589***
				(0.00813)
log(size)	-0.00898***	-0.0110***	-0.00849***	-0.00887***
	(0.00226)	(0.00235)	(0.00219)	(0.00224)
Leverage	-0.0854***	-0.0846***	-0.0826***	-0.0825***
	(0.0185)	(0.0181)	(0.0179)	(0.0181)
Price-to-Book	0.000229**	0.000235**	0.000233**	0.000230**
	(8.99e-05)	(9.17e-05)	(9.06e-05)	(9.01e-05)
Constant	0.143***	0.138***	0.123***	0.138***
	(0.0487)	(0.0470)	(0.0470)	(0.0485)
Observations	334,608	334,608	334,608	334,608
R-squared	0.071	0.094	0.104	0.088
Time Dummies	Y	Y	Y	Y
Industry Dummies	Y	Y	Y	Y

Table 2.3: Macroeconomic Factors Summary Statistics

		PPP adjusted PCGDP (2014)	Human Capital Index	Financial Development Index	Triadic Patents	Government Efficiency
Australia	AUS	44,241	3.48	0.86	355	1.59
Austria	AUT	45,705	3.21	0.67	317	1.60
Belgium	BEL	14,811	3.04	0.66	435	1.33
Brazil	BRA	39,950	2.30	0.57	53	0.01
Canada	CAN	43,368	3.58	0.82	579	1.63
Chile	CHL	21,317	2.89	0.47	6	1.14
China	CHN	12,513	2.28	0.48	558	(0.52)
Colombia	COL	12,858	2.29	0.31	3	(0.48)
Czech Republic	CZE	29,187	3.60	0.35	19	0.82
Denmark	DNK	44,423	3.38	0.74	276	1.83
Finland	FIN	38,343	3.24	0.63	332	1.89
France	FRA	38,584	2.99	0.73	2,511	1.21
Germany	DEU	46,507	3.61	0.76	5,802	1.50
Greece	GRC	24,685	2.85	0.57	13	0.61
Hong Kong	HKG	45,134	2.98	0.76	26	1.31
Hungary	HUN	22,750	3.13	0.48	38	0.84
India	IND	5,452	1.88	0.41	166	(0.26)
Indonesia	IDN	9,798	2.29	0.32	2	(0.63)
Ireland	IRL	51,927	2.95	0.79	65	1.51
Israel	ISR	31,606	3.43	0.57	333	0.60
Italy	ITA	35,324	2.89	0.77	756	0.66
Japan	JPN	35,566	3.43	0.78	15,135	1.15
Malaysia	MYS	21,650	2.75	0.62	15	0.36
Mexico	MEX	15,520	2.52	0.35	15	(0.11)
Netherlands	NLD	48,178	3.21	0.79	1,158	1.73
New Zealand	NZL	34,066	3.26	0.62	57	1.77
Norway	NOR	78,293	3.47	0.69	108	1.72
Peru	PER	10,931	2.68	0.30	0	(0.30)
Philippines	PHL	6,638	2.52	0.35	3	(0.36)
Poland	POL	24,450	3.13	0.42	24	0.68
Portugal	PRT	27,047	2.28	0.68	14	1.10
Russia	RUS	24,056	3.22	0.43	75	(0.73)
Singapore	SGP	66,482	2.87	0.72	94	1.50
South Africa	ZAF	12,067	2.32	0.55	35	0.32
South Korea	KOR	34,955	3.34	0.79	1,527	0.67
Spain	ESP	32,858	2.73	0.87	195	1.01
Sweden	SWE	42,605	3.27	0.74	784	1.76
Switzerland	CHE	62,637	3.59	0.97	947	1.76
Thailand	THA	13,725	2.41	0.54	7	(0.05)
Turkey	TUR	19,675	2.12	0.44	14	(0.15)
United Kingdom	GBR	38,757	3.60	0.89	1,843	1.49
United States	USA	51,959	3.64	0.87	14,212	1.32

Table 2.4: Macroeconomic factors and Capital Efficiency

VARIABLES	(1) DK 97-14	(2) DK 97-14	(3) DK 97-14	(4) DK 97-14	(5) DK 97-14	(6) DK 97-14	(7) DK 97-14
IKratioˆ2	0.213*** (0.0194)						
IKratioˆ2*log(PCGDP)		0.0204*** (0.00190)					
IKratioˆ2*Triadic Patents			3.98e-05*** (4.53e-06)				
IKratioˆ2*Govn't Efficiency				0.148*** (0.0136)			
IKratioˆ2*Financial Development					0.272*** (0.0242)		
IKratioˆ2*Secondary Education						0.00278*** (0.000213)	
IKratioˆ2*Tertiary Education							0.00768*** (0.000428)
Constant	0.123*** (0.0470)	0.123*** (0.0469)	0.125*** (0.0433)	0.120** (0.0464)	0.124*** (0.0464)	0.124*** (0.0460)	0.125*** (0.0446)
Observations	334,608	334,608	334,608	334,608	334,608	334,608	334,608
R-squared	0.104	0.104	0.085	0.103	0.106	0.107	0.109
Time Dummies	Y	Y	Y	Y	Y	Y	Y
Industry Dummies	Y	Y	Y	Y	Y	Y	Y

CHAPTER 3

MULTI-CONE EVIDENCE FROM THE FIRM-LEVEL DATA

3.1 Introduction

For decades Heckscher-Ohlin(H-O) model has been a workhorse model in the international trade literature providing an explicit and tractable predictions about the link between the country's endowment, industry factor requirements and the international trade. H-O models trade as a transfer of endowments, where exchange of goods is "indirect factor arbitrage, transferring the services of otherwise immobile factors of production from locations where these factors are abundant to locations where they are scarce." (Leamer, 1995) Therefore, assuming identical technology across countries, the theory suggests that countries export goods that intensively use the factors of production that are relatively abundant locally.

The research has particularly flowered in the one-cone version of the model, which assumes that countries produce the same set of goods. In this set-up, the international trade equalizes factor prices globally even in the absence of the international factor mobility (FPE, Factor price equalization theorem). However, despite wide-spread use of the one-cone H-O model, empirical examination of the FPE theorem has yielded a rather disappointing results. Even Ohlin(1933) stated "Complete equality of factor prices is ... almost unthinkable and certainly highly improbable." Thus, although it is easy to dismiss the FPE empirically, "the real question isn't whether FPE is true or not. Trust us, it isn't true. The real question is what causes the violation that we observe." (Leamer and Levinsohn, 1994)

Popular answers to the question posed in Leamer and Levinsohn is technology difference, which gained a significant attention following the seminal paper by Leontief (1953). In this paper, Leontief points out that US exports were less capital intensive relative to its imports despite the fact that US is the most capital abundant country. In this paper, Leontief suggested that the cross-country productivity difference can explain the observed phenomena; US is labor intensive when

one adjust for the productivity difference across countries. Trefler (1993) takes the argument step further by showing that productivity difference across countries can explain much of the factor price variation across countries. Interest in cross-country difference in productivity also led some researchers (e.g. Stern and Maskus, 1981) to move away from two-factor (labor, and capital) to 3-factor model including human capital as an additional input to explained the observed patterns in international trade.

Multi-cone version of the model, where countries produce differentiated goods, hasn't gained much attention until more recently. One of the most heavily cited papers on multi-cone H-O model is Schott (2003), which showed using US import data that unit value of exports vary systematically with exporter relative factor endowment. This finding contradicts the implications of single-cone H-O model, as no systematic relationship should be found between relative factor endowment and the product price due to factor price equalization (FPE). However, this empirical finding is consistent with the multi-cone version of the H-O theory, where countries specialize in production of final goods.

In the paper, Schott also suggests a new framework for testing the multi-cone version of the H-O model. Unlike others in the literature which searched for the evidence of specialization across industries, Schott suggested that the countries do not specialize across industries, but within; i.e. the "capital- and skill-abundant countries use their endowment advantage to produce vertically superior varieties". This finding is significant as it suggests that previous empirical researches that showed little evidence of endowment driven specialization across industries cannot rule-out the mutli-cone version of the H-O model. Thus, there is no prima facie reason to believe that the countries occupy the identical cone of production. Other key papers on the subject include Deardorff (2000) which investigated the effect of growth on the international trade patterns in the multi-cone setting, and Debaere and Demiroglu (2003), which showed that the endowments are too dissimilar across countries to ensure production of the same set of goods across countries. More recently, Xiang (2007) showed that the factor intensities difference among the countries are sufficiently different across countries, implying a weak factor market linkage across countries.

In this paper, I first reaffirm the finding of Schott using the firm-level accounting and market

data. In his 2003 paper, Schott used the unit import prices as a measure of the industry input intensity in the respective country. Although it is a good proxy, it is still an indirect measure of factor price. In this paper, I use the firm-level marginal product of capital estimate to test the multi-cone version of the H-O model. I show that there is a statistically significant downward relationship between the relative aggregate endowment and the firm return to capital even after adjusting for the firm specific factors, empirical finding that is in-line with Schott (2003).

While this relationship between the firm return to capital supports the multi-cone version of the H-O model, which allows factor price variation across countries, it may also be driven by technology difference across countries; i.e. is the observed empirical findings due to greater efficiency in production in developed countries relative to emerging or is there a quality difference between the products manufactured? I therefore use firm-level output-to-capital ratio to show that technology difference cannot sufficiently describe the observed trend. Technology difference suggests that output-to-capital ratio and marginal product of capital have identical cross-country patterns. However, empirical result using the firm-level data suggests that although marginal product of capital decrease with relative level of per capita GDP, the output-per capita increase with per capita GDP. This finding is consistent a vertical specialization, and the quality-ladder model of trade.

The vertical specialization implied by the data relates this paper to Acemoglu and Ventura (2002) and Cunat and Maffezzoli (2002), which study the effect of cross-country specialization on convergence. Their result suggests vertical specialization and the innovation may permanently set apart the developed and emerging economies, as the rich countries continuously innovate a superior product. This finding is consistent with Grossman and Helpman (1991) in that it suggests that the high wage countries continue to lead the emerging countries over time with its ability to innovate the higher quality product.

This paper is also related to emerging body of literature in the development economics that attempts to investigate the link between macroeconomy and the firm-level accounting earnings. Earlier works in the field includes Davis, et al (1992), which documented a reallocation of resources within industry following an exogenous shock using a plant level data. Others have studied the

difference in the firm characteristics between the exporters and non-exporters within the country.[1] This papers differs from the others in that I attempt to draw the aggregate trend using the firm-level accounting data. This approach is based on the Konchitchki and Patatoukas (2014), which found that accounting earnings growth is an incrementally significant leading indicator of growth in nominal Gross Domestic Product (GDP), documenting a significant link between the accounting and macroeconomic data.

The paper proceeds as follows. In section 2, I introduce the basic Heckscher Ohlin model of comparative advantage and its predictions about international factor price convergence. Section 3 describes the firm-level data used in the analysis and the summary statistics. Section 4 and 5 present empirical results; I show that the observed trend is more consistent with the multi-cone version of the H-O model than single-cone version with cross-country technological differences. Section 6 concludes.

3.2 Benchmark Model: Heckscher Ohlin model of Comparative Advantage

The essence of Heckscher Ohlin theorem is well described in the Lerner diagram shown in Figure 1. The diagram features the world with two factors of production (Labor and Capital), and four industries (Electronics, Machinery, Textile, and Food Products). Industries differ in the required input intensity, as shown by the slopes of the line connecting the isoquants and the origin. In this set-up, Electronics is the most capital intensive industry, and Food Products is the most labor intensive industry. The four lines from the origin, delineate the cones of production. In this set-up, capital intensive Japan, which enjoy lower cost of capital should produce Electronics and Machinery, whereas labor intensive Philippines and India should produce Textile and Food Products. Countries do not have an incentive to produce goods in industries that lie outside the cone, since diverting the factors of production will yield a lower output.

As shown in Figure 1, if two countries to occupy the same cone of production, they must share the same unit cost line. Therefore the factor price should identical in India and Philippines, which lie the same cone of production. On the other hand, unit cost line is steeper for Japan relative to

[1] See Aw and Hwang(1995), and Bernard and Jensen (1995)

Philippines. Therefore, two countries Japan and Philippines that occupy different cones will face different factor costs. Relative to Philippines, capital cost (return to capital) in Japan will be lower but the labor cost (wages) will be higher.

The algebra behind the Lerner diagram is as follows. Consider a small open economy, where agents share identical homothetic preference. There is costless transfer of goods across countries (perfect mobility of goods) but factors are immobile across borders. Within each country, there is perfectly competitive factor and goods market. There is a single constant return to scale technology for each good and there is no factor intensity reversals. In this set-up, each country faces the resource constraint

$$\boldsymbol{Aq} \leq \boldsymbol{v} \tag{3.1}$$

such that $\boldsymbol{A}$ is the technology matrix that convert factors to goods, $\boldsymbol{q}$ is the output vector and $\boldsymbol{v}$ is the factor endowment vector. If dimension of the $\boldsymbol{v}$ and $\boldsymbol{q}$ are identical (i.e. number of factors equal the number of goods produced within the country), then technology matrix can be inverted to yield the following factor market clearing condition.

$$\text{Factor Market Clearing Condition:} \quad \boldsymbol{q} \ = \boldsymbol{A^{-1}v} \tag{3.2}$$

Since firms in each country produce in the competitive market, they will satisfy the zero profit condition

$$\text{Zero Profit Condition:} \quad \boldsymbol{w} \ = \boldsymbol{A'^{-1}p} \tag{3.3}$$

such that $\boldsymbol{p}$ is the vector of product price, and $\boldsymbol{w}$ is the vector of factor price. This equation has three interesting features: it 1) relates the global price of goods, to the local price of factors; 2) shows that if countries produce the same goods (thus share same $\boldsymbol{A}$), they should share the same factor price since price of goods are identical everywhere due to free trade; and 3) suggests that the factor return doesn't change with the level of endowment ($\boldsymbol{v}$) within the cone of diversification. The latter is

the essence of the Factor Price Equalization condition that has been put forth by Samuelson(1948). Within the cone, increase in endowment of labor leads to an increased production of labor-intensive good without changing the factor price; factor price adjust only when country moves out of the cone of diversification.

As all individuals have identical homothetic tastes, each agent will consume equal proportion (s) of goods produced in the world. Based on this observation, one can write the Heckscher-Ohlin-Vanek (Vanek, 1968) relationship of the international trade flows:

$$\text{Heckscher-Ohlin-Vanek theorem:} \quad \boldsymbol{T} = \boldsymbol{q} - \boldsymbol{c} = \boldsymbol{A}^{-1}(\boldsymbol{v} - s\boldsymbol{v}_{\boldsymbol{w}}) \tag{3.4}$$

$\boldsymbol{T}$ is the vector of net exports, and $\boldsymbol{c}$ is the goods consumption vector. The second equality suggests that the "traded commodities are really bundles of factors... The exchange of commodities internationally is therefore indirect factor arbitrage, transferring the services of otherwise immobile factors of production from location where these factors are abundant to locations where they are scarce." (Leamer,1995). This relationship suggests that countries indirectly export relatively abundant factors and and import relatively scarce factor.

In the following chapters, I will focus on the equation (3), which relates the factor price and the goods produced. In the single-cone model, the factor price shouldn't vary with the changes in the relative factor endowment. Thus, a systematic relationship between the factor price and relative factor endowment across countries should provide an evidence in favor of the multi-cone version of the model.

3.3 Empirical Methodology and Data

3.3.1 Empirical Methodology

Consider a standard economies where firm maximizes profit by producing that quantity of output where marginal product equals marginal cost. Under the standard Cobb-Douglas production function, firm's marginal product of capital is

$$MPK = \alpha \frac{y}{k} \tag{3.5}$$

such that α is the capital share, y is the output and k is the capital. Since α is the capital share in output, this expression suggests that the marginal product of capital is the ratio between the portion of earnings that accrue to capital holders (in the model these is simply the firm), and the firm's assets.[2] This expression is quite similar to ROA, an accounting measure of firm profitability that is the ratio between the firm's net earning and the total assets. In this paper, ROA is calibrated using two different methods:

$$ROA^b_{c,t,i,f} = \frac{EBITDA_{c,t,i,f}}{Asset_{c,t-1,i,f}(1+infl_{c,t})} \tag{3.6}$$

$$ROA^v_{c,t,i,f} = \frac{EBITDA_{c,t,i,f}}{(Debt_{c,t-1,i,f}+MV_{c,t-1,i,f})(1+infl_{c,t})} \tag{3.7}$$

ROA^b represents the ROA calculated using a book value of an asset, a standard approach used in the accounting literature. Value of asset at the end of period $t-1$ is used in the denominator as it is the amount that the firm owned entering period t, and thus was capital that was employed during period t to generate the $EBITDA_{c,t,i,f}$. $Infl_{c,t}$ represents the inflation in country c in period t. One main issue with using the book value of an asset is that it doesn't represent the "current" value of assets in place. Thus, to check the robustness of the result, I also repeat the regression using ROA^v, which uses book value of debt($Debt_{c,t-1,i,f}$) and market value of equity($MV_{c,t-1,i,f}$) to estimate the current value of an asset in period $t-1$. Under perfect capital market, this should correctly estimate a replacement value of an asset.

3.3.2 Data Descriptions

In this paper, I limit my analysis to listed firms in MSCI emerging and developed countries as these countries make up majority of the world exports and imports.[3] This is a simplification, but should be able to provide a good approximation of the model as these countries accounted for more than 80% of the world exports by value as of 2011 according to the World Trade Report (2013).

Financial and market data used to calculate the return to capital for firms in these countries are

[2]Note that this general expression of the marginal product of capital should hold even if the firms have increasing/decreasing return to scale Cobb-Douglas type production function

[3]Saudi Arabia is dropped from the sample due to limited availability of the firm-level data in early-2000s.

obtained from Worldscope Datastream. Datastream is a preferred source of data for the cross-country comparison because it not only provides an extensive accounting and market data on listed firms across countries, but also aims to "provide the data in a manner that allows maximum comparability between one company and another, and between various reporting regimes" (Worldscope/Disclosure Partners, 1992). These adjustments by the Worldscope help minimize the potential bias from the cross-country differences in accounting standards.

Although Worldscope "makes several adjustments to the data to make the definitions more comparable to their US counterparts,"(Wald, 1999), the difference in accounting standard across countries can severely skew the result. Thus, for precision, I further check for the effects of cross-country differences in accounting standards by running robustness test restricting the analysis to the countries that adopted International Financial Reporting Standards (IFRS). Since the mid-2000s there has been increasing attempt led by Euro-zone countries to unify the accounting standards across countries. This has led to a formation of International Accounting Standards Boards (IASB), with the explicit goal "to develop an internationally acceptable set of high quality financial reporting standards." (Barth, et al 2008). Although the United States is yet to adopt IFRS, the standard has been adopted in EU countries by 2005, and majority of MSCI developed and emerging countries by 2011.

The period of interest in the main analysis is 1997-2014. The lower bound is set on 1997 due to the limited availability of data for firms in emerging countries in pre-1997. Within each year I exclude firms with missing market value, book value, sales or EBITDA. I also winsorize the return estimate at 1% to control for the outliers. I use Standard Industry Classification (SIC) code to sort the firms into industries, following the convention of US Securities and Exchange Commission (SEC). For within-industry analysis, I focus on the manufacturing industries as they "are more likely to be motivated by exporter skill and capital abundance." (Schott, 2004). Also, these industries are likely to contain "fewer non-tradables than these other sectors, so that their actual development paths may more closely resemble the theoretical archetypes described above." (Schott, 2003). The summary statistics of the raw data is provided in Table 1. After exclusions have been applied, the main analysis uses 334,608 firm-years across 42 countries.

Penn World Table 9.0 provide aggregate capital stock estimate, which is constructed from the annual investment data using perpetual inventory method. [4] Although Penn World Table is the highly respected source for macroeconomic data, it is important to note that the Per capita capital are estimated values, and thus involves measurement errors. For example, capital stock estimate based on the investment on reproducible goods excludes the land and natural capital that contributes to the income flow within the economy, an issue which has been raised by Caselli and Feyrer(2007). Therefore, in their paper they attempt to separate natural capital from reproducible capital using the World Bank's data on the land and natural resources, and find that this adjustment reduces the return gap between advanced and developing economies. Empirical findings of the previous chapters further suggests that the standard capital accumulation process used to construct the capital stock estimate is likely erroneous. Therefore, instead of relying on the estimates of capital stock, I use Purchasing power parity (PPP) adjusted real per capita GDP to proxy for the per capita capital. In the standard model with two factors and identical technologies, higher per capita GDP should imply higher per capita capital. For robustness, I do repeat the analysis using per capita capital stock estimate from PWT [5], and the result remain unchanged.

3.4 Single vs. Multi-cone Heckscher Ohlin Model

One of the most significant conclusion of the Heckscher Ohlin model is Factor Price Equalization, which states that "within a cone of diversification, factor return do not responds to changes in endowments."(Schott,2003) Thus, if the world is described by the standard single-cone model, the return to capital should be equalized across countries. This suggests that one shouldn't observe a systematic relationship between the relative endowment and the firm return to capital after one control for the firm specific risk. Conversely, statistically significant relationship between the firm return to capital and relative endowment should favor the multi-cone version of H-O model over the single cone version. Based on this observation, I run the following regression analysis to test

[4] The detailed description of the method is provided in in Feenstra, et al (2015)

[5] see results in the appendix

the two-versions of Heckscher Ohlin model:

$$q_{c,t,i,f} = \alpha + \beta_1 log(PCGDP_{c,t}) + \beta_2 D_t + \beta_3 F_i + \boldsymbol{\gamma X_{c,t,i,f}} + \epsilon_{c,t,i,f} \tag{3.8}$$

- $q_{c,t,i,f}$: Return to capital for firm f in industry i in country c in period t.
- $PCGDP_{c,t}$: Purchasing Power Parity adjusted real per capita Capital in country c in period t (in 2011 US dollars)
- $\boldsymbol{X_{c,t,i,f}}$: Vector of firm specific factors, including book value of total assets, book debt-to-equity ratio, and market to book equity ratio of firm f in industry i in country c in period t
- D_t: Time dummies
- F_i: Industry dummies

In the regression I control for firm-specific effects such as size, leverage, and price-to-book, as the model doesn't account for the firm specific risk. The industry dummies are added to adjust for industry specific effect as a country may be heavily invested in certain industries, and this industry bias can potentially skew the results. Time dummies are added to control for the global macroeconomic shock that may have occurred during the period of analysis. This adjustment is particularly important since the period of analysis includes the Global Financial Crisis (2007-2009), which led to a large volatility in the firm earnings and the current value of assets.

The regression result presented in Table 2 shows that the firm productivity decrease with increase in the country's per capita GDP even after controlling for the firm specific effect. This empirical result, which shows the systematic relationship between the relative endowment and the return to capital, favors the multi-cone version of H-O model over the single cone version. This suggests a weak link among international factor prices, and implies that trade liberalization can only have a limited effect on the factor price convergence. Thus, wage inequality across countries should remain even in the world of free trade. The result is consistent for both ROA^b and

ROA^v, and the finding is robust across different time periods (2000-2014 and the post-financial crisis periods). I also repeat the regression using only the Euro-zone countries in 2011-2014 years to control for the potential effect of the accounting standard difference across the world. Despite some corrections made by the Worldscope Datastream, the difference across countries still persists, and it may skew the results if it is systematically related to the per capita capital. However, as shown in table 2, the result remain robust even among the Euro-zone countries that share the same accounting standards.

3.5 Technology Difference vs. Product Specialization

The findings in the previous section supports the multi-cone model of the Heckscher-Ohlin model. However, the result may also be due to technology difference (i.e. there is more than one method to produce a good, and more efficient method is used by the firms in developed countries). Therefore, in this chapter I investigate the firm-level data to explore the factors that drive the specialization across countries.

3.5.1 Alternative Explanation: Technology Differences

As stated in the previous sub-section, the negative and statistically significant relationship between firm return to capital and the relative aggregate endowment observed in the data is inconsistent with the single cone H-O model, and favors the multi-cone approach. However, as mentioned in the introduction, the cross-country difference in return to capital can also be due to difference in the level of technology. In eq (3), the model assumes that the countries share the same technology matrix $\boldsymbol{A'^{-1}}$, and thus, if the countries produce the same good and price is equalized across countries, factor price should be identical. However, if the level of technology is positively correlated with the relative endowment, one should be able to observe a higher return to capital in emerging countries compared to developed, even when the countries are producing identical goods.

Thus, to test the validity of this alternative explanation, I run the following regression to test the alternative hypothesis:

$$\left(\frac{y}{k}\right)_{c,t,i,f} = \alpha + \beta_1 log(PCGDP_{c,t}) + \beta_2 D_t + \beta_3 F_i + \boldsymbol{\gamma X_{c,t,i,f}} + \epsilon_{c,t,i,f} \tag{3.9}$$

$\left(\frac{y}{k}\right)_{c,t,i,f}$ is the output-to-capital ratio of the firm f in industry i in country c in time t. I proxy this using the asset-turnover ratio, which is the ratio between sales and the market value of the firm's capital. For "technology difference" explanation to hold, the output-to-capital ratio should also be downward sloping due to the equality in eq (2); i.e. if one observe a statistically significant downward trend between the firm asset turnover and the aggregate relative endowment, then one cannot rule out the technological difference as the possible explanation for the trend observed in the previous subsection.

The regression results in Table 3, however, show that the relationship between the aggregate endowment ratio and firm asset turnover is statistically insignificant across MSCI developed and emerging countries during 2000-2014 period and even positive during 2011-2014 period. This suggests that that the observed downward trend between firm ROA and log(PCGDP) more likely fit the multi-cone model than a single-cone model with technology difference across countries. On the other hand, among EU countries, one cannot reject the single-cone technology difference explanation, as the downward slope is statistically significant. This is plausible, as it suggests that compared to the rest of the world, the aggregate relative endowment among EU countries are sufficiently similar that they reside in the identical cone of production.

3.5.2 Specialization Within vs. Across Industries

In the traditional H-O model of specialization, the countries are assumed to specialize across industries as shown in Figure 1. The capital abundant developed countries should specialize in capital intensive industries (Electronics and Machinery in Figure 1) and labor abundant emerging countries should specialize in labor intensive industries (Textiles and Food Products in Figure 1). However, in Table 4, I show that there isn't any 2-digit SIC manufacturing industry that are exclusive to MSCI developed or emerging countries in 2014.[6] In Appendix A show that the only industry that is exclusive to developed country in 2014 is Legal Services, and there is no industry that is exclusive to emerging countries. This suggests that specialization does not occur across

[6]As stated in the previous sub-section, I focus on the manufacturing industries for the intra-industry analysis. However, the result for other 2-digit SIC industries are also available in the appendix, and are consistent with the results observed for the manufacturing industries.

industries as suggested by the traditional H-O model, finding which is consistent with Bowen, et al (1987).

On the other hand, empirical evidence strongly supports the within-industry specialization that was suggested in Schott (2003). Table 5 displays the result of estimating the following modified version of equation (9) within each 2-digit manufacturing industry:

$$q_{c,t,f} = \alpha + \beta_1 log(PCGDP_{c,t}) + \beta_2 D_t + \boldsymbol{\gamma X_{c,t,f}} + \epsilon_{c,t,f} \tag{3.10}$$

The regression result shows a statistically significant negative relationship between the firm ROA and log(PCGDP) within most of the 2-digit manufacturing industries; the slope is negative and statistically significant in 15 industries and is non- and is not significant in 5 industries. Positive relationship is not observed in any manufacturing industry. If the specialization occurred across industries, the factor returns should be constant within each industry. The statistically significant downward trend found in Table 4 suggests that the specialization occurs with-in and not across.

This finding is significant as it suggests that even within the industry, developed and emerging countries do not engage in a direct competition. This finding also suggests that previous empirical researches that showed little evidence in favor of endowment driven specialization across industries cannot rule-out the mutli-cone version of the H-O model. This finding is consistent with Grossman and Helpman (1991) in that it suggests that the high wage countries continue to lead the emerging countries over time with its ability to innovate the higher quality product.

3.6 Conclusion

In this paper, I investigated the implication of the H-O model using the firm-level data. The empirical result supports the multi-cone version of H-O model, over the single-cone version and suggests that the specialization occur within the industry rather than across. This finding is consistent with Schott (2003, 2004) and suggests that free international trade can only have a limited impact on the factor price convergence even in the long run.

This paper differs from others in that it used the firm-level accounting data to analyse the macroeconomic problem. Most of the factor price equalization analysis thus far has focused on

the cross-country wage difference rather than the return to capital difference due to the difficulty of measuring the returns at the aggregate economy level.[7] In this paper, I attempt to side-step the issue of aggregate measurement by utilizing the firm-level accounting data. Firm level data has advantage over macroeconomic data in that it allows direct measurement of capital that is used to generate income. However, it restricts the analysis to mid-to large-size firms that are listed in the stock market. One may argue that the return found using only the firm level data is biased upward as it doesn't include self-employed workers, or mom-and-pop stores. This is a plausible argument, and future research on the subject should attempt to address these issues.

In this paper, I have also side-stepped the issue of the tariffs and trade barriers, impediment to the free trade, which can also cause a cross-country difference in the factor price. The future research should also investigate how the non-zero trade cost affect the factor price differences across countries.

[7]Some has attempted to use the investment return, but as stated in the previous chapters, this can lead to an erroneous conclusion, as MPK and investment return relationship is not necessarily linear across countries.

Figure 3.1: Lerner Diagram

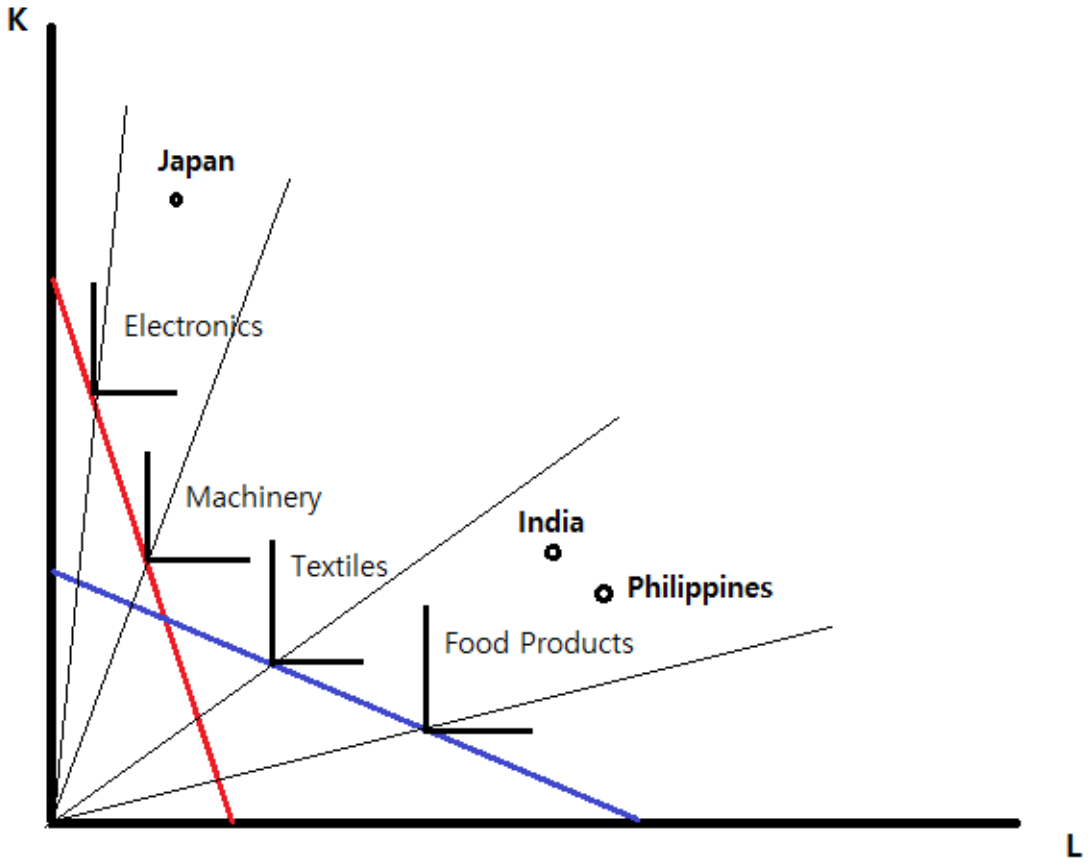


Table 3.1: Data Summary Statistics (1997-2014)

The sample includes all non-financial (all SIC codes except 6000∼6999) balance sheet solvent firm-years in the Worldscope database with 1) market value(WC08001), assets(WC02999), liabilities(WC03351), depreciation(WC01151), EBITDA(WC18198), extraordinary credit(WC01253) and extraordinary charge(WC01254) data for the year and; 2) debt and market value data for the previous year in the MSCI developed and emerging countries (excluding Saudi Arabia, Qatar and UAE) between 1997 and 2014. Purchasing Power Parity (PPP) adjusted per capita GDP (PCGDP) is calibrated using the PPP adjusted GDP(rgdpo) and the population (pop) estimate from the Penn World Table 9.0. Employed population (emp), and average hours worked per employed (avh) are also from the Penn World Table 9.0. CPI inflation is from the World Bank

Country	wbcode	Firm-years	Fama French Industries	PPP adjusted PCGDP (2014)	CPI Inflation (2014)	Population (2014, millions)	Employed (2014, millions)	Average Hours Worked per Employed (2014)
Australia	AUS	14,838	44	44,241	0.025	23.6	12.0	1,803
Austria	AUT	1,147	28	45,705	0.016	8.5	4.4	1,629
Brazil	BRA	1,450	35	14,811	0.063	206.1	105.9	1,711
Belgium	BEL	3,250	38	39,950	0.003	11.2	4.9	1,575
Canada	CAN	12,632	44	43,368	0.019	35.6	18.8	1,688
Chile	CHL	2,080	30	21,317	0.044	17.8	7.8	1,990
China	CHN	20,092	44	12,513	0.020	1,369.4	798.4	NA
Colombia	COL	365	24	12,858	0.029	47.8	24.6	1,772
Czech Republic	CZE	436	24	29,187	0.003	10.5	5.1	1,771
Denmark	DNK	1,890	37	44,423	0.006	5.6	2.8	1,438
Finland	FIN	1,929	36	38,343	0.010	5.5	2.6	1,643
France	FRA	8,637	43	38,584	0.005	66.1	27.3	1,473
Germany	DEU	9,037	43	46,507	0.009	80.6	42.5	1,371
Greece	GRC	3,643	37	24,685	-0.013	11.0	4.0	2,042
Hong Kong	HKG	11,342	42	45,134	0.044	7.2	3.7	2,234
Hungary	HUN	423	23	22,750	-0.002	9.9	4.2	1,860
India	IND	17,621	44	5,452	0.064	1,295.3	510.3	2,162
Indonesia	IDN	3,826	37	9,798	0.064	254.5	113.0	2,027
Ireland	IRL	782	26	51,927	0.002	4.7	1.9	1,821
Israel	ISR	3,187	40	31,606	0.005	7.9	3.9	1,880
Italy	ITA	3,141	36	35,324	0.002	59.8	23.6	1,734
Japan	JPN	52,501	44	35,566	0.027	126.8	65.0	1,729
Malaysia	MYS	11,427	42	21,650	0.031	29.9	13.8	2,268
Mexico	MEX	1,470	35	15,520	0.040	125.4	51.4	2,137
Netherlands	NLD	2,120	39	48,178	0.010	16.9	8.7	1,420
New Zealand	NZL	1,385	36	34,066	0.009	4.5	2.4	1,762
Norway	NOR	2,260	33	78,293	0.020	5.1	2.7	1,427
Peru	PER	986	26	10,931	0.032	31.0	14.7	1,790
Philippines	PHL	1,706	33	6,638	0.041	99.1	34.9	2,115
Poland	POL	3,053	40	24,450	0.001	38.6	15.8	2,039
Portugal	PRT	812	30	27,047	-0.003	10.4	4.3	1,857
Russia	RUS	1,869	35	24,056	0.078	143.4	71.9	1,985
Singapore	SGP	7,146	43	66,482	0.010	5.5	3.4	2,263
South Africa	ZAF	3,621	41	12,067	0.064	54.0	18.3	2,215
South Korea	KOR	16,906	43	34,955	0.013	50.1	26.1	2,124
Spain	ESP	1,883	36	32,858	-0.001	46.3	17.6	1,689
Sweden	SWE	4,761	42	42,605	-0.002	9.7	4.8	1,609
Switzerland	CHE	2,936	34	62,637	0.000	8.2	5.0	1,568
Thailand	THA	5,740	41	13,725	0.019	67.7	38.9	2,284
Turkey	TUR	2,907	36	19,675	0.089	77.5	24.6	1,832
United Kingdom	GBR	18,827	44	38,757	0.015	64.3	31.0	1,675
United States	USA	69,400	44	51,959	0.016	319.4	148.5	1,765
Total		335,464	44					

Table 3.2: ROA vs. log (PCGDP)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	ROA^b	ROA^b	ROA^b	ROA^b	ROA^v	ROA^v	ROA^v	ROA^v
VARIABLES	97-14	'11-14	'11-14 IFRS	05-14 EU	97-14	'11-14	'11-14 IFRS	05-14 EU
log(PCGDP)	-0.0404***	-0.0419***	-0.0503***	-0.0280***	-0.0197***	-0.0165***	-0.00968**	-0.00936**
	(0.00238)	(0.00348)	(0.00644)	(0.00722)	(0.00193)	(0.00369)	(0.00379)	(0.00451)
log(Size)	0.0203***	0.0185***	0.0165***	0.0273***	0.00990***	0.00855***	0.00906***	0.0139***
	(0.00211)	(0.00403)	(0.00423)	(0.00186)	(0.000796)	(0.00172)	(0.00185)	(0.000601)
Leverage	-0.0544***	-0.0576***	-0.0264**	-0.0625***	-0.0338***	-0.0333***	-0.0104	-0.0259***
	(0.00673)	(0.00980)	(0.0116)	(0.00907)	(0.00367)	(0.00635)	(0.00878)	(0.00595)
Price-to-Book	-6.04e-05***	-5.03e-05*	-0.000190*	-0.000115**	-2.04e-05**	-2.31e-05*	-7.71e-05***	-5.56e-05***
	(1.60e-05)	(2.87e-05)	(0.000103)	(4.95e-05)	(8.19e-06)	(1.35e-05)	(2.93e-05)	(1.92e-05)
Constant	0.315***	0.319***	0.426***	0.148**	0.189***	0.166***	0.0597	0.0545
	(0.0336)	(0.0492)	(0.0828)	(0.0729)	(0.0227)	(0.0411)	(0.0469)	(0.0466)
Year Dummies	Y	Y	Y	Y	Y	Y	Y	Y
Industry Dummies	Y	Y	Y	Y	Y	Y	Y	Y
Observations	334,608	88,527	44,640	34,031	334,608	88,527	44,640	34,031
R-squared	0.126	0.140	0.150	0.120	0.127	0.119	0.136	0.116

Table 3.3: Turnover vs. log(Per capita GDP)

	(1)	(2)	(3)	(4)
	Turnover	Turnover	Turnover	Turnover
VARIABLES	97-14	'11-14	'11-14 IFRS	05-14 EU
log(PCGDP)	0.0610***	0.0772**	0.193***	-0.0676
	(0.0158)	(0.0382)	(0.0371)	(0.0464)
log(Size)	-0.00967**	-0.0137*	0.0162***	-0.0250***
	(0.00424)	(0.00747)	(0.00486)	(0.00300)
Leverage	0.471***	0.480***	0.503***	0.675***
	(0.0270)	(0.0407)	(0.0498)	(0.0522)
Price-to-Book	-0.000251***	-0.000250*	-0.000494	-0.000426
	(7.64e-05)	(0.000133)	(0.000352)	(0.000311)
Constant	0.0742	0.0512	-1.644***	1.580***
	(0.178)	(0.425)	(0.408)	(0.488)
Year Dummies	Y	Y	Y	Y
Industry Dummies	Y	Y	Y	Y
Observations	334,608	88,527	44,640	34,031
R-squared	0.185	0.180	0.207	0.173

Table 3.4: Countries by SIC 2-Digit Manufacturing Industries (2014)

SIC 2-Digit	Developed	Emerging
20 FOOD AND KINDRED PRODUCTS	AUS, AUT, BEL, CAN, DNK, FIN, FRA, DEU, HKG, IRL, ISR, ITA, JPN, NLD, NZL, NOR, PRT, SGP, ESP, SWE, CHE, GBR, USA	BRA, CHL, CHN, COL, GRC, HUN, IND, IDN, MYS, MEX, PER, PHL, POL, RUS, ZAF, KOR, THA, TUR
21 TOBACCO PRODUCTS	BEL, CAN, JPN, GBR, USA	GRC, IND, IDN, MYS, MEX, KOR
22 TEXTILE MILL PRODUCTS	AUS, AUT, BEL, CAN, DNK, FIN, FRA, DEU, HKG, ISR, ITA, JPN, NZL, SGP, GBR, USA	BRA, CHN, COL, CZE, GRC, IND, IDN, MYS, MEX, PER, POL, KOR, THA, TUR
23 APPAREL AND OTHER TEXTILE PRODUCTS	AUS, BEL, CAN, DNK, FIN, FRA, DEU, HKG, ISR, ITA, JPN, NOR, SGP, ESP, SWE, CHE, GBR, USA	BRA, CHN, GRC, IND, IDN, MYS, POL, KOR, THA, TUR
24 LUMBER AND WOOD PRODUCTS	BEL, CAN, FRA, DEU, HKG, IRL, ISR, JPN, NZL, NOR, PRT, SGP, SWE, GBR, USA	CHL, CHN, GRC, IND, IDN, MYS, MEX, POL, ZAF, KOR, THA, TUR
25 FURNITURE AND FIXTURES	AUS, BEL, CAN, FIN, DEU, HKG, JPN, NLD, NOR, SGP, SWE, GBR, USA	CHL, CHN, GRC, IND, IDN, MYS, POL, KOR, THA, TUR
26 PAPER AND ALLIED PRODUCTS	AUS, AUT, BEL, CAN, DNK, FIN, FRA, DEU, HKG, IRL, ISR, ITA, JPN, NLD, NOR, PRT, SGP, ESP, SWE, CHE, GBR, USA	CHL, CHN, COL, GRC, HUN, IND, IDN, MYS, MEX, POL, RUS, ZAF, KOR, THA, TUR
27 PRINTING AND PUBLISHING	AUS, BEL, CAN, DNK, FIN, FRA, DEU, HKG, ISR, ITA, JPN, NLD, NOR, PRT, SGP, ESP, SWE, CHE, GBR, USA	BRA, CHN, GRC, HUN, IND, IDN, MYS, PER, PHL, POL, ZAF, KOR, THA, TUR
28 CHEMICALS AND ALLIED PRODUCTS	AUS, AUT, BEL, CAN, DNK, FIN, FRA, DEU, HKG, IRL, ISR, ITA, JPN, NLD, NZL, NOR, PRT, SGP, ESP, SWE, CHE, GBR, USA	BRA, CHL, CHN, COL, GRC, HUN, IND, IDN, MYS, MEX, PER, PHL, POL, RUS, ZAF, KOR, THA, TUR
29 PETROLEUM AND COAL PRODUCTS	AUS, AUT, BEL, CAN, FRA, DEU, HKG, ISR, ITA, JPN, NZL, NOR, PRT, ESP, GBR, USA	CHL, CHN, CZE, GRC, HUN, IND, IDN, MYS, MEX, PER, PHL, POL, RUS, KOR, THA, TUR
30 RUBBER AND MISCELLANEOUS PLASTICS PRODUCTS	AUS, AUT, BEL, CAN, FIN, FRA, DEU, HKG, ISR, ITA, JPN, NZL, NOR, SGP, SWE, CHE, GBR, USA	BRA, CHN, COL, GRC, HUN, IND, IDN, MYS, PER, POL, RUS, ZAF, KOR, THA, TUR
31 LEATHER AND LEATHER PRODUCTS	BEL, FRA, DEU, HKG, ITA, JPN, GBR, USA	CHL, CHN, IND, IDN, MYS, POL, KOR, THA
32 STONE, CLAY, GLASS, AND CONCRETE PRODUCTS	AUS, AUT, BEL, CAN, DNK, FRA, DEU, HKG, IRL, ITA, JPN, NLD, NZL, PRT, SGP, ESP, CHE, GBR, USA	CHL, CHN, COL, GRC, IND, IDN, MYS, MEX, PER, PHL, POL, ZAF, KOR, THA, TUR
33 PRIMARY METAL INDUSTRIES	AUS, AUT, BEL, CAN, DNK, FIN, FRA, DEU, HKG, ISR, ITA, JPN, NLD, NZL, NOR, PRT, SGP, ESP, SWE, CHE, GBR, USA	BRA, CHL, CHN, COL, GRC, IND, IDN, MYS, MEX, PER, PHL, POL, RUS, ZAF, KOR, THA, TUR
34 FABRICATED METAL PRODUCTS	AUS, AUT, BEL, CAN, DNK, FIN, FRA, DEU, HKG, ISR, ITA, JPN, NLD, NZL, SGP, ESP, SWE, CHE, GBR, USA	BRA, CHL, CHN, IND, IDN, MYS, POL, RUS, ZAF, KOR, THA, TUR
35 INDUSTRIAL MACHINERY AND EQUIPMENT	AUS, AUT, BEL, CAN, DNK, FIN, FRA, DEU, HKG, ISR, ITA, JPN, NLD, NZL, NOR, SGP, ESP, SWE, CHE, GBR, USA	BRA, CHN, GRC, IND, IDN, MYS, PER, PHL, POL, RUS, ZAF, KOR, THA, TUR
36 ELECTRONIC AND OTHER ELECTRIC EQUIPMENT	AUS, AUT, BEL, CAN, DNK, FIN, FRA, DEU, HKG, ISR, ITA, JPN, NLD, NZL, NOR, PRT, SGP, ESP, SWE, CHE, GBR, USA	BRA, CHL, CHN, IND, IDN, MYS, MEX, PER, PHL, POL, RUS, ZAF, KOR, THA, TUR
37 TRANSPORTATION EQUIPMENT	AUS, AUT, BEL, CAN, FRA, DEU, HKG, ISR, ITA, JPN, NLD, NZL, NOR, PRT, SGP, ESP, SWE, CHE, GBR, USA	BRA, CHL, CHN, HUN, IND, IDN, MYS, MEX, PHL, POL, RUS, ZAF, KOR, THA, TUR
38 INSTRUMENTS AND RELATED PRODUCTS	AUS, BEL, CAN, DNK, FIN, FRA, DEU, HKG, IRL, ISR, ITA, JPN, NLD, NZL, NOR, SGP, SWE, CHE, GBR, USA	BRA, CHN, GRC, IND, MYS, POL, RUS, ZAF, KOR, THA, TUR
39 MISCELLANEOUS MANUFACTURING INDUSTRIES	AUS, BEL, DNK, FIN, FRA, DEU, HKG, ITA, JPN, NLD, SWE, CHE, GBR, USA	CHN, IND, MYS, KOR, THA, TUR

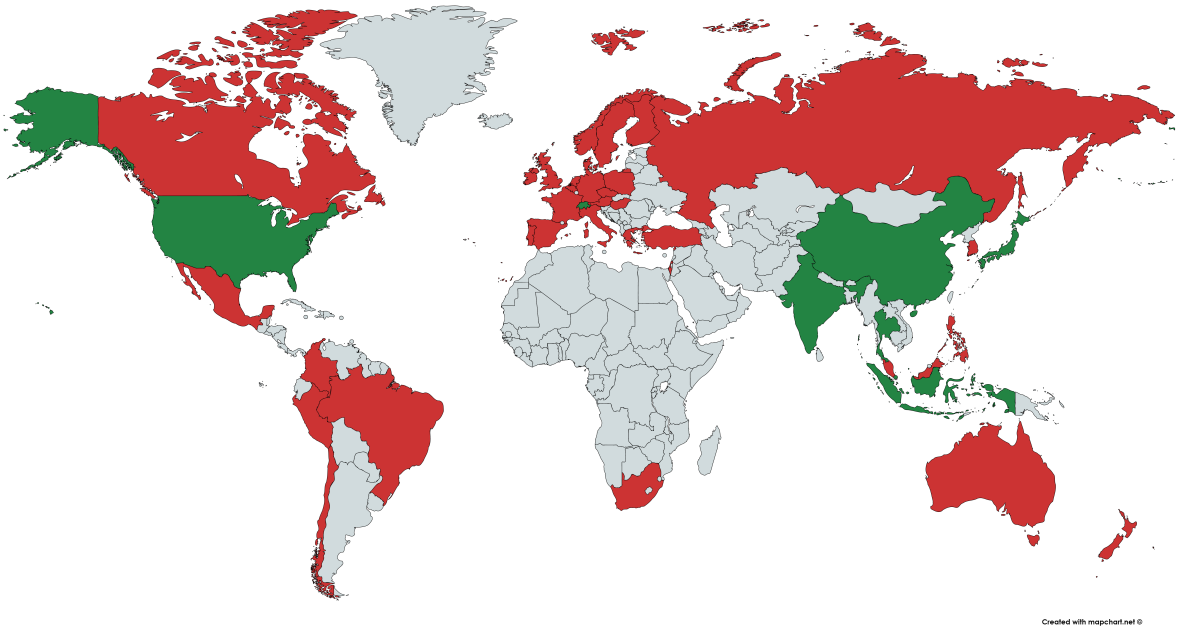
Table 3.5: Manufacturing: ROA vs. log(PCGDP)

SIC Code	log(PCGDP)	log(Size)	Leverage	Price-to-Book	Observations	R-squared
20 FOOD AND KINDRED PRODUCTS	-0.0144***	0.00548***	-0.0721***	-0.000232***	15,460	0.097
21 TOBACCO PRODUCTS	0.00123	0.00501***	-0.0529***	-0.000489**	481	0.169
22 TEXTILE MILL PRODUCTS	-0.0243***	0.00377***	-0.0778***	-0.000656***	5,077	0.094
23 APPAREL AND OTHER TEXTILE PRODUCTS	-0.0160***	0.00492***	-0.107***	-0.000796***	3,676	0.112
24 LUMBER AND WOOD PRODUCTS	-0.00873**	0.00672***	-0.0604***	-0.00210***	2,214	0.090
25 FURNITURE AND FIXTURES	-0.0266***	0.00444***	-0.109***	0.000459**	1,805	0.105
26 PAPER AND ALLIED PRODUCTS	-0.0102***	0.00275***	-0.0909***	-1.90e-05***	5,102	0.091
27 PRINTING AND PUBLISHING	-0.00705**	0.00584***	-0.0450***	-0.000580***	4,922	0.067
28 CHEMICALS AND ALLIED PRODUCTS	-0.0416***	0.0148***	-0.0238***	-6.87e-05**	25,242	0.197
29 PETROLEUM AND COAL PRODUCTS	0.00325	0.0111***	-0.121***	-0.00159***	2,060	0.247
30 RUBBER AND MISCELLANEOUS PLASTICS PRODUCTS	-0.0216***	0.00554***	-0.0841***	-0.000718**	4,666	0.109
31 LEATHER AND LEATHER PRODUCTS	-0.0263***	-0.00127	-0.163***	-0.000408	1,028	0.143
32 STONE, CLAY, GLASS, AND CONCRETE PRODUCTS	-0.0156***	0.00575***	-0.0916***	-0.000348***	6,831	0.114
33 PRIMARY METAL INDUSTRIES	-0.0169***	0.00481***	-0.0932***	-0.000621***	10,213	0.123
34 FABRICATED METAL PRODUCTS	-0.0134***	0.00481***	-0.108***	-0.000377*	6,722	0.097
35 INDUSTRIAL MACHINERY AND EQUIPMENT	-0.0182***	0.00653***	-0.0453***	-0.000619***	18,232	0.069
36 ELECTRONIC AND OTHER ELECTRIC EQUIPMENT	-0.0178***	0.00851***	-0.0286***	-4.78e-05	23,572	0.072
37 TRANSPORTATION EQUIPMENT	-0.0142***	0.00529***	-0.0639***	-0.000135***	9,505	0.058
38 INSTRUMENTS AND RELATED PRODUCTS	-0.0311***	0.0162***	-0.0283***	-5.46e-05**	11,695	0.135
39 MISCELLANEOUS MANUFACTURING INDUSTRIES	-0.0114***	0.00275**	-0.0838***	-0.000255**	3,107	0.066

APPENDIX A

CHAPTER 1 APPENDIX

Figure A.1: Countries with IFRS Standards



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[1]Countries included in the sample are highlighted in red or green. Countries colored in red has adopted IFRS by 2017

Table A.1: Accounting Standard and IFRS Adoption Date by Country

Country	Accounting Standard	IFRS Adoption Date
Australia	IFRS	2005
Austria	IFRS	2005
Belgium	IFRS	2005
Brazil	IFRS	2010
Canada	IFRS	2011
Chile	IFRS	2010
China*	Chinese Accounting Standards	2007
Colombia	IFRS	2015
Czech Republic	IFRS	2005
Denmark	IFRS	2005
Finland	IFRS	2005
France	IFRS	2005
Germany	IFRS	2005
Greece	IFRS	2005
Hong Kong	IFRS	2005
Hungary	IFRS	2005
India	India accounting standards	NA
Indonesia	Indonesian national GAAP	NA
Ireland	IFRS	2005
Israel	IFRS	2008
Italy	IFRS	2005
Japan	Japanese Accounting Standards	NA
Malaysia	IFRS	2017
Mexico	IFRS	2012
Netherlands	IFRS	2005
New Zealand	IFRS	2007
Norway	IFRS	2005
Peru	IFRS	2012
Philippines	IFRS	2005
Poland	IFRS	2005
Portugal	IFRS	2005
Russia	IFRS	2012
Singapore	Singapore Financial Reporting Standards (SFRS)	NA
South Africa	IFRS	2011
South Korea	IFRS	2011
Spain	IFRS	2005
Sweden	IFRS	2005
Switzerland	Swiss GAAP	NA
Thailand	Thai Accounting Standards	NA
Turkey	IFRS	2005
UK	IFRS	2005
US	US GAAP	NA

Table A.2: Firm and Country Fixed Effects: MPK and IRR for 1996-2014

	(1)	(2)	(3)	(1)	(2)	(3)
Variables	ROA	ROA	ROA	IRR	IRR	IRR
Years	97-14	97-14	97-14	97-14	97-14	97-14
log(PCGDP)	-0.0436***	-0.0308***	-0.0197***	0.0613***	-0.0255	-0.00209
	(0.00206)	(0.00889)	(0.00193)	(0.00772)	(0.0744)	(0.0181)
log(size)	0.0187***	0.0148***	0.00990***	-0.0772***	0.00253	0.000712
	(0.000574)	(0.000573)	(0.000796)	(0.00266)	(0.00197)	(0.00213)
Leverage	-0.0798***	-0.0508***	-0.0338***	-0.0601***	-0.114***	-0.121***
	(0.00214)	(0.00389)	(0.00367)	(0.0102)	(0.0168)	(0.0187)
Price-to-Book	4.01e-06	-1.47e-05**	-2.04e-05**	0.000344***	0.000209**	0.000212**
	(3.24e-06)	(6.84e-06)	(8.19e-06)	(0.000106)	(8.25e-05)	(8.39e-05)
Constant	0.329***	0.220**	0.189***	0.450***	0.433	0.154
	(0.0204)	(0.0932)	(0.0227)	(0.0763)	(0.773)	(0.192)
Observations	334,608	334,608	334,608	334,608	334,608	334,608
R-squared	0.037	0.168	0.127	0.070	0.068	0.064
Firm Dummies	Y	N	N	Y	N	N
Year Dummies	NA	Y	N	NA	Y	N
Time Dummies	NA	Y	Y	NA	Y	Y
Industry Dummies	NA	Y	Y	NA	Y	Y

Table A.3: Country Clusters: MPK and IRR for 1996-2014 and 2011-2014

	(1)	(2)	(3)	(4)
Variables	ROA	ROA	IRR	IRR
Years	97-14	11-14	97-14	11-14
log(PCGDP)	-0.0197***	-0.0165**	-0.00209	0.0303**
	(0.00605)	(0.00720)	(0.00731)	(0.0124)
log(size)	0.00990***	0.00855**	0.000712	1.45e-05
	(0.00288)	(0.00343)	(0.00150)	(0.00184)
Leverage	-0.0338***	-0.0333***	-0.121***	-0.0897***
	(0.0112)	(0.0119)	(0.0128)	(0.0135)
Price-to-Book	-2.04e-05***	-2.31e-05*	0.000212***	0.000103
	(6.96e-06)	(1.36e-05)	(7.66e-05)	(8.52e-05)
Constant	0.189***	0.166**	0.154**	-0.271**
	(0.0688)	(0.0787)	(0.0735)	(0.130)
Observations	334,608	88,527	334,608	88,527
R-squared	0.127	0.119	0.064	0.037
Time Dummies	Y	Y	Y	Y
Industry Dummies	Y	Y	Y	Y

Table A.4: Non-Financial 2-digit SIC Industries: Firm ROA and PCGDP

SIC Code	log(PCGDP)	log(Size)	Leverage	Price-to-Book	Observations	R-squared
1	-0.0245***	0.0139***	-0.0601***	-0.00413***	1,915	0.130
2	-0.0238***	0.00600**	-0.0630***	-0.00286***	823	0.107
7	0.00216	0.00151	0.0212	-0.00217**	422	0.051
8	-0.0177*	0.0163***	-0.0409	-0.00352**	418	0.183
9	-0.0353***	0.0148***	-0.0253	-0.00231	272	0.210
10	-0.0348***	0.0332***	-0.0175*	1.32e-05	9,834	0.305
12	-0.0340***	0.0260***	0.0277	-1.17e-06	1,902	0.272
13	-0.0112***	0.0229***	0.0147*	-0.000157	9,821	0.227
14	-0.0485***	0.0184***	0.0502***	-0.000139***	1,034	0.206
15	-0.00136	0.00398***	-0.0620***	-2.81e-06	11,389	0.045
16	-0.0140***	0.00109	-0.0567***	-0.000645	4,789	0.049
17	-0.00249	0.00397**	-0.0932***	-6.02e-05***	1,621	0.062
20	-0.0144***	0.00548***	-0.0721***	-0.000232***	15,460	0.097
21	0.00123	0.00501***	-0.0529***	-0.000489**	481	0.169
22	-0.0243***	0.00377***	-0.0778***	-0.000656***	5,077	0.094
23	-0.0160***	0.00492***	-0.107***	-0.000796***	3,676	0.112
24	-0.00873**	0.00672***	-0.0604***	-0.00210***	2,214	0.090
25	-0.0266***	0.00444***	-0.109***	0.000459**	1,805	0.105
26	-0.0102***	0.00275***	-0.0909***	-1.90e-05***	5,102	0.091
27	-0.00705**	0.00584***	-0.0450***	-0.000580***	4,922	0.067
28	-0.0416***	0.0148***	-0.0238***	-6.87e-05**	25,242	0.197
29	0.00325	0.0111***	-0.121***	-0.00159***	2,060	0.247
30	-0.0216***	0.00554***	-0.0841***	-0.000718**	4,666	0.109
31	-0.0263***	-0.00127	-0.163***	-0.000408	1,028	0.143

32	-0.0156***	0.00575***	-0.0916***	-0.000348***	6,831	0.114
33	-0.0169***	0.00481***	-0.0932***	-0.000621***	10,213	0.123
34	-0.0134***	0.00481***	-0.108***	-0.000377*	6,722	0.097
35	-0.0182***	0.00653***	-0.0453***	-0.000619***	18,232	0.069
36	-0.0178***	0.00851***	-0.0286***	-4.78e-05	23,572	0.072
37	-0.0142***	0.00529***	-0.0639***	-0.000135***	9,505	0.058
38	-0.0311***	0.0162***	-0.0283***	-5.46e-05**	11,695	0.135
39	-0.0114***	0.00275**	-0.0838***	-0.000255**	3,107	0.066
40	0.0120*	0.00203*	-0.140***	-0.00601**	576	0.241
41	0.0105**	0.00205	-0.110***	-0.00100	977	0.078
42	0.000783	0.00159**	-0.0321***	-0.00414***	3,213	0.038
43	0.105	-0.312	1.105	-0.0810	13	1.000
44	-0.0106***	0.00236***	-0.0157	-0.00102**	3,947	0.065
45	0.00295	0.00428***	-0.0570***	-0.000217***	2,204	0.061
46	-0.0362**	0.0120***	-0.0655**	0.000917**	370	0.363
47	-0.00613**	0.00423***	-0.0292**	2.63e-06	1,671	0.047
48	-0.0167***	0.0152***	-0.0323***	-8.95e-06	9,283	0.181
49	-0.0158***	0.0101***	-0.0396***	-3.73e-05	11,191	0.118
50	-0.0105***	0.00649***	-0.0472***	-8.49e-05***	10,735	0.045
51	-0.0100***	0.00450***	-0.0662***	-7.57e-06**	6,966	0.057
52	-0.0153***	0.00195	-0.0607***	-3.03e-05**	794	0.069
53	0.00256	0.00288***	-0.0750***	-0.000241***	2,811	0.097
54	0.00428*	0.00338***	-0.0305***	-0.00210***	2,997	0.050
55	-0.0121***	0.00749***	-0.0515***	-0.00139*	1,543	0.070
56	-0.00347	0.00449***	-0.0593***	-2.06e-05	2,921	0.057
57	0.00652*	0.00677***	-0.0357***	-0.000304	2,015	0.034
58	-0.0159***	0.00469***	-0.0421***	-0.000120	3,846	0.055
59	-0.0111***	0.00823***	-0.0400***	-9.74e-05*	4,172	0.058

70	-0.00895***	0.00477***	-0.0233***	-1.86e-06	4,104	0.030
72	-0.104***	0.0166***	-0.0737***	-0.000715	788	0.141
73	-0.0257***	0.0114***	-0.00358	-8.39e-06	31,394	0.101
75	-0.0181***	0.0167***	0.0416*	-0.000434*	763	0.209
76	-0.0537	0.00124	-0.0431	0.00164	195	0.061
78	-0.0112**	0.00689***	0.00485	-7.65e-05	2,129	0.035
79	-0.00651**	0.00890***	-0.0230**	-0.000755***	3,043	0.051
80	-0.0201***	0.0117***	0.00940	-0.00148***	3,151	0.125
81	-0.0556	0.0218	-0.264	0.100*	24	0.891
82	-0.0108**	0.00375**	-0.0497***	-0.00121***	1,317	0.056
83	0.00673	0.0158***	-0.0354	-0.000619***	285	0.184
84	0.0133	0.00275	-0.0507	-0.00612***	128	0.257
86	4.235	0.588	3	1.000		
87	-0.0285***	0.0162***	0.0280**	-0.000190**	8,399	0.125

Table A.5: Non-Financial 2-digit SIC Industries: Firm IRR and PCGDP

SIC Code	log(PCGDP)	log(Size)	Leverage	Price-to-Book	Observations	R-squared
1	-0.0283*	0.0297***	-0.132***	0.0282***	1,915	0.173
2	-0.000291	0.0106	-0.170**	0.00784	823	0.102
7	0.0151	-0.00130	-0.270	0.0325*	422	0.233
8	0.0224	0.0143	-0.129	0.0248***	418	0.241
9	-0.000509	0.0237***	-0.150	0.122***	272	0.517
10	-0.0181	0.00377	-0.227***	0.000322***	9,834	0.116
12	-0.0270	-0.00553	-0.247*	-1.39e-05	1,902	0.110
13	0.00311	0.00338	-0.289***	0.00328***	9,821	0.110
14	0.0131	0.00290	-0.273***	0.000717**	1,034	0.062
15	-0.00154	-0.00470	-0.0788**	0.000446	11,389	0.106
16	0.0161	0.00176	-0.230***	0.0950***	4,789	0.260
17	0.0122	-0.00612	-0.0525	0.000396***	1,621	0.063
20	-0.0108	0.00292	-0.149***	0.00134	15,460	0.067
21	-0.0383	0.0120	-0.00228	0.00355**	481	0.107
22	0.0159	-0.000329	-0.103**	0.00479*	5,077	0.074
23	0.0193	-0.000489	-0.169***	0.00504	3,676	0.082
24	0.0178	0.00532	-0.191***	0.0442***	2,214	0.210
25	-0.00812	0.00360	-0.153***	0.00557*	1,805	0.089
26	0.0136	0.000325	-0.126***	0.000472***	5,102	0.130
27	0.00471	0.00151	-0.145***	0.00137	4,922	0.079
28	-0.0103	0.00474	-0.151***	0.000292	25,242	0.072
29	0.00784	0.00213	-0.255***	0.00749	2,060	0.153
30	0.00842	0.00267	-0.139***	0.00328*	4,666	0.094
31	-0.0218	-0.000923	-0.265***	0.0146	1,028	0.119

32	-0.00906	0.00397	-0.133***	0.00470***	6,831	0.108
33	0.00179	0.000874	-0.103***	0.00627***	10,213	0.120
34	-0.00902	0.00256	-0.132***	0.00977**	6,722	0.128
35	-0.0165	0.00314	-0.114***	0.00677***	18,232	0.117
36	0.00150	-0.000685	-0.143***	0.000315	23,572	0.109
37	-0.00575	-0.00115	-0.115***	0.000581**	9,505	0.102
38	-0.00569	0.00521	-0.134***	0.000415**	11,695	0.100
39	-0.00124	0.00259	-0.214***	0.00406*	3,107	0.082
40	-0.0335	0.0101**	-0.194***	0.0564***	576	0.219
41	-0.0239	0.00943**	-0.147***	0.00548	977	0.141
42	0.00328	0.000446	-0.195***	0.0423***	3,213	0.152
43	0.624	-2.953	11.46	-0.842	13	1.000
44	-0.00235	0.000756	-0.104*	0.00692**	3,947	0.127
45	-0.00552	-0.00401	-0.151***	0.000796	2,204	0.118
46	0.0616	0.00727	-0.177*	0.0116***	370	0.436
47	0.0201	0.00360	-0.119**	0.000152***	1,671	0.094
48	0.0151	-0.00245	-0.0700**	6.89e-05*	9,283	0.128
49	0.00552	-0.00251	-0.0944***	0.000193	11,191	0.080
50	0.00587	0.00287	-0.107***	0.000833**	10,735	0.059
51	-0.0128	-0.00201	-0.114***	7.35e-05*	6,966	0.052
52	-0.0590*	0.0146***	-0.177***	0.000110**	794	0.148
53	-0.00676	-0.000687	-0.150***	0.0123***	2,811	0.217
54	0.0186	-0.00302	-0.126***	0.0372***	2,997	0.166
55	0.00852	0.00986**	-0.141**	0.00914	1,543	0.092
56	0.0220	0.00799	-0.154***	0.000317	2,921	0.078
57	-0.0322	0.00892	-0.167***	0.0264**	2,015	0.158
58	-0.00976	-0.00423	-0.185***	0.00182	3,846	0.085
59	-0.00123	0.00837*	-0.145***	0.00276***	4,172	0.080

70	0.0120	0.000328	-0.0197	0.000179	4,104	0.073
72	-0.0414	0.0179**	-0.108	0.0174*	788	0.073
73	-0.00670	0.00433	-0.151***	7.87e-05	31,394	0.098
75	0.00928	-0.00908	-0.112	0.00263	763	0.093
76	-0.0225	-0.0107	-0.356*	0.127***	195	0.384
78	-0.00171	0.000884	-0.0735	0.000298	2,129	0.045
79	0.00563	0.00733*	-0.177***	0.00355**	3,043	0.056
80	-0.000539	0.00862	-0.189***	0.00847**	3,151	0.078
81	-0.627	0.252	-2.737	0.750**	24	0.956
82	-0.0159	0.00374	-0.256***	0.0297***	1,317	0.135
83	0.101	0.00722	-0.270	0.0122***	285	0.255
84	0.106	0.0206	-0.466**	0.0401**	128	0.301
86	16.50	1.457			3	1.000
87	0.0241	0.00443	-0.0208	0.000994*	8,399	0.063

APPENDIX B

CHAPTER 3 APPENDIX

Table B.1: ROA vs. log(Per Capita Capital)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	ROA^b	ROA^b	ROA^b	ROA^b	ROA^v	ROA^v	ROA^v	ROA^v
VARIABLES	97-14	'11-14	'11-14 IFRS	05-14 EU	97-14	'11-14	'11-14 IFRS	05-14 EU
log(PCK)	-0.0159***	-0.0146***	-0.00792***	-0.00730***	-0.0341***	-0.0365***	-0.0394***	-0.0192***
	(0.00195)	(0.00336)	(0.00301)	(0.00237)	(0.00241)	(0.00323)	(0.00503)	(0.00390)
log(Size)	0.00979***	0.00853***	0.00906***	0.0138***	0.0201***	0.0185***	0.0166***	0.0273***
	(0.000793)	(0.00170)	(0.00187)	(0.000599)	(0.00211)	(0.00399)	(0.00433)	(0.00186)
Leverage	-0.0329***	-0.0327***	-0.00984	-0.0250***	-0.0528***	-0.0560***	-0.0236*	-0.0602***
	(0.00370)	(0.00635)	(0.00883)	(0.00590)	(0.00681)	(0.0101)	(0.0121)	(0.00904)
Price-to-Book	-2.08e-05**	-2.31e-05*	-7.71e-05***	-5.61e-05***	-6.10e-05***	-5.03e-05*	-0.000190*	-0.000116**
	(8.26e-06)	(1.37e-05)	(2.92e-05)	(1.94e-05)	(1.62e-05)	(2.92e-05)	(0.000102)	(5.00e-05)
Constant	0.170***	0.165***	0.0533	0.0433	0.292***	0.309***	0.367***	0.0832*
	(0.0253)	(0.0413)	(0.0423)	(0.0292)	(0.0363)	(0.0491)	(0.0775)	(0.0472)
Year Dummies	Y	Y	Y	Y	Y	Y	Y	Y
Industry Dummies	Y	Y	Y	Y	Y	Y	Y	Y
Observations	334,608	88,527	44,640	34,031	334,608	88,527	44,640	34,031
R-squared	0.123	0.119	0.136	0.117	0.123	0.138	0.148	0.120

Table B.2: Turnover vs. log(per capita Capital)

	(1)	(2)	(3)	(4)
	Turnover	Turnover	Turnover	Turnover
VARIABLES	97-14	'11-14	'11-14 IFRS	05-14 EU
log(PCK)	0.0568***	0.0646*	0.134***	-0.150***
	(0.0154)	(0.0342)	(0.0383)	(0.0248)
log(Size)	-0.00950**	-0.0135*	0.0162***	-0.0241***
	(0.00424)	(0.00748)	(0.00532)	(0.00308)
Leverage	0.469***	0.476***	0.494***	0.699***
	(0.0269)	(0.0397)	(0.0508)	(0.0503)
Price-to-Book	-0.000251***	-0.000250*	-0.000497	-0.000431
	(7.61e-05)	(0.000132)	(0.000356)	(0.000313)
Constant	0.0495	0.0993	-1.213**	2.642***
	(0.191)	(0.417)	(0.475)	(0.303)
Year Dummies	Y	Y	Y	Y
Industry Dummies	Y	Y	Y	Y
Observations	334,608	88,527	44,640	34,031
R-squared	0.185	0.180	0.200	0.178

Table B.3: Manufacturing: ROA vs. log (Per capita capital)

Industries	log(PCK)	log(Size)	Leverage	Price-to-Book	Observations	R-squared
20 FOOD AND KINDRED PRODUCTS	-0.0981	0.00202	0.00589	-0.000613	13,483	0.002
21 TOBACCO PRODUCTS	-0.022	0.00426	-0.00708	-0.000602	387	0.037
22 TEXTILE MILL PRODUCTS	-0.0278***	0.00461***	-0.0849***	-0.00377***	4,494	0.147
23 APPAREL AND OTHER TEXTILE PRODUCTS	-0.00867	0.00358	-0.0886***	-0.000613	3,225	0.015
24 LUMBER AND WOOD PRODUCTS	-0.0125***	0.00969***	-0.0870***	-0.00169**	1,936	0.069
25 FURNITURE AND FIXTURES	-0.0265***	0.00805***	-0.118***	-6.51E-07	1,552	0.081
26 PAPER AND ALLIED PRODUCTS	-0.0152***	0.00378***	-0.100***	-0.000268**	4,456	0.089
27 PRINTING AND PUBLISHING	-0.0171***	0.00473***	-0.0742***	-0.000961	4,244	0.052
28 CHEMICALS AND ALLIED PRODUCTS	-0.0535***	0.0171***	-0.0254	-8.89e-05*	22,627	0.014
29 PETROLEUM AND COAL PRODUCTS	0.000493	0.0126***	-0.154***	-0.00148**	1,805	0.196
30 RUBBER AND MISCELLANEOUS PLASTICS PRODUCTS	-0.0244***	0.00599***	-0.0884***	-0.000649**	4,089	0.061
31 LEATHER AND LEATHER PRODUCTS	-0.0292***	-0.00269	-0.209***	-0.0025	912	0.131
32 STONE, CLAY, GLASS, AND CONCRETE PRODUCTS	-0.0211***	0.00699***	-0.106***	-0.000417***	5,859	0.087
33 PRIMARY METAL INDUSTRIES	-0.0193***	0.00548***	-0.106***	-0.000780***	9,136	0.09
34 FABRICATED METAL PRODUCTS	-0.0141***	0.00523***	-0.126***	-0.000361*	5,902	0.085
35 INDUSTRIAL MACHINERY AND EQUIPMENT	-0.0210***	0.00758***	-0.0547***	-0.00121*	16,081	0.061
36 ELECTRONIC AND OTHER ELECTRIC EQUIPMENT	-0.0197***	0.00996***	-0.0513***	-3.63E-05	21,260	0.028
37 TRANSPORTATION EQUIPMENT	-0.0210***	0.00818***	-0.0921***	-0.000105***	8,421	0.02
38 INSTRUMENTS AND RELATED PRODUCTS	-0.0332***	0.0298***	0.0132	-0.000105***	10,317	0.002
39 MISCELLANEOUS MANUFACTURING INDUSTRIES	-0.0186	0.00154	-0.0671**	-0.000398*	2,690	0.006

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